Lower Duwamish Waterway Group

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

Lower Duwamish Waterway Remedial Investigation

REMEDIAL INVESTIGATION REPORT

FINAL

For submittal to:

The US Environmental Protection Agency
Region 10
Seattle, WA

The Washington State Department of Ecology
Northwest Field Office
Bellevue, WA

July 9, 2010

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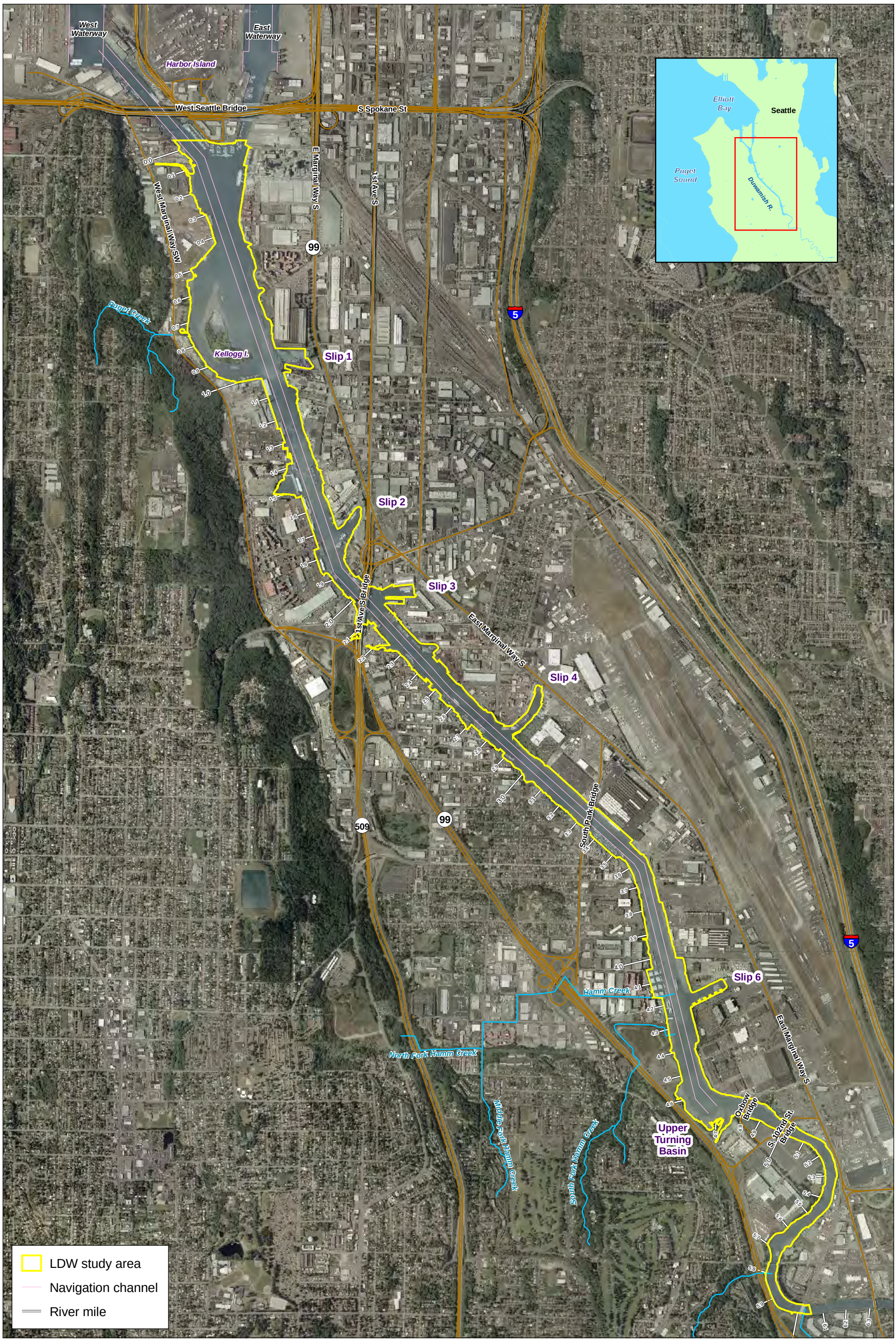

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0 0.25 0.5 Miles

0 0.25 0.5 Kilometers

Map ES-1. Lower Duwamish Waterway

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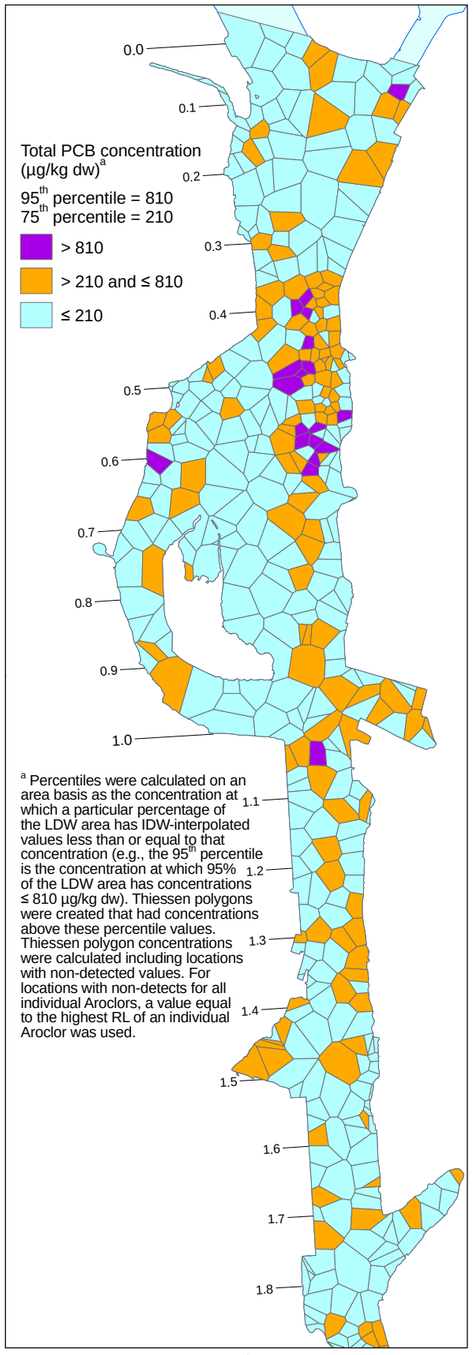
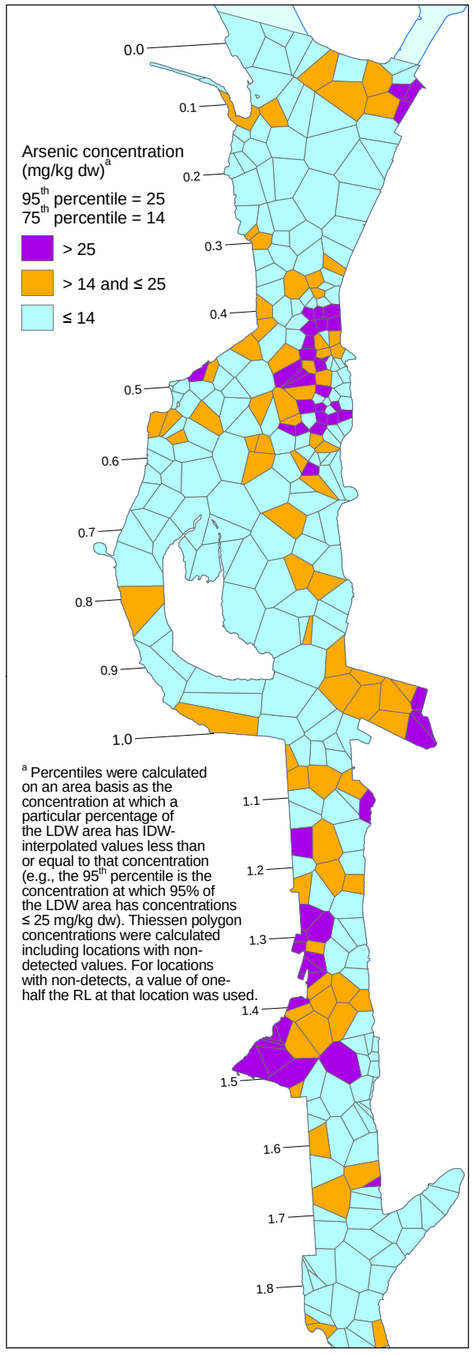
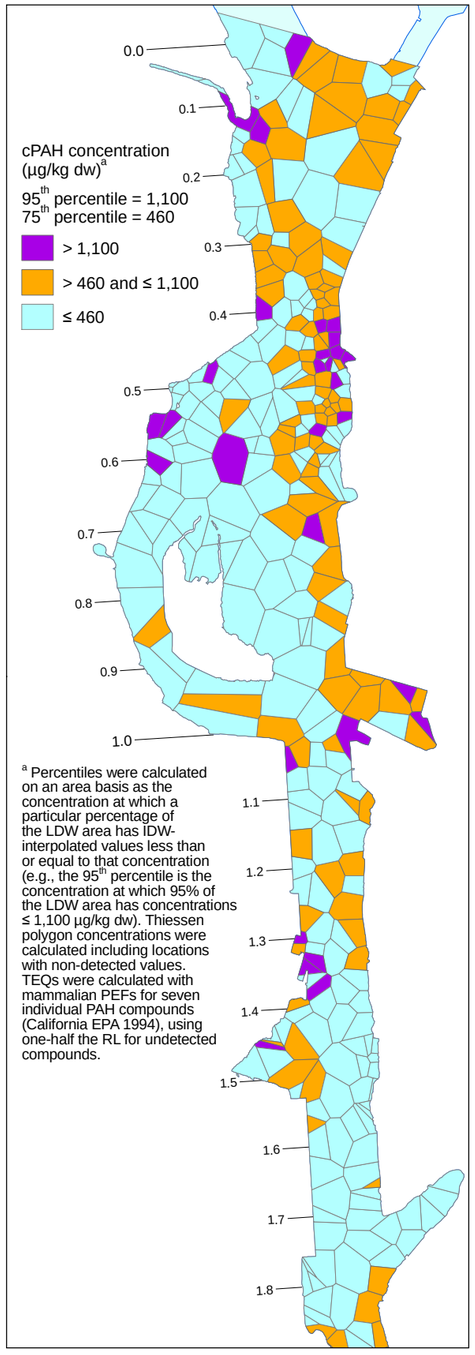


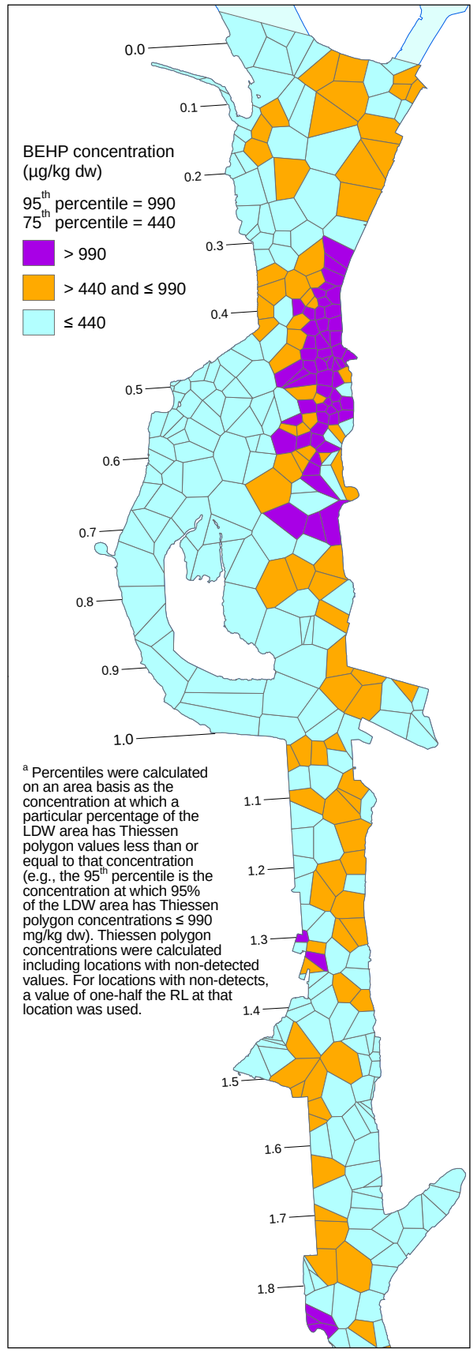
[a] Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has IDW-interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has concentrations ≤ 810 µg/kg dw). Thiessen polygons were created that had concentrations above these percentile values. Thiessen polygon concentrations were calculated including locations with non-detected values. For locations with non-detects for all individual Aroclors, a value equal to the highest RL of an individual Aroclor was used.



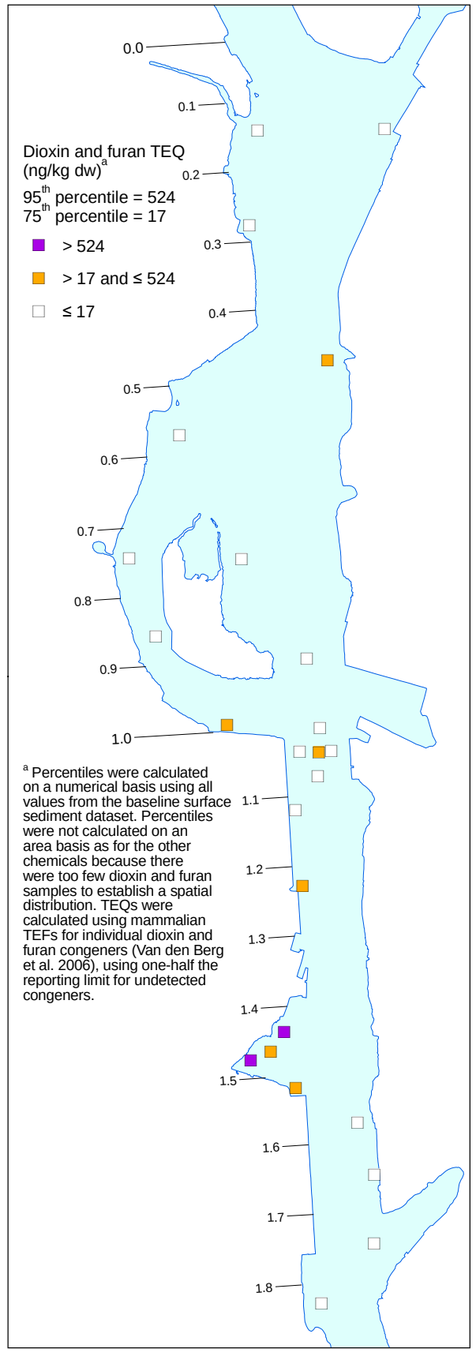
[a] Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has IDW-interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has concentrations ≤ 25 mg/kg dw). Thiessen polygon concentrations were calculated including locations with non-detected values. For locations with non-detects, a value of one-half the RL at that location was used.



[a] Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has IDW-interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has concentrations ≤ 1,100 µg/kg dw). Thiessen polygon concentrations were calculated including locations with non-detected values. TEQs were calculated with mammalian PEFs for seven individual PAH compounds (California EPA 1994), using one-half the RL for undetected compounds.



[a] Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has Thiessen polygon values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has Thiessen polygon concentrations ≤ 990 mg/kg dw). Thiessen polygon concentrations were calculated including locations with non-detected values. For locations with non-detects, a value of one-half the RL at that location was used.



[a] Percentiles were calculated on a numerical basis using all values from the baseline surface sediment dataset. Percentiles were not calculated on an area basis as for the other chemicals because there were too few dioxin and furan samples to establish a spatial distribution. TEQs were calculated using mammalian TEFs for individual dioxin and furan congeners (Van den Berg et al. 2006), using one-half the reporting limit for undetected congeners.

Wind Ward environmental LLC

0 1,000 2,000 Feet

0 250 500 Meters

Scale is the same for each inset map

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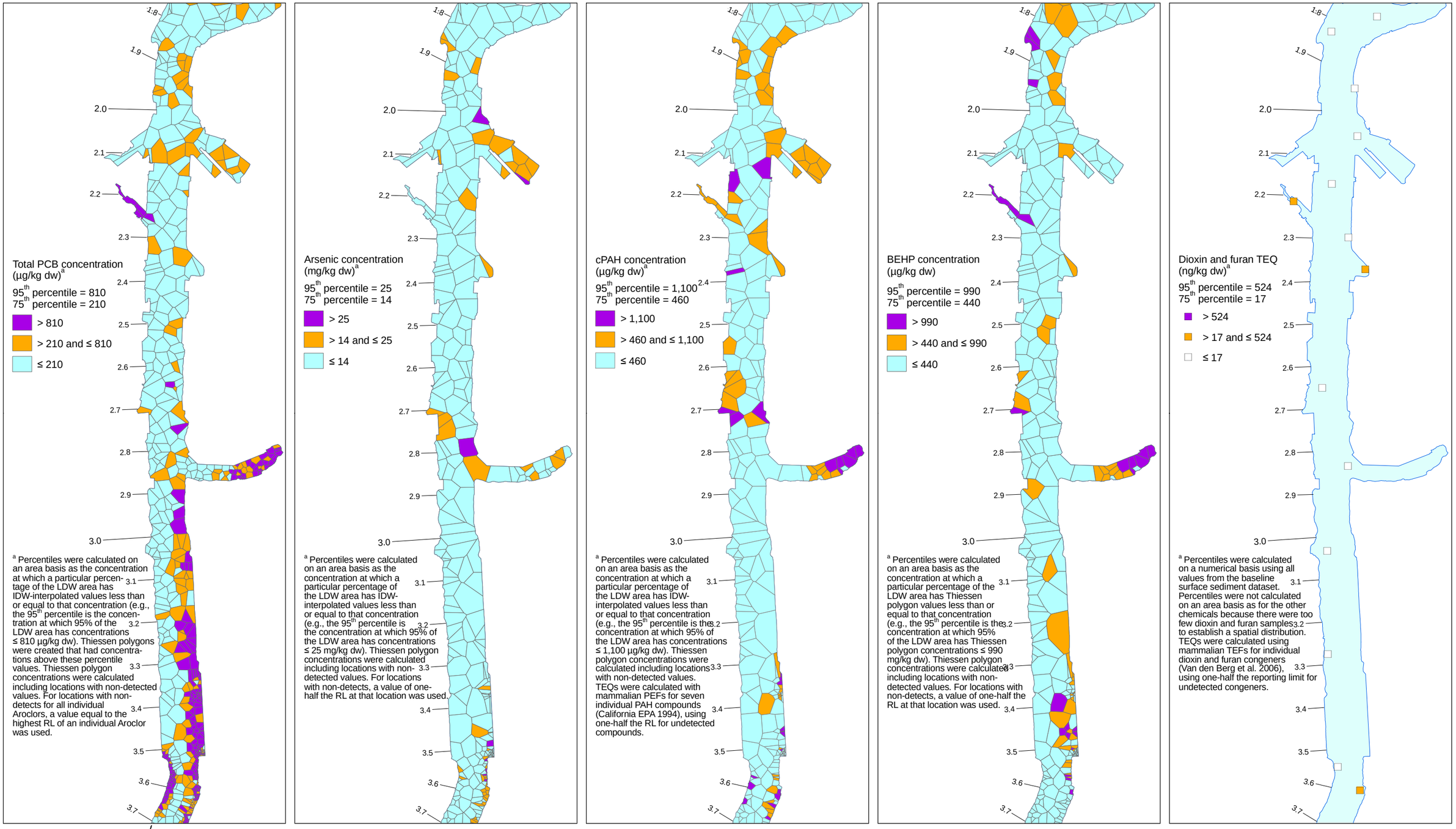
Map ES-2a. 95th and 75th Percentiles of risk driver chemicals, RM 0.0 to RM 1.8

Produced by CEH, 06/28/2010, MAP 3056, W:\Projects\00-08-06_Duwamish_Ph\data\GIS\Phase2 RI\mro - Env Setting

For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005.



Wind Ward environmental LLC

0 1,000 2,000 Feet

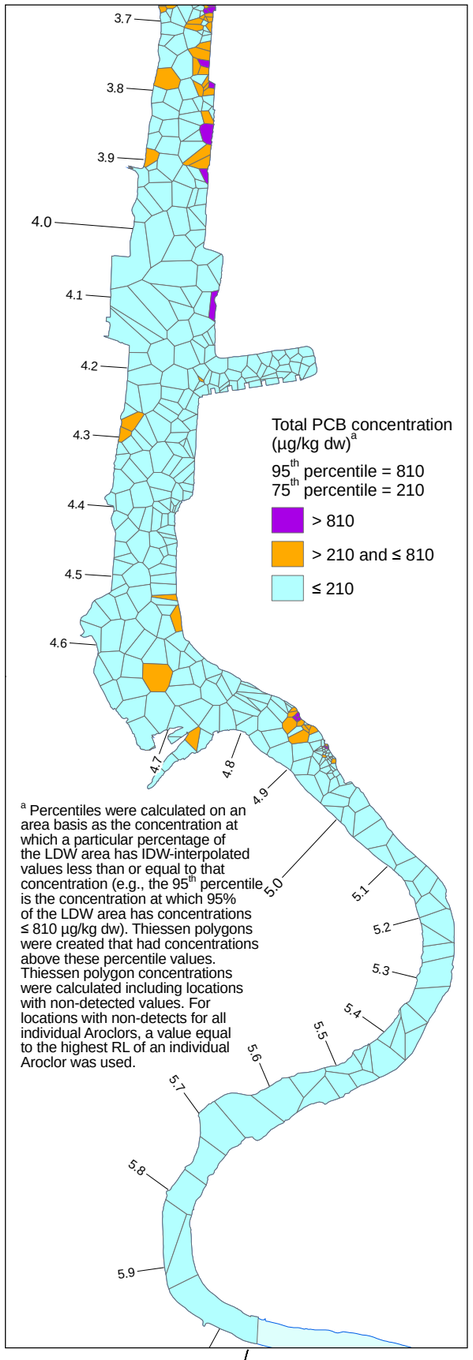
0 250 500 Meters

Scale is the same for each inset map

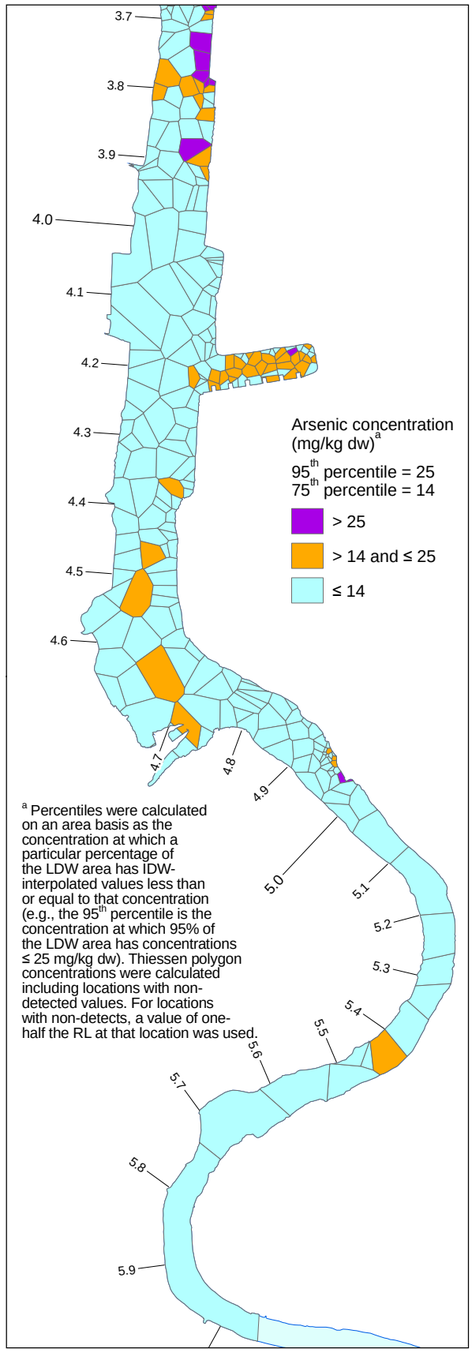
N

Map ES-2b. 95th and 75th Percentiles of risk driver chemicals, RM 1.8 to RM 3.7

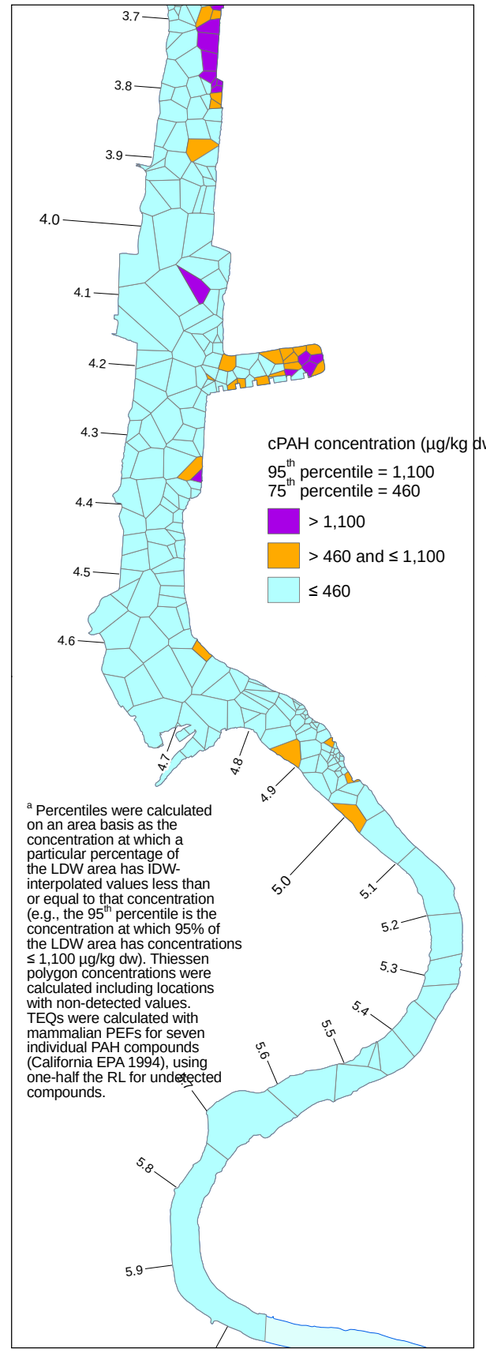
Produced by CEH, 06/28/2010, MAP 3056, W:\Projects\00-08-06_Duwamish_Rfidata\GIS\Phase2 RI\Intro - Env Setting



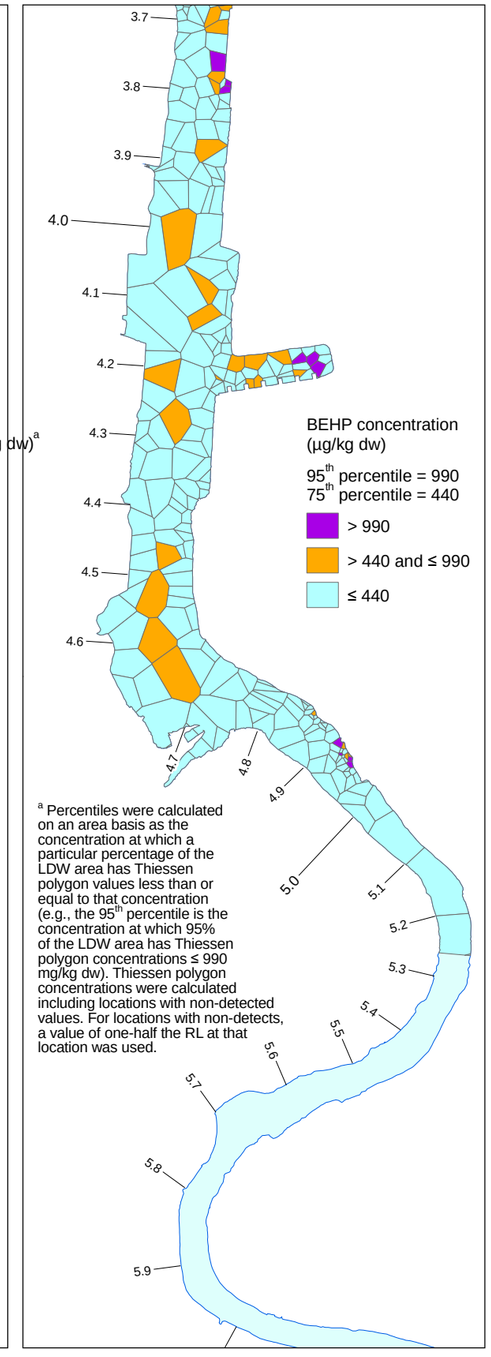
[a] Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has IDW-interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has concentrations ≤ 810 µg/kg dw). Thiessen polygons were created that had concentrations above these percentile values. Thiessen polygon concentrations were calculated including locations with non-detected values. For locations with non-detects for all individual Aroclors, a value equal to the highest RL of an individual Aroclor was used.



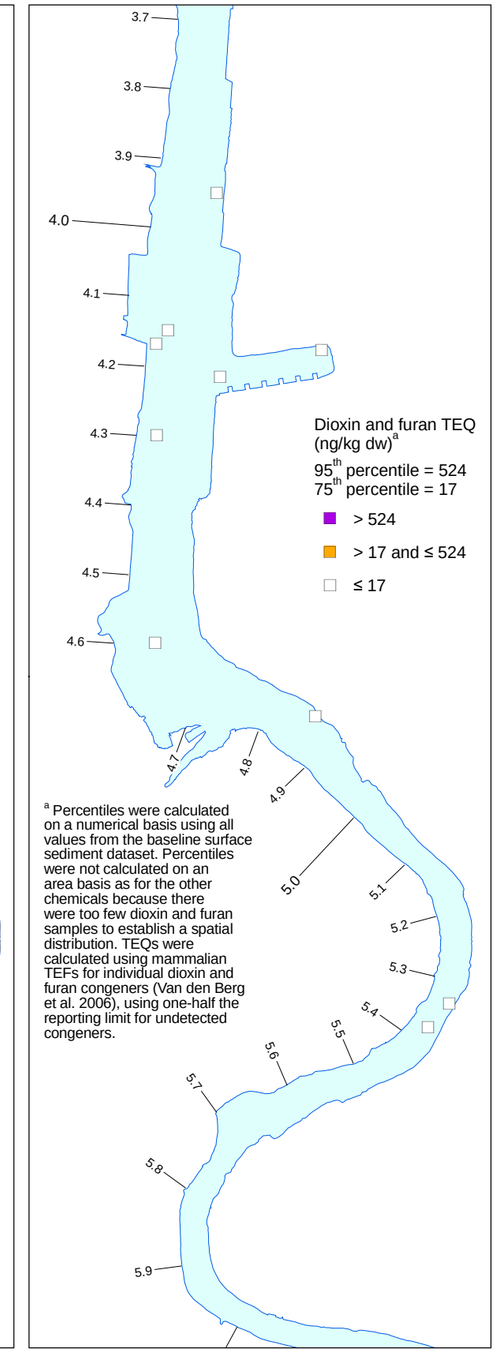
[a] Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has IDW-interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has concentrations ≤ 25 mg/kg dw). Thiessen polygon concentrations were calculated including locations with non-detected values. For locations with non-detects, a value of one-half the RL at that location was used.



[a] Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has IDW-interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has concentrations ≤ 1,100 µg/kg dw). Thiessen polygon concentrations were calculated including locations with non-detected values. TEQs were calculated with mammalian PEFs for seven individual PAH compounds (California EPA 1994), using one-half the RL for undetected compounds.



[a] Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has Thiessen polygon values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has Thiessen polygon concentrations ≤ 990 mg/kg dw). Thiessen polygon concentrations were calculated including locations with non-detected values. For locations with non-detects, a value of one-half the RL at that location was used.



[a] Percentiles were calculated on a numerical basis using all values from the baseline surface sediment dataset. Percentiles were not calculated on an area basis as for the other chemicals because there were too few dioxin and furan samples to establish a spatial distribution. TEQs were calculated using mammalian TEFs for individual dioxin and furan congeners (Van den Berg et al. 2006), using one-half the reporting limit for undetected congeners.

Wind Ward environmental LLC

0 1,000 2,000 Feet

0 250 500 Meters

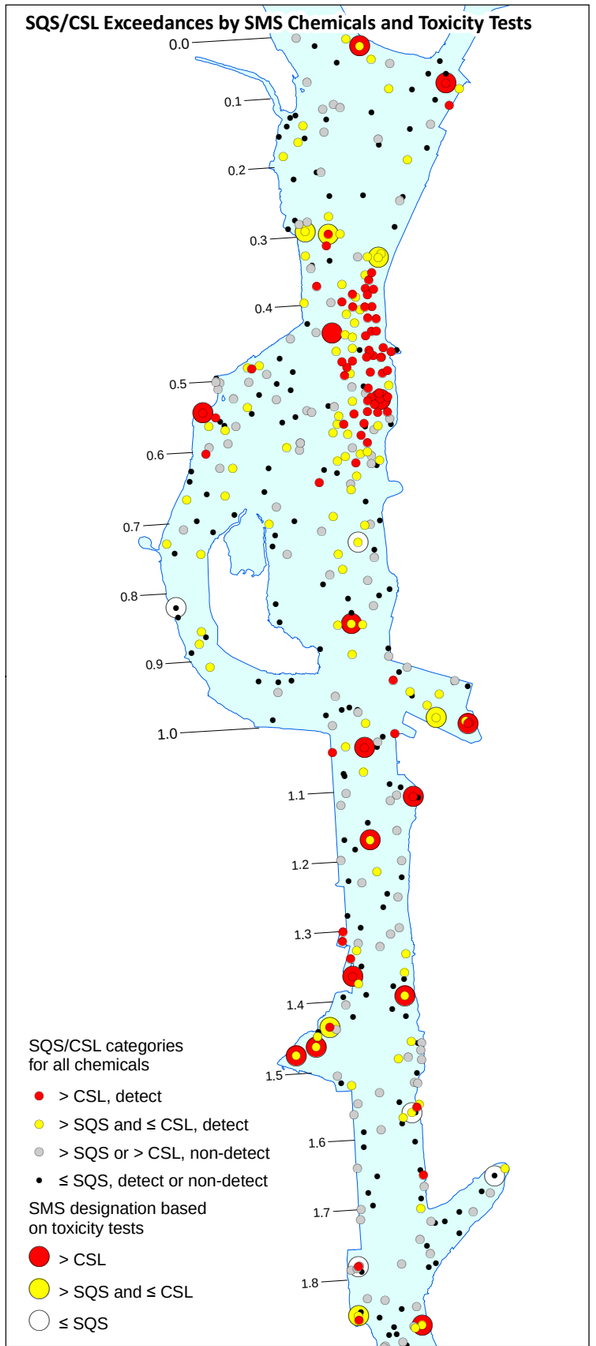
Scale is the same for each inset map

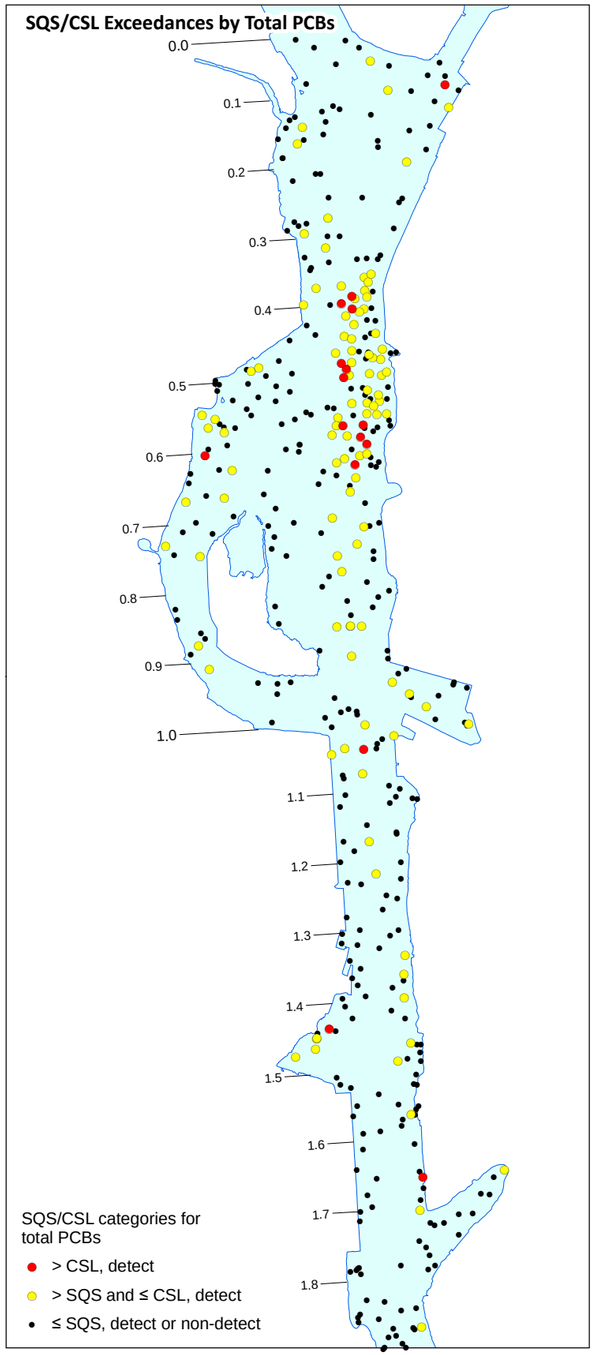
N

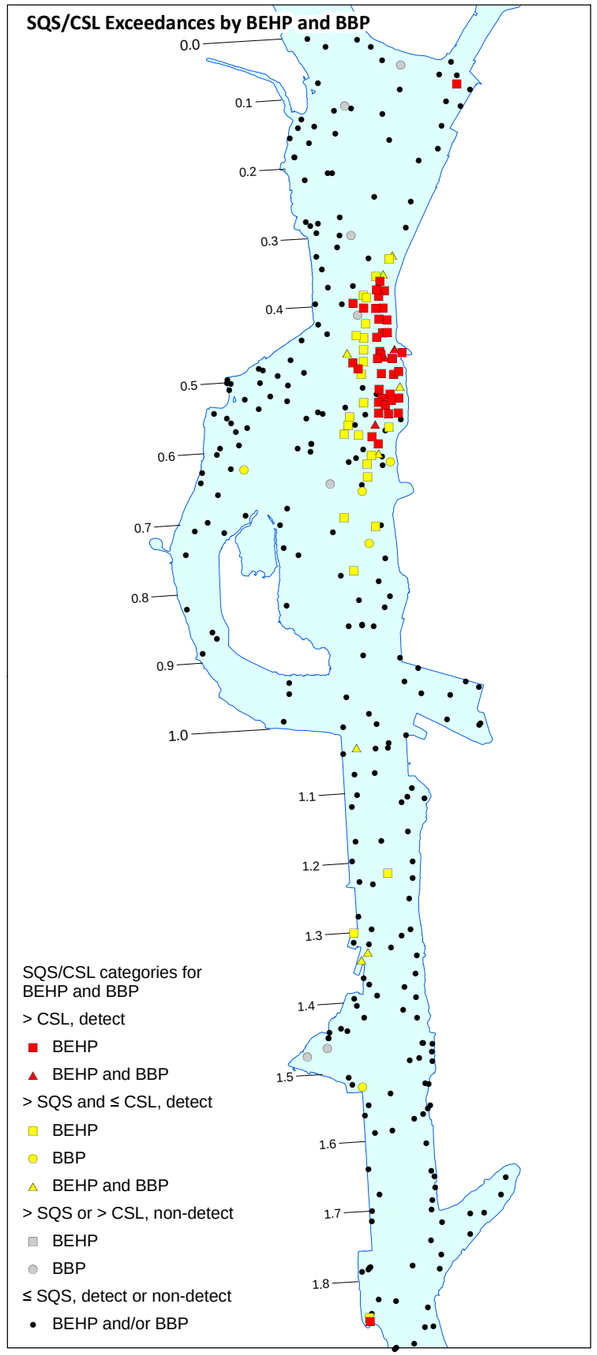
Map ES-2c. 95th and 75th Percentiles of risk driver chemicals, RM 3.7 to RM 6.0

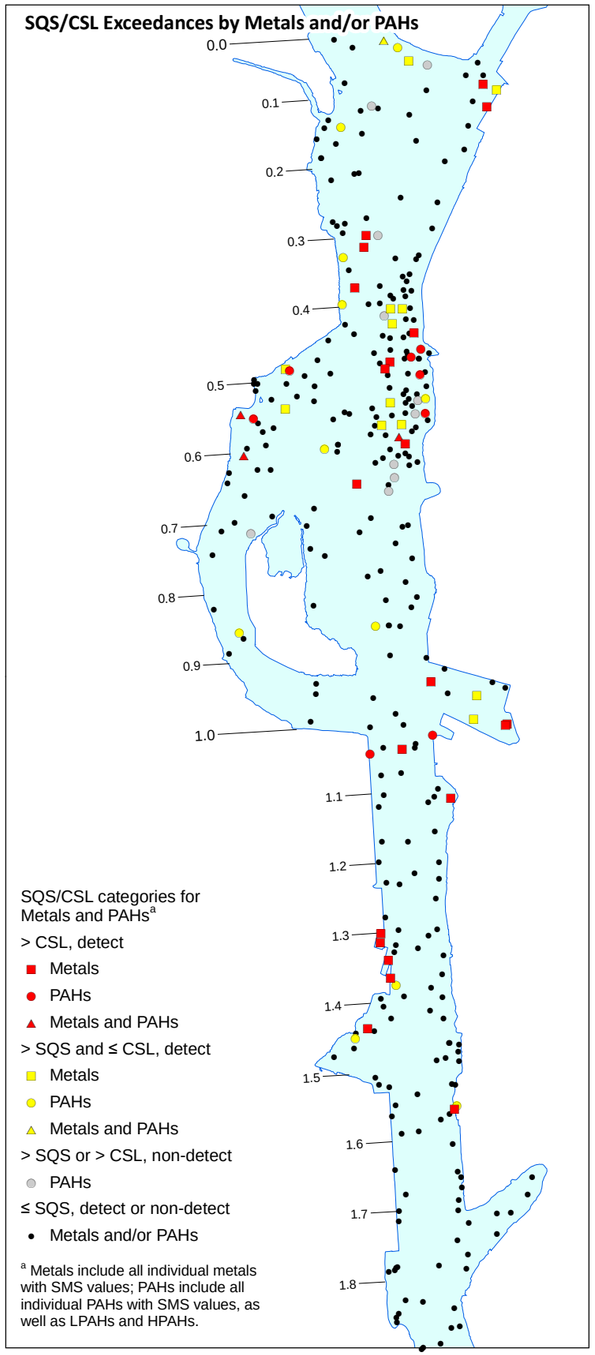
For the Norfolk Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 and 2004.

Produced by CEH, 06/28/2010, MAP 3056, W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\mxd - Env Setting









Wind Ward environmental LLC

0 1,000 2,000 Feet

0 250 500 Meters

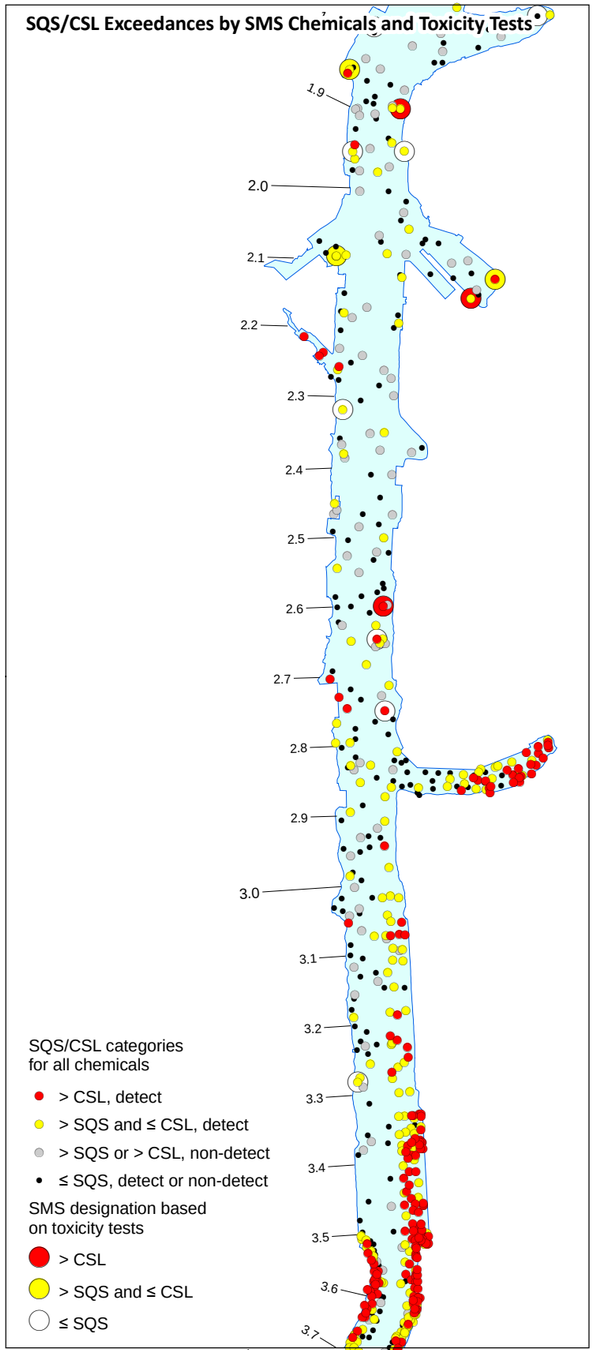
Scale is the same for each inset map

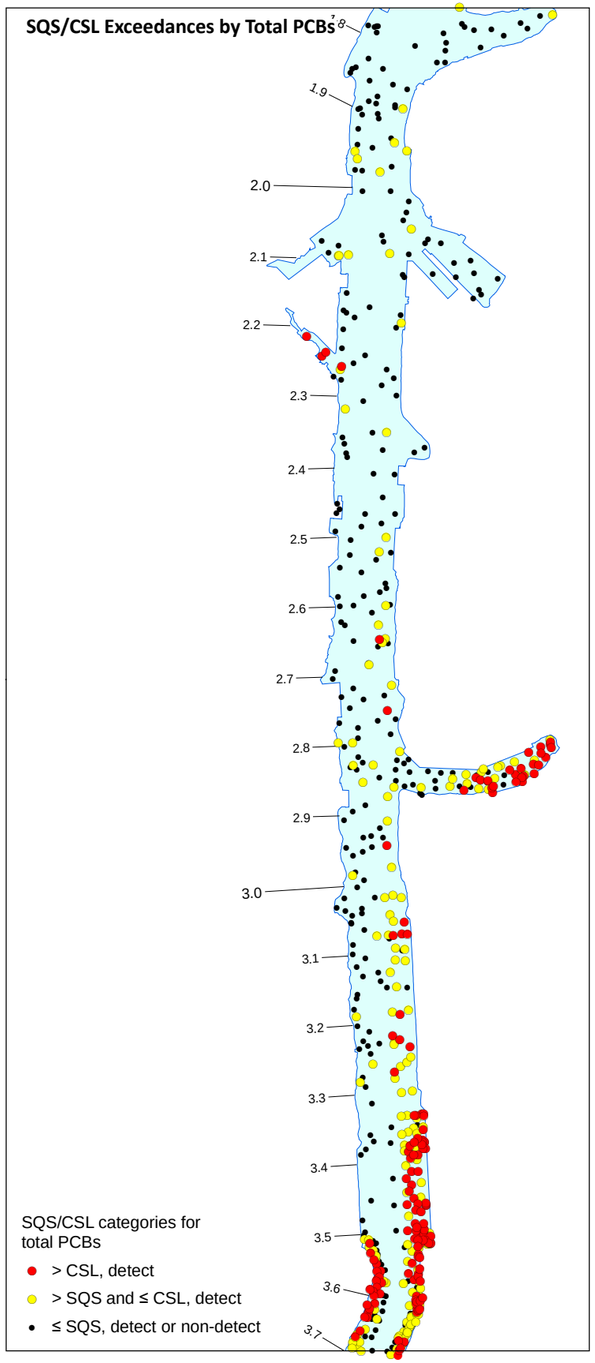
N

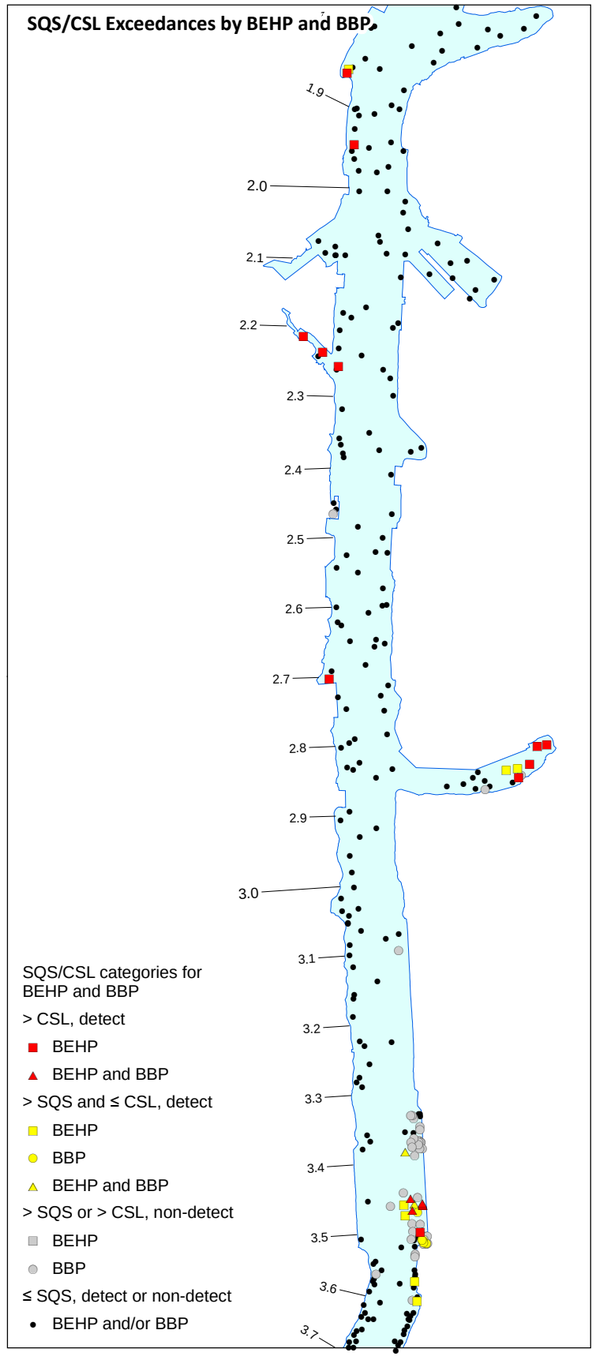
Map ES-3a. Exceedances of SMS criteria in LDW surface sediment, RM 0.0 to RM 1.8

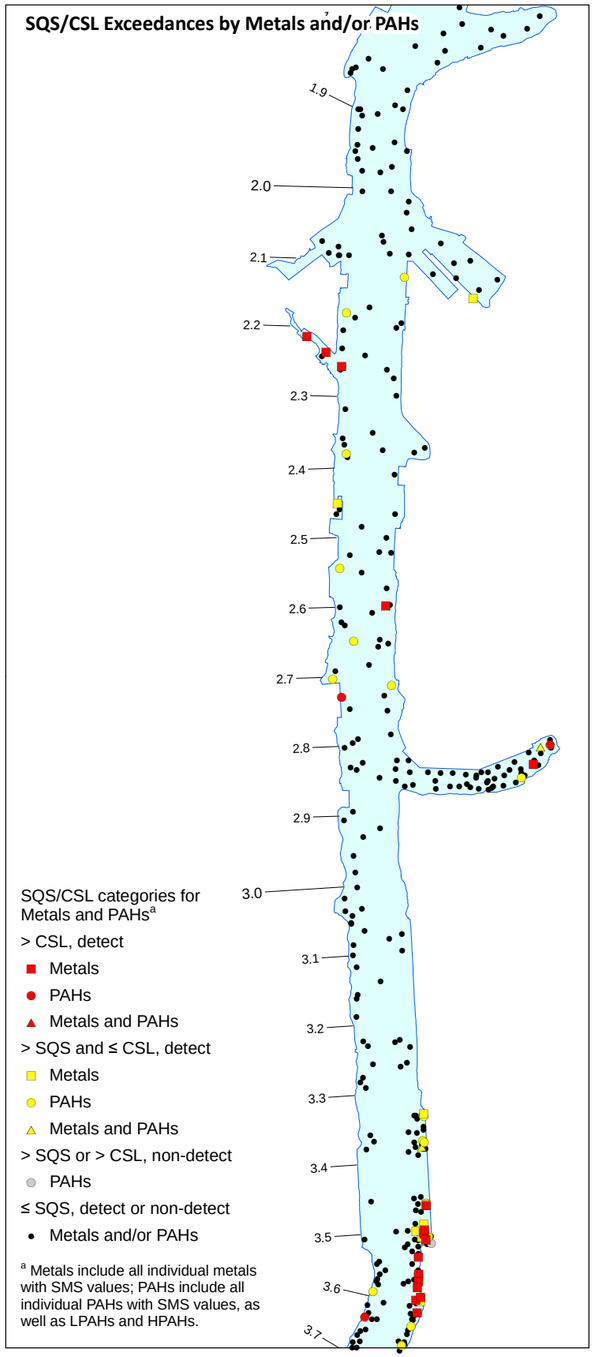
For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005.

Produced by CEH, 06/28/2010, MAP #3375, W:\Projects\50-08-06_Duwamish_Rivbasin\Phase2 RI\Intro - Env Setting









Wind Ward environmental LLC

0 1,000 2,000 Feet

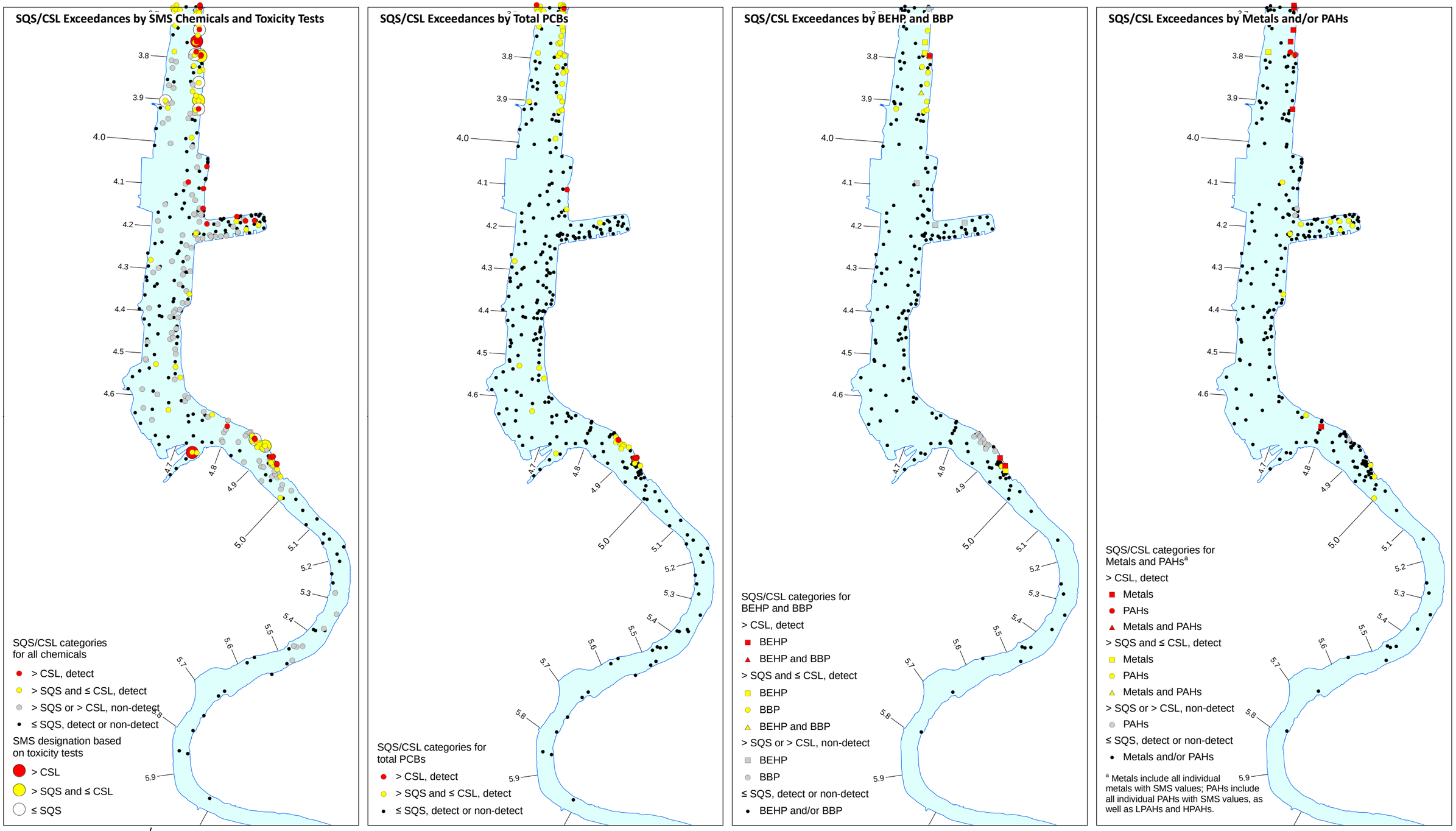
0 250 500 Meters

Scale is the same for each inset map

N

Map ES-3b. Exceedances of SMS criteria in LDW surface sediment, RM 1.8 to RM 3.7

Produced by CEH, 06/26/2019, MAP #3375; W:\Projects\00-08-06_Duwamish_R\data\gis\Phase2 RI\mmo - Env Setting

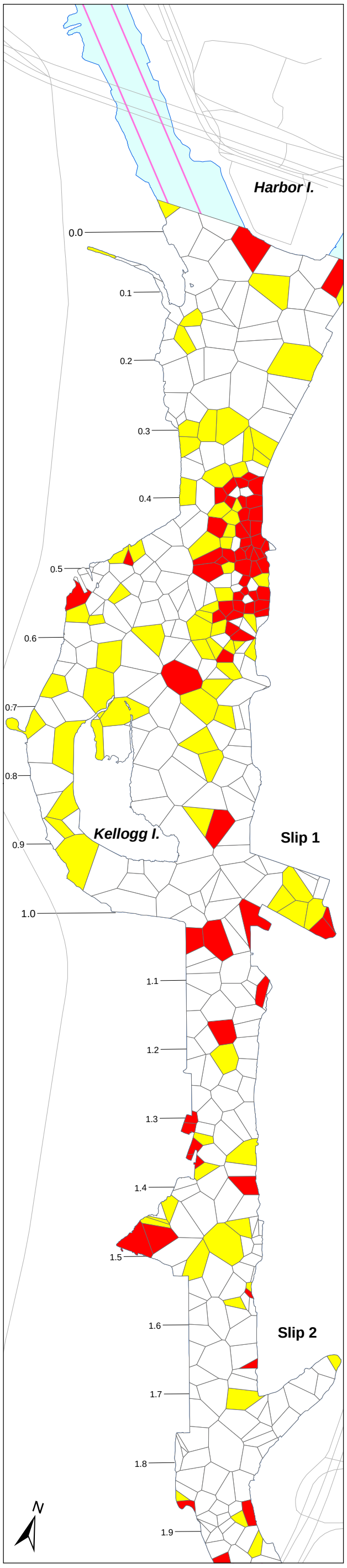


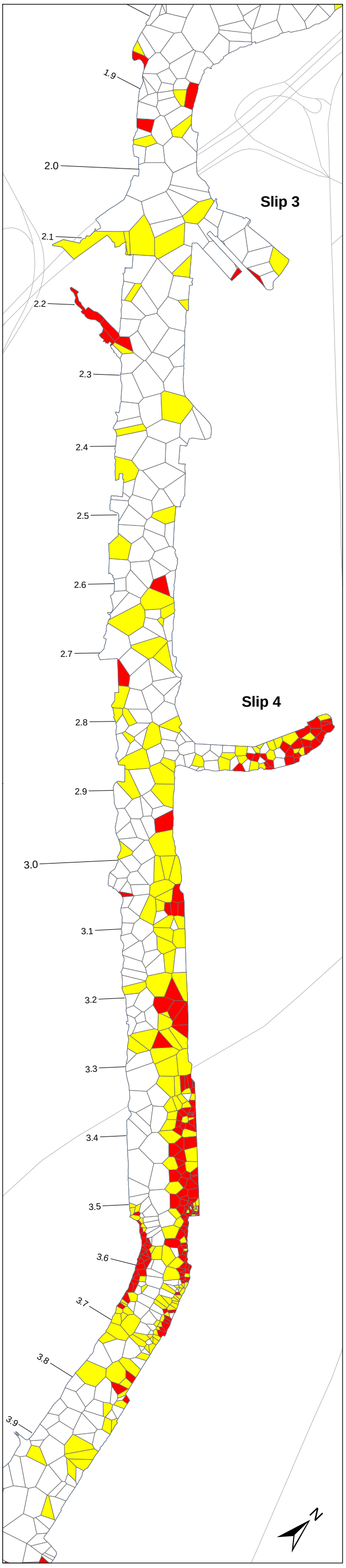
Wind Ward environmental LLC

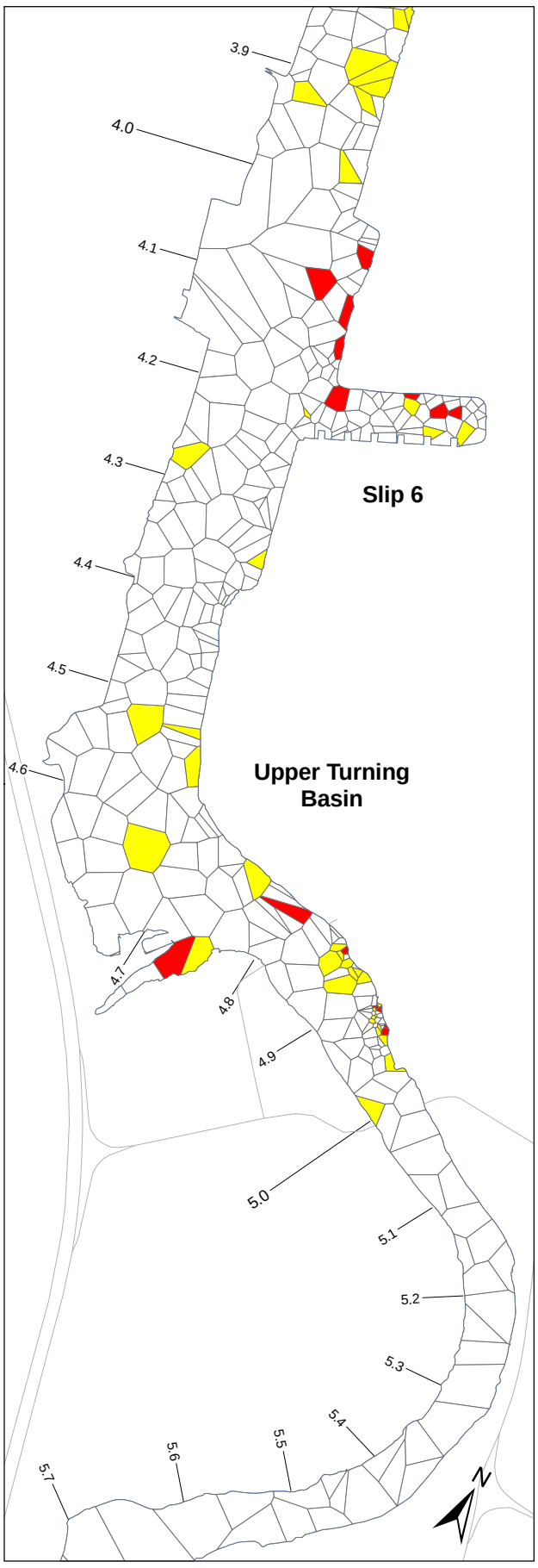
Map ES-3c. Exceedances of SMS criteria in LDW surface sediment, RM 3.7 to RM 6.0

For the Norfolk Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 and 2004.

Produced by CEH, 06/28/2010, MAP #3375; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Intro - Env Setting







> CSL toxicity or
> CSL chemistry if no toxicity data[a]

> SQS and ≤ CSL toxicity or
> SQS and ≤ CSL chemistry
if no toxicity data[a]

≤ SQS toxicity or
≤ SQS chemistry if no toxicity data[a]

Outside LDW study area

Road

River mile

Navigation channel

[a] Exceedances of the SQS and CSL chemical criteria are based on detected concentrations. For chemicals whose SQS and CSL are on an organic carbon normalized basis, if the TOC was < 0.5% or > 4.0%, the dry weight concentration of that chemical was compared to the LAET and 2LAET, and exceedances of the LAET and 2LAET were equated with exceedances of the SQS and CSL, respectively.

Wind Ward environmental LLC

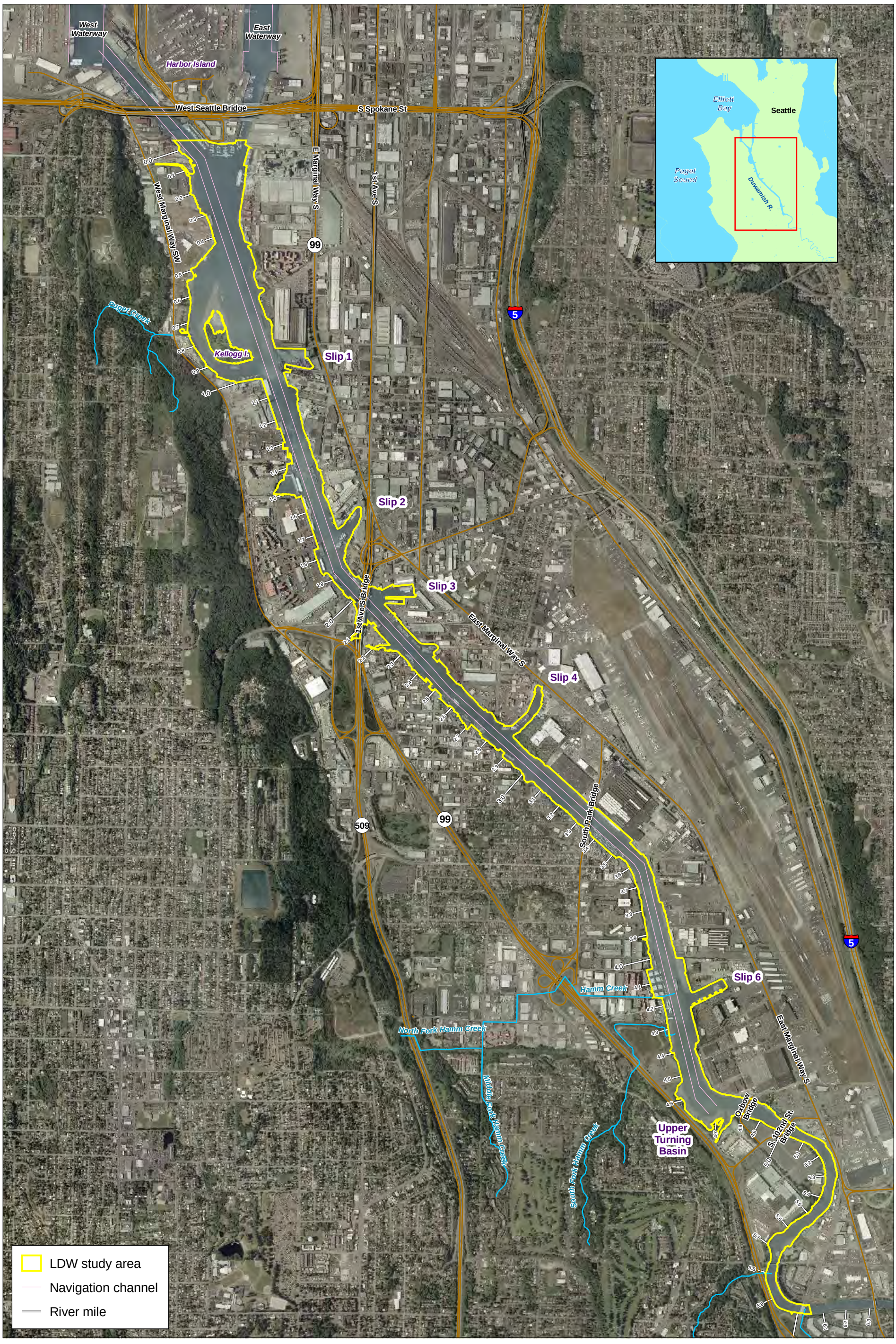
0 0.1 0.2 Miles

0 0.1 0.2 Kilometers

Scale is the same for each inset map

Map ES-4. Exceedances of SQS and CSL (chemical criteria and toxicity combined) using Thiessen polygons for the baseline surface sediment dataset

Prepared by CEH, 06/29/2010; MAP #2383; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Intro - Env Setting



Wind Ward environmental LLC

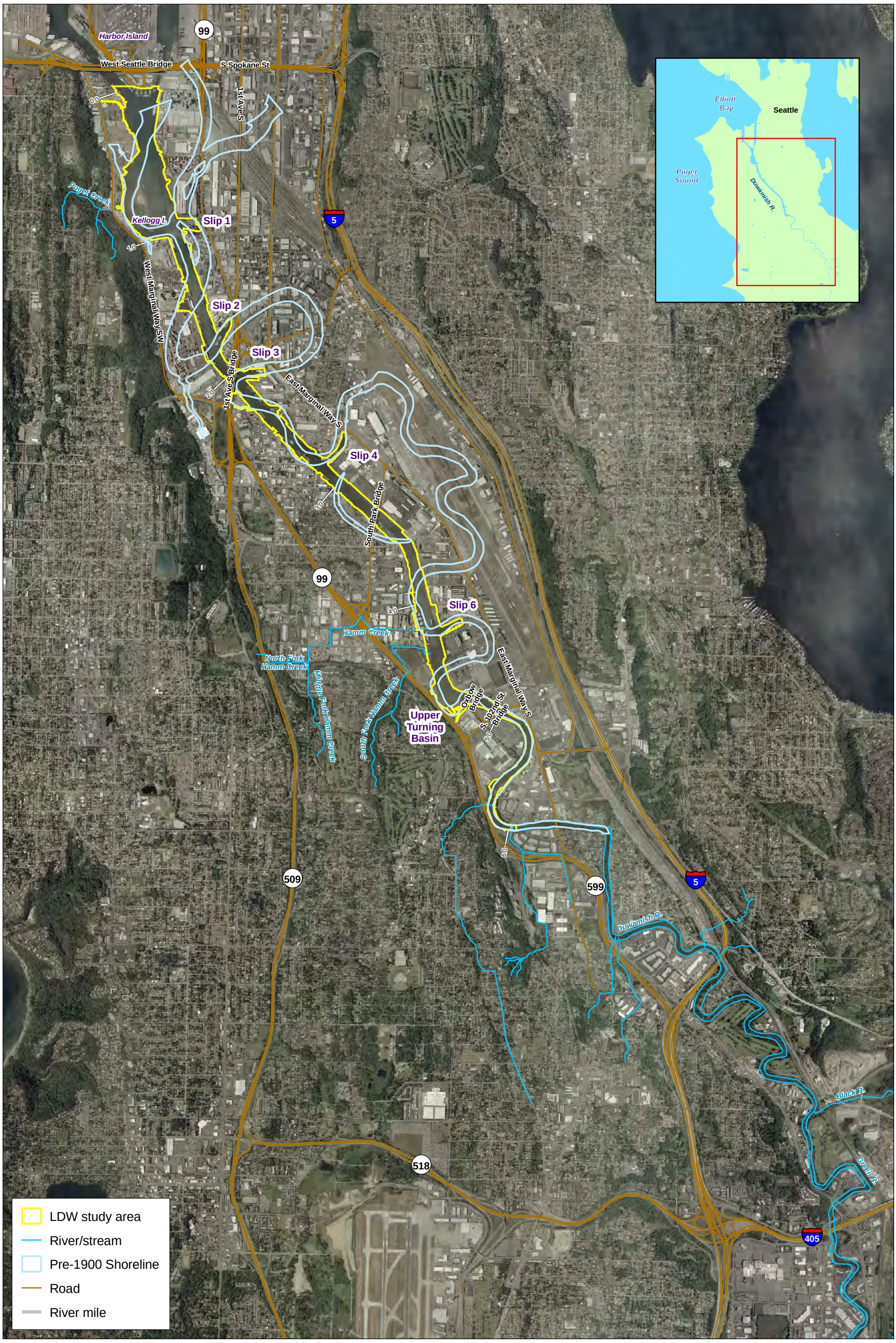
N

0 0.25 0.5 Miles

0 0.25 0.5 Kilometers

Map 1-1. Lower Duwamish Waterway

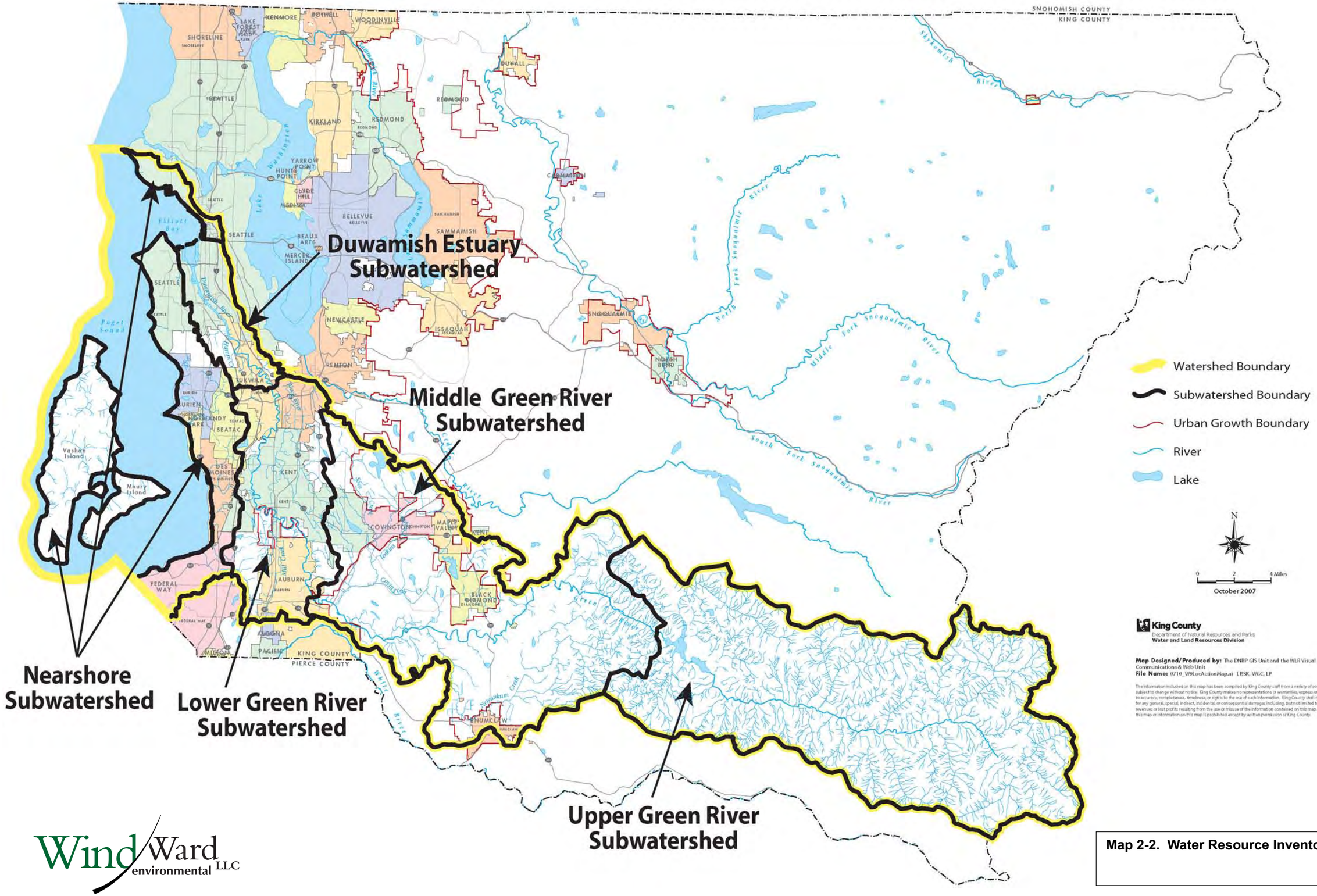
Prepared by CEH 06/28/2010; MAP #2387; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Intro - Env Setting



Wind Ward environmental LLC

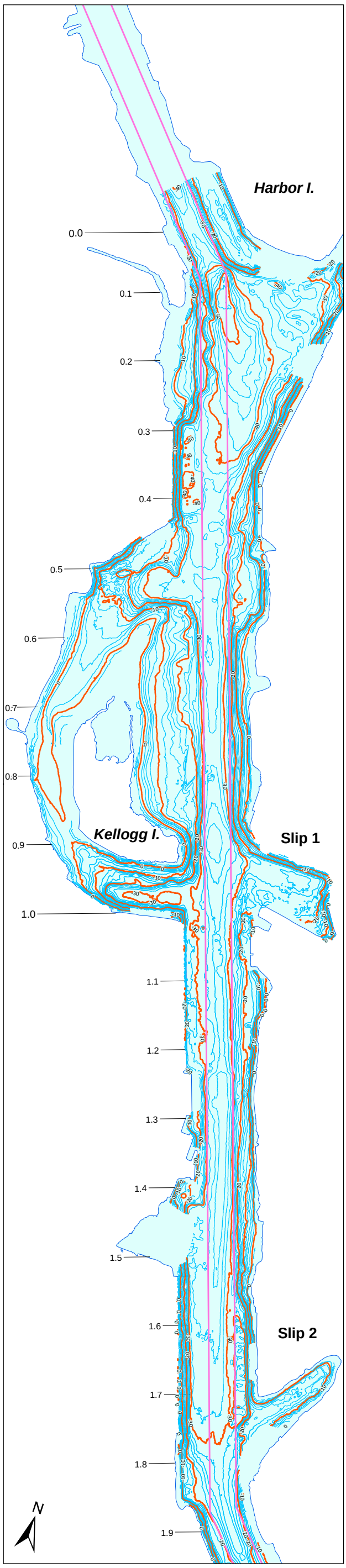
Map 2-1. LDW and historical meanders

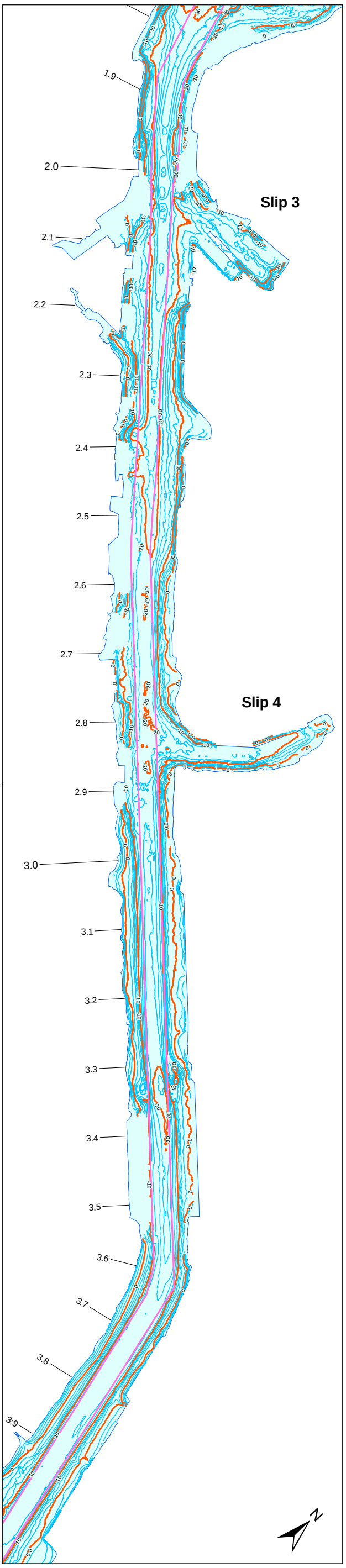
Prepared by CEH 06/28/2010. MAP #3091; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Intro - Env Setting

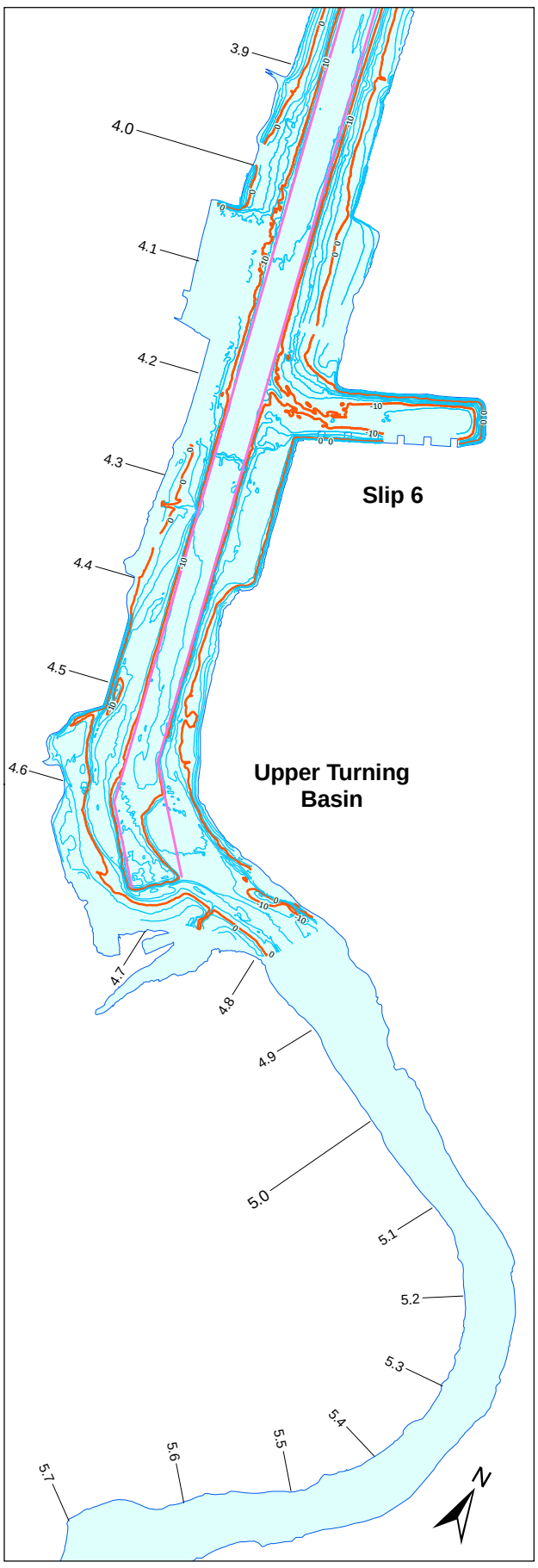


Wind Ward environmental LLC

Map 2-2. Water Resource Inventory Area 9







Bathymetry[a]

- 10 ft interval
- 2 ft interval
- River mile
- Navigation channel

[a] David Evans and Associates, 2003

0 0.1 0.2 Miles

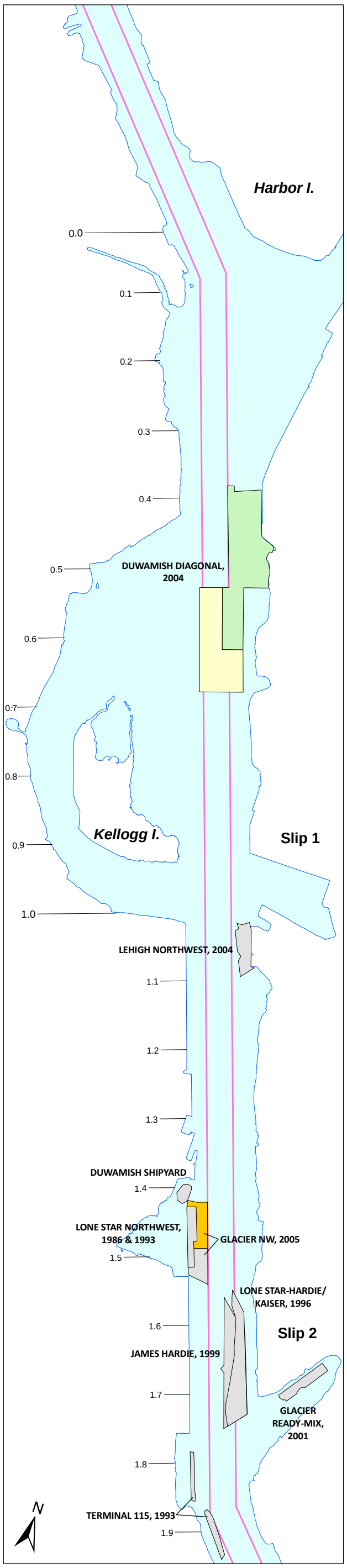
0 0.1 0.2 Kilometers

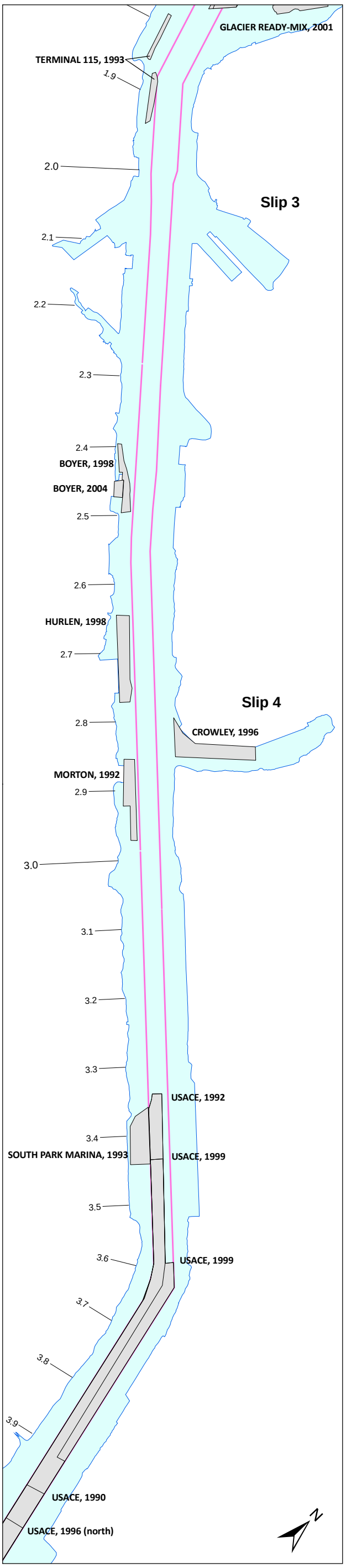
Scale is the same for each inset map

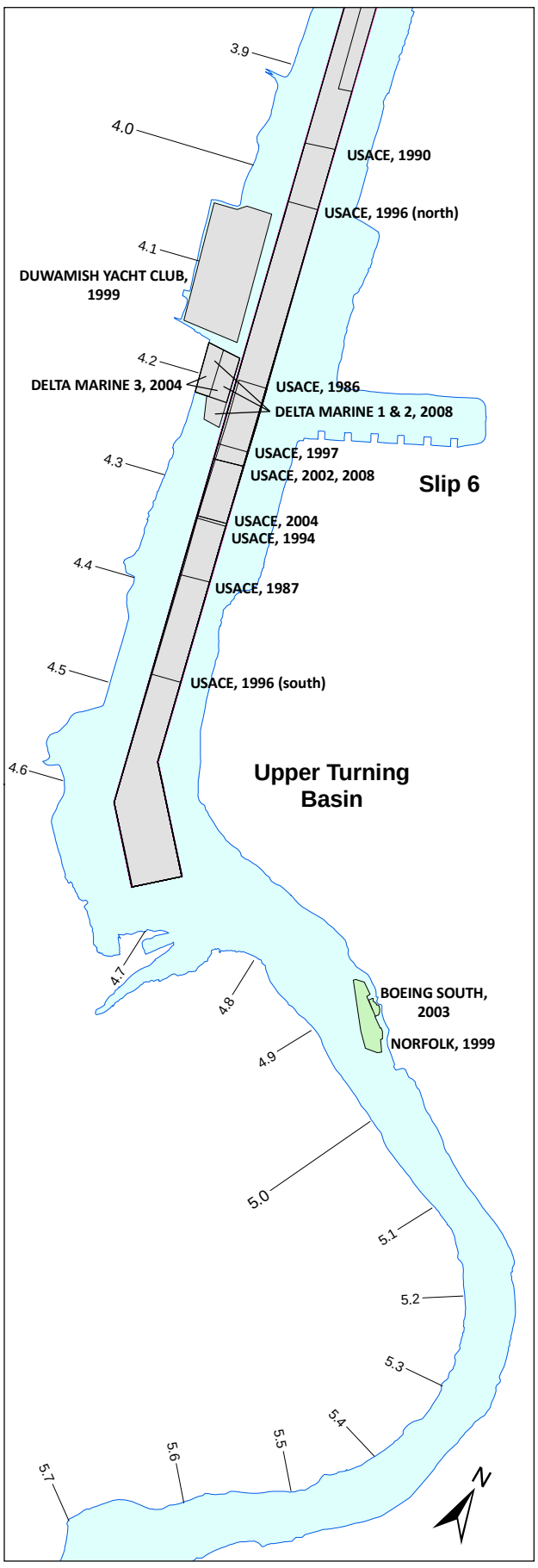
Map 2-3. LDW bathymetry contours

Wind Ward environmental LLC

Prepared by CEH, 06/28/2010; MAP #3318; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Intro - Env Setting







Dredged area

Dredged and capped area

Dredged and thin-layer placement

Thin-layer placement

River mile

Navigation channel

Note: Navigation channel dredging event dates and locations are provided in Table 2-1.

USACE labels mark the northern extent of the dredge event; the southern extent for all USACE dredge events is RM 4.65, except for the 1996 event which ends at RM 4.48 as marked.

Wind Ward environmental LLC

0 0.1 0.2 Miles

0 0.1 0.2 Kilometers

Scale is the same for each inset map

Map 2-4. Locations of LDW dredging events, 1986 to present

Prepared by CEH, 06/28/2010; MAP #3317; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Intro - Env Setting

Dredging information provided by AECOM.

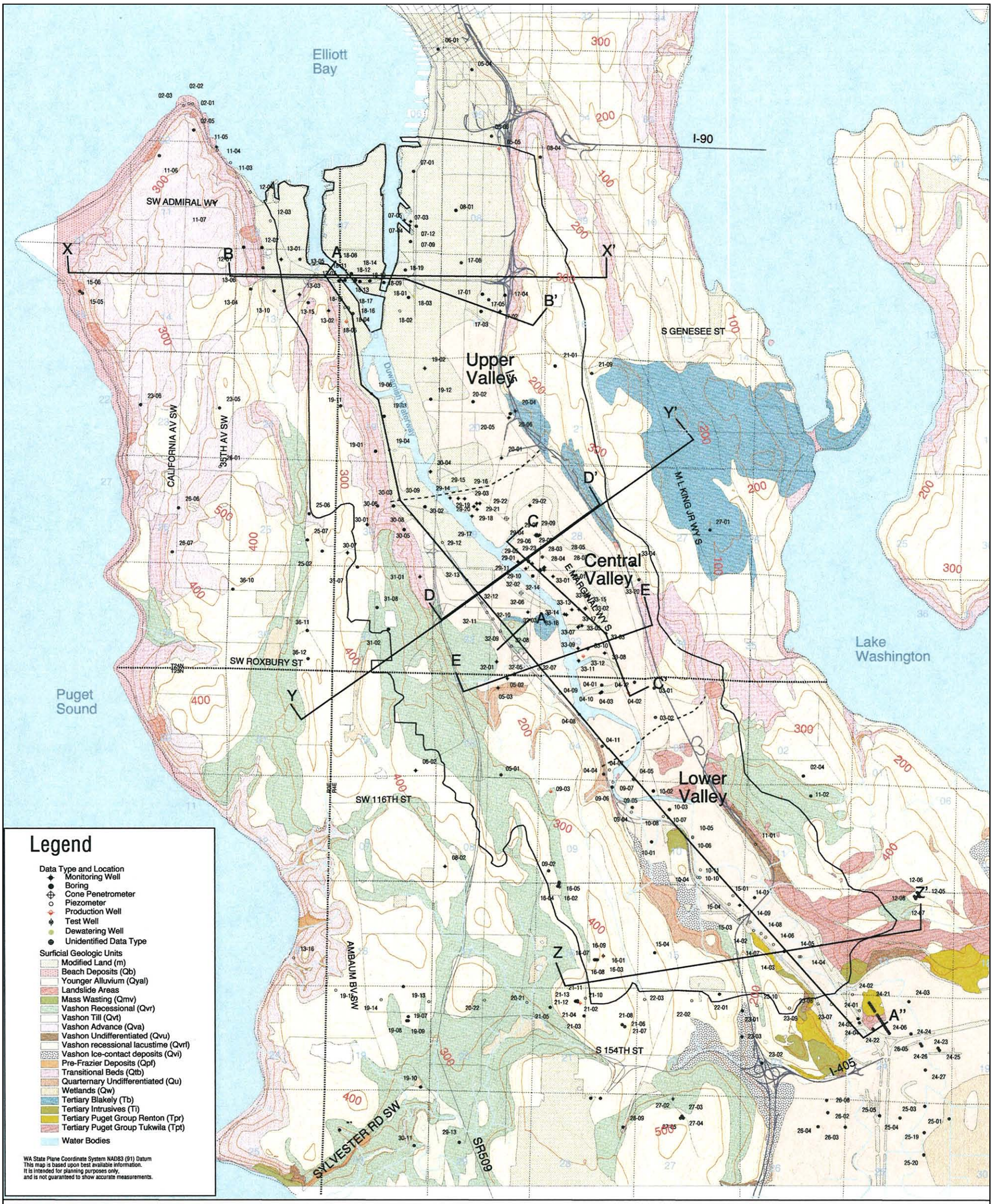


Plate 2. Surficial Geology Map with Cross-Section Locations

Duwamish Hydrogeologic Pathways Project

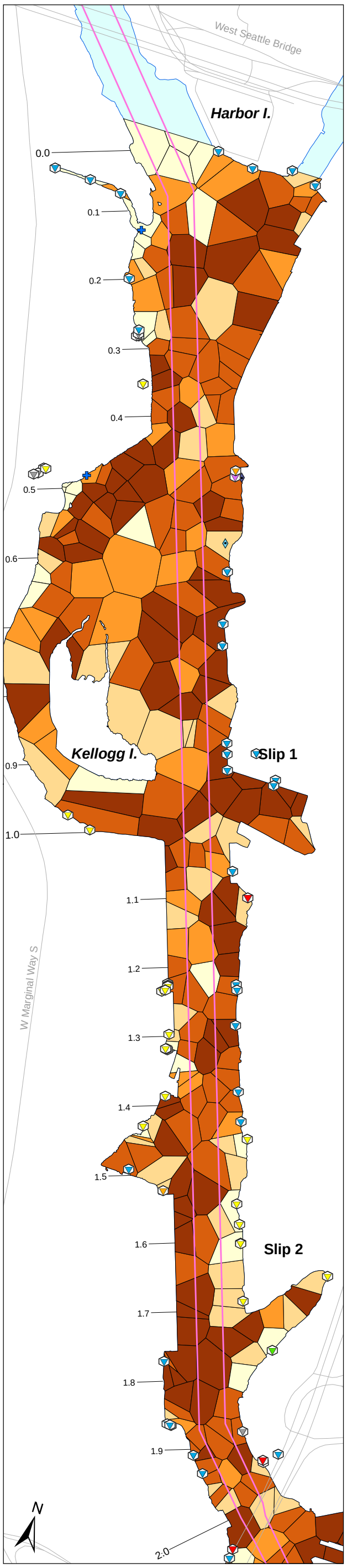
City of Seattle Office of Economic Development
King County Office of Budget and Strategic Planning

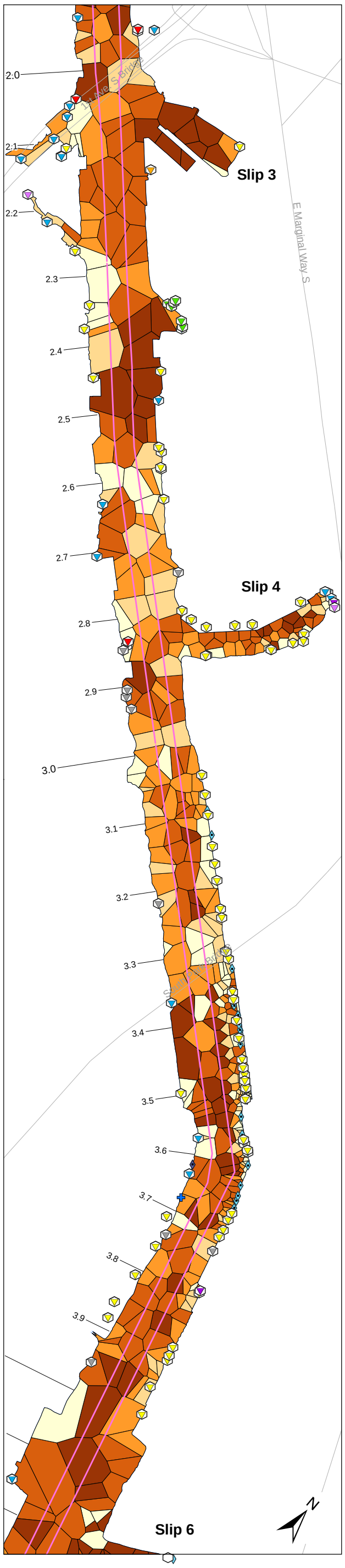
March 1998

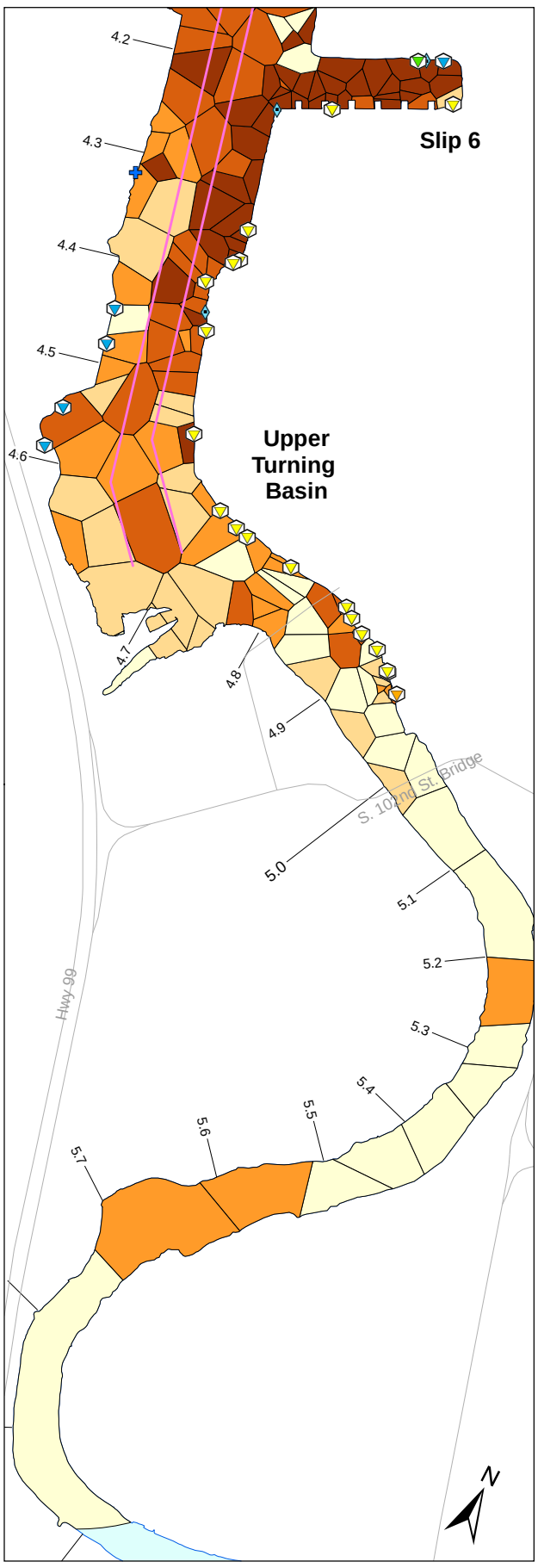
Floyd & Snider Hart Crowser Black & Veatch Gambrell Urban University of Washington

Wind Ward environmental LLC

Map 2-5. Surficial geology in the Greater Duwamish Valley and associated cross section locations







Silt+clay (% fines dw)	Outfall classification[a]
> 80%	CSO
> 60% and ≤ 80%	CSO/storm drain
> 40% and ≤ 60%	EOF
> 20% and ≤ 40%	EOF/storm drain
≤ 20%	Permitted private storm drain
Navigation channel	Private storm drain
Road	Public storm drain
River mile	Pipe of unresolved origin and/or use
	Abandoned
	Not an outfall
	Stream, channel, or swale

[a] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

Wind Ward environmental LLC

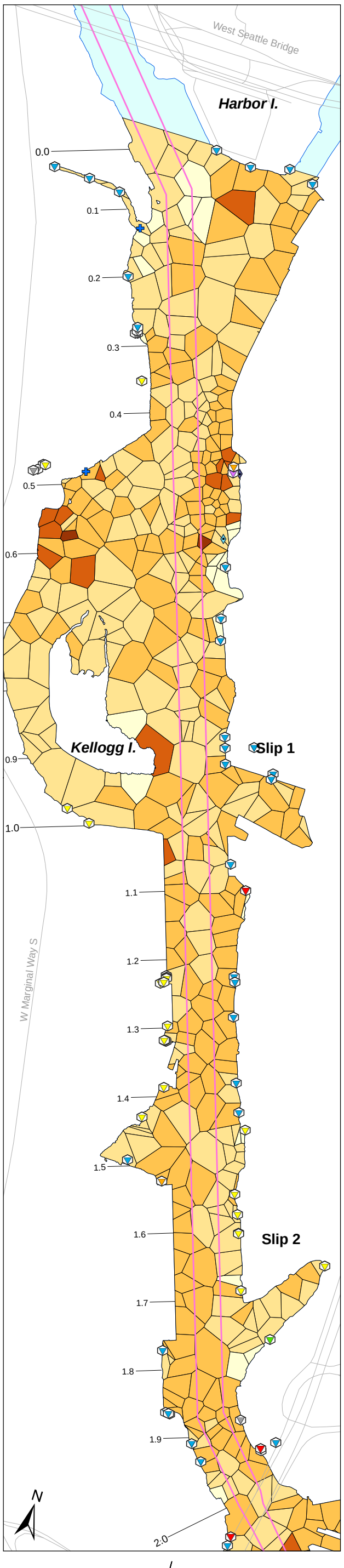
0 0.1 0.2 Miles

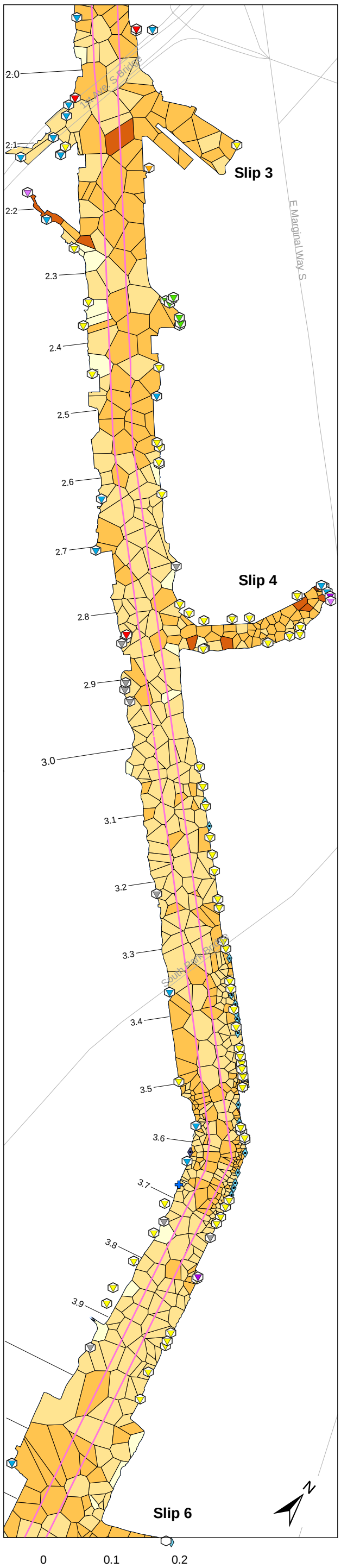
0 0.1 0.2 Kilometers

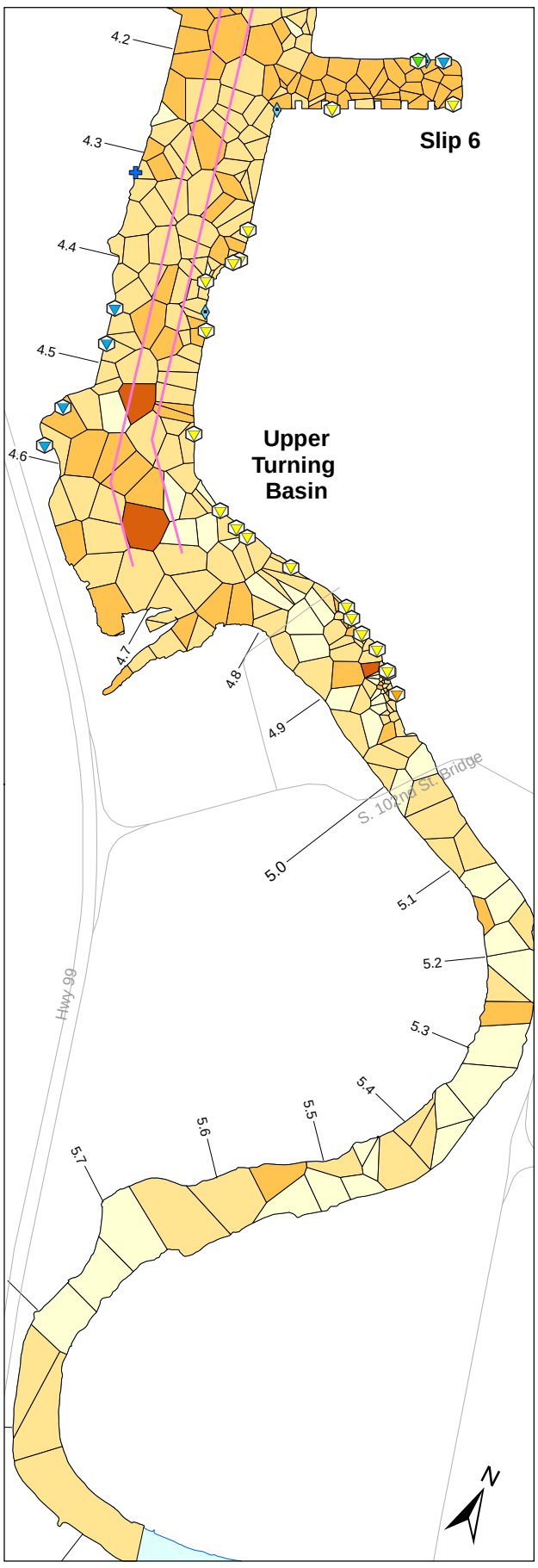
Scale is the same for each inset map

Map 2-6. Grain size distribution in surface sediment using Thiessen polygons

Prepared by CEH 06/29/2010; Map 2865; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Intro - Env Setting







Percent total organic carbon

- > 6%
- > 4% and ≤ 6%
- > 2% and ≤ 4%
- > 0.5% and ≤ 2%
- ≤ 0.5%
- Road
- Navigation channel
- River mile

Outfall classification[a]

- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale

[a] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

0 0.1 0.2 Miles

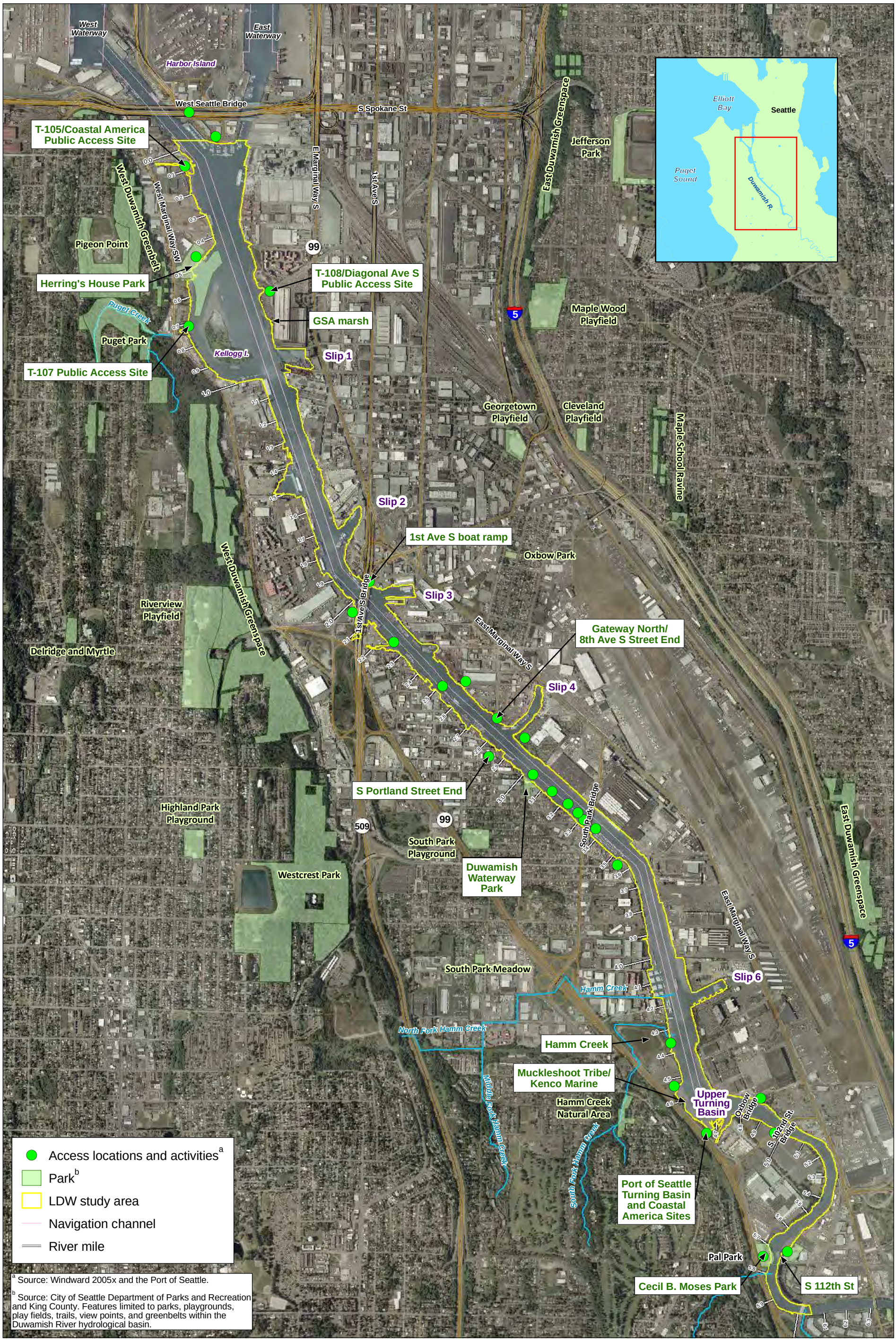
0 0.1 0.2 Kilometers

Scale is the same for each inset map

Wind Ward environmental LLC

Map 2-7. Percent total organic carbon in surface sediment using Thiessen polygons

Prepared by CEH 06/28/2010; Map 2866; W:\Projects\00-08-06 Duwamish RI\data\gis\Phase2 RI\Intro - Env Setting

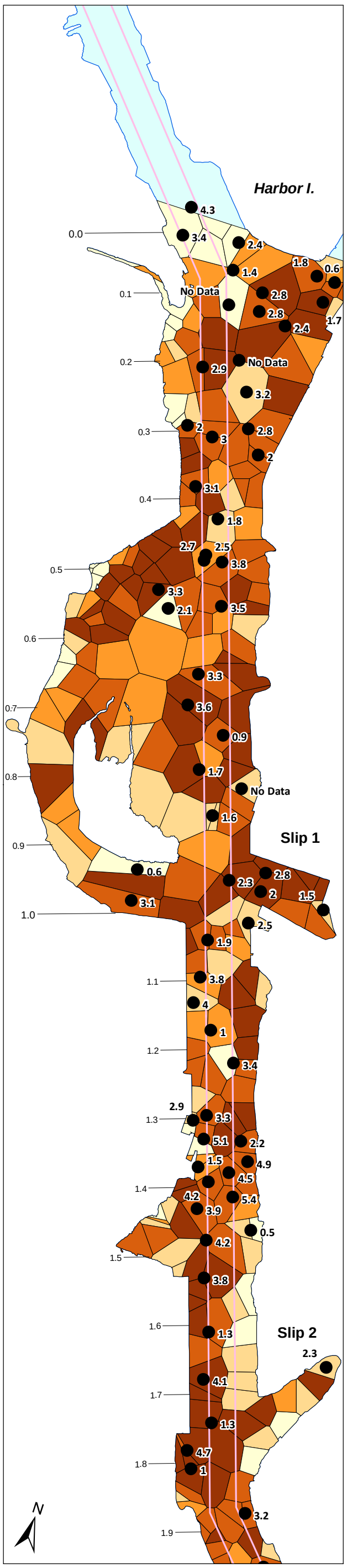


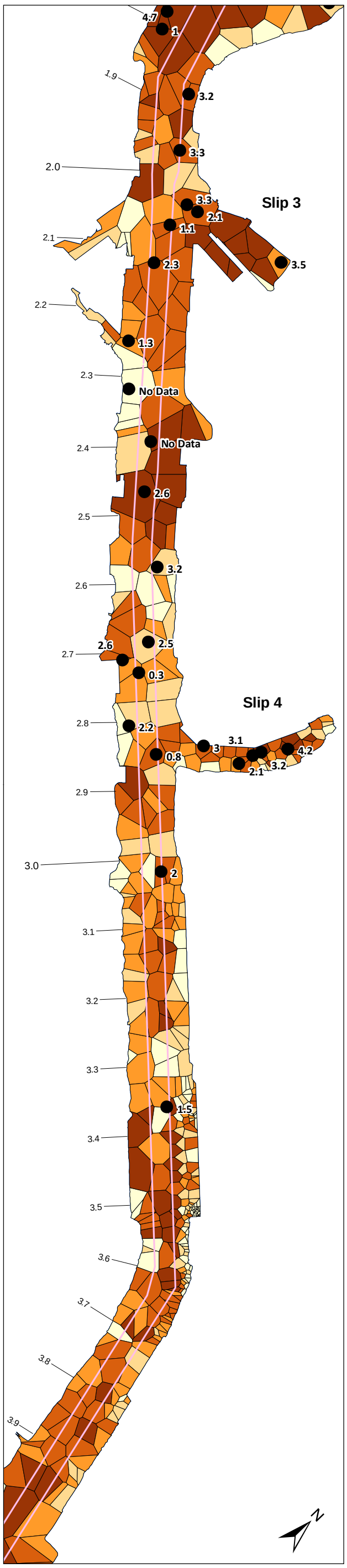
Windward environmental LLC

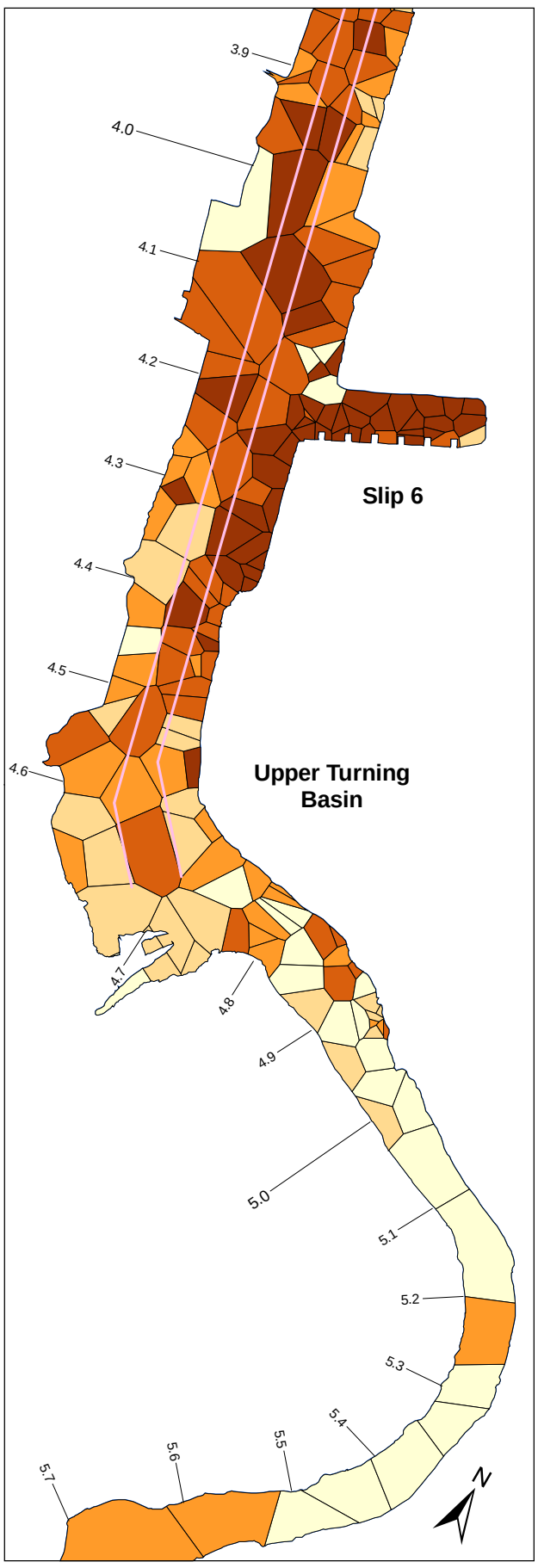
Map 2-8. LDW restoration areas and parks

Prepared by CEH, 06/28/2010; Map#3097; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Intro - Env Setting

Photo source: "USGS High Resolution Orthoimage, Seattle/Tacoma, WA", United States Geological Survey, 2003. Distributed by King County GIS. Photo date 06/11/2002.







- Station mean apparent redox potential discontinuity (aRPD) depth (cm below mudline)

Silt+clay (% fines dw)

- > 80%
- > 60% and ≤ 80%
- > 40% and ≤ 60%
- > 20% and ≤ 40%
- ≤ 20%
- River mile
- Navigation channel

Data are based on the Ecology SPI survey (2006). Statistics are based on mean aRPD depth (from three replicate images) at each station.
Minimum: 0.3 cm
Maximum: 5.4 cm
Mean: 2.6 cm
Std Dev: 1.1 cm
N: 80
95% UCL: 2.9 cm

Wind Ward environmental LLC

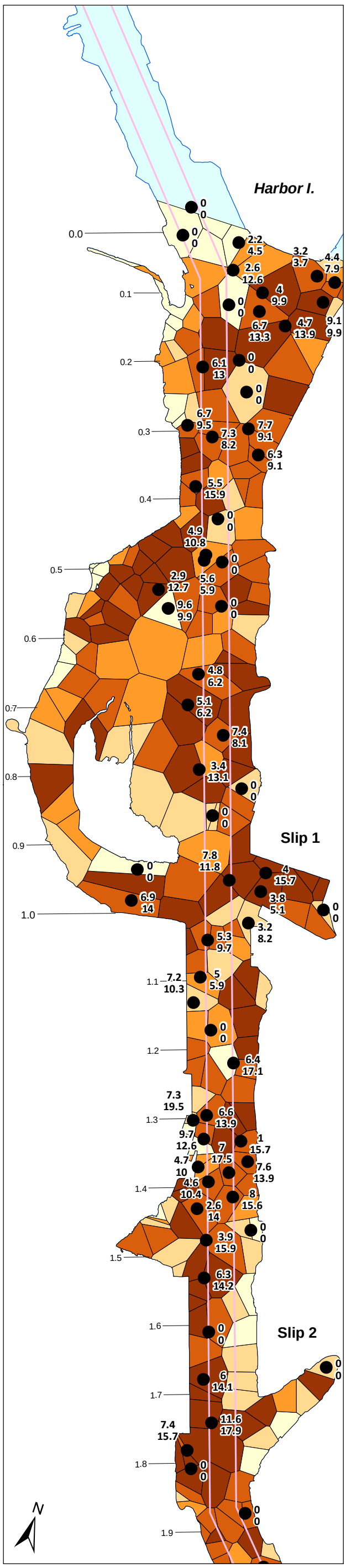
0 0.1 0.2 Miles

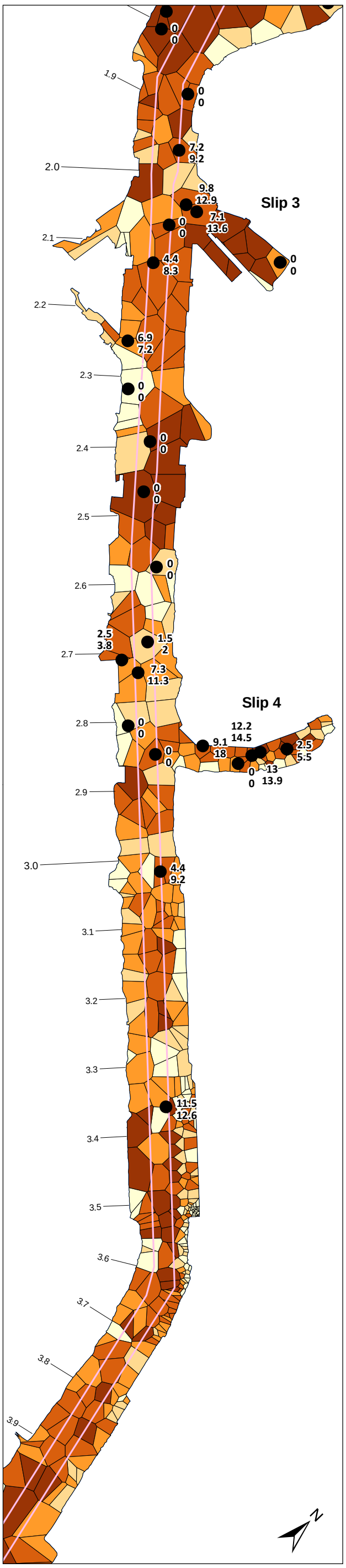
0 0.1 0.2 Kilometers

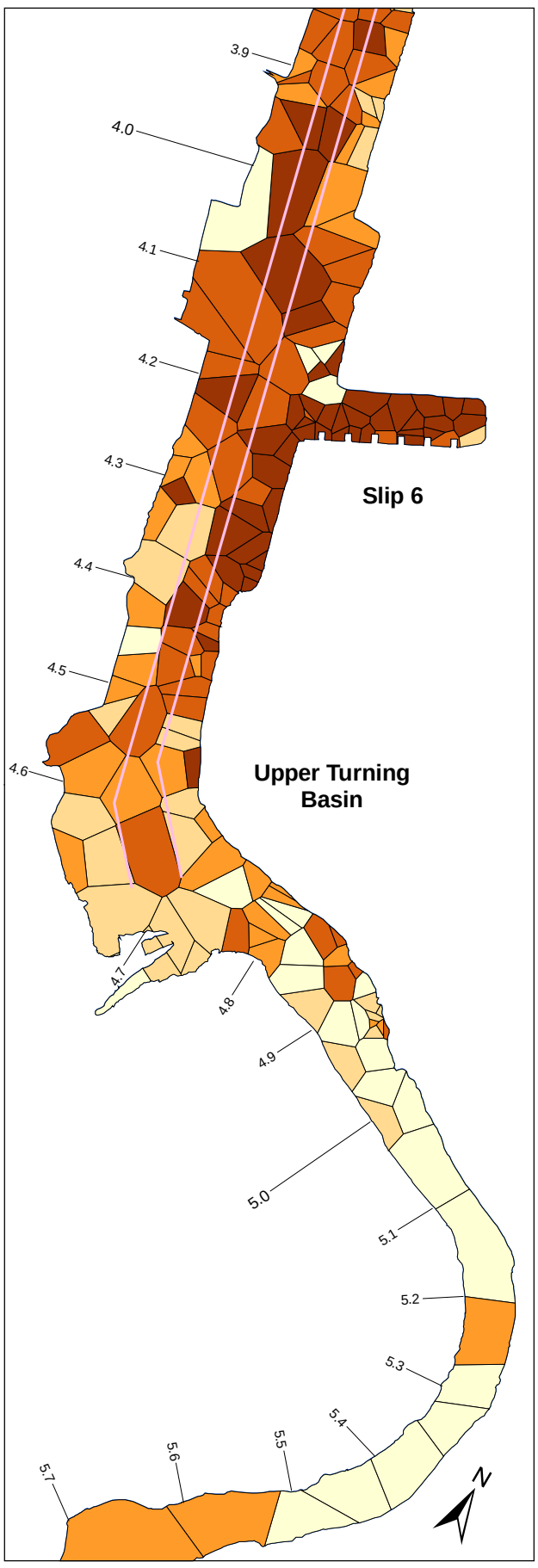
Scale is the same for each inset map

Map 2-9. SPI station mean aRPD depth with percent fines using Thiessen polygons

Prepared by CEH, 06/28/2010, MAP #3744; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase 2 RI\Intro - Env Setting







● Station minimum and maximum depth below the mudline of observed feeding voids (cm below mud-line)

Silt+clay (% fines dw)

- > 80%
- > 60% and ≤ 80%
- > 40% and ≤ 60%
- > 20% and ≤ 40%
- ≤ 20%
- River mile
- Navigation channel

Data are based on the Ecology SPI survey (2006). Statistics based on deepest void depth observed in each replicate image at each station.
Minimum: 0 cm
Maximum: 19.5 cm
Mean: 10.3 cm
Std Dev: 3.9 cm
N: 119
95% UCL: 11.0 cm

Wind Ward environmental LLC

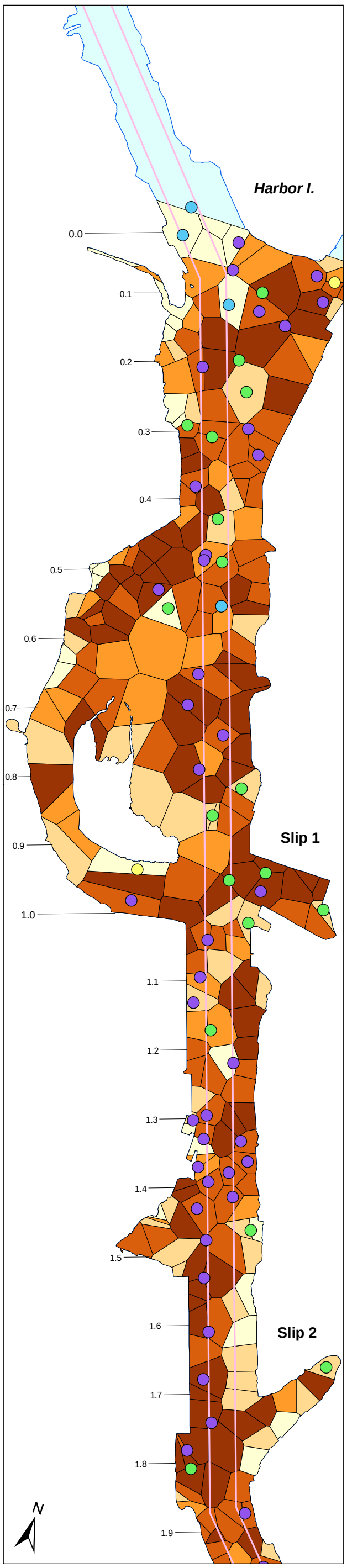
0 0.1 0.2 Miles

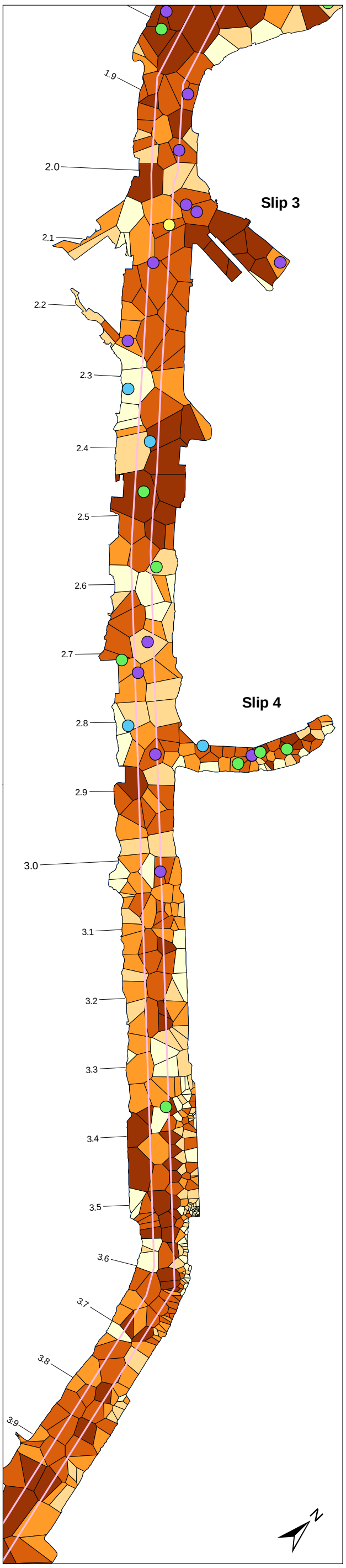
0 0.1 0.2 Kilometers

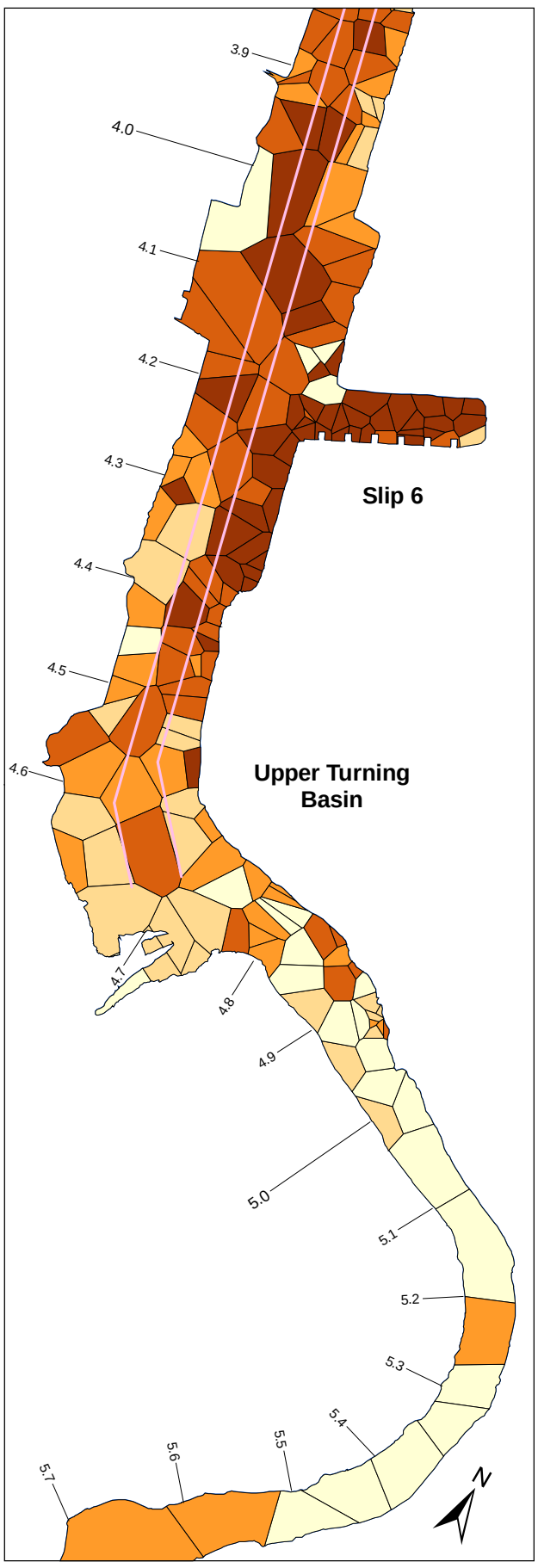
Scale is the same for each inset map

Map 2-10. SPI station minimum and maximum void depth with percent fines using Thiessen polygons

Prepared by CEH, 06/28/2010, MAP #3780 W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Intro - Env Setting







Successional Stage

- Early Colonizing Communities
- Transitional Communities
- Mature Communities
- Indeterminate

Silt+clay (% fines dw)

- > 80%
- > 60% and ≤ 80%
- > 40% and ≤ 60%
- > 20% and ≤ 40%
- ≤ 20%
- River mile
- Navigation channel

Data are based on the Ecology SPI survey (2006).

Wind Ward environmental LLC

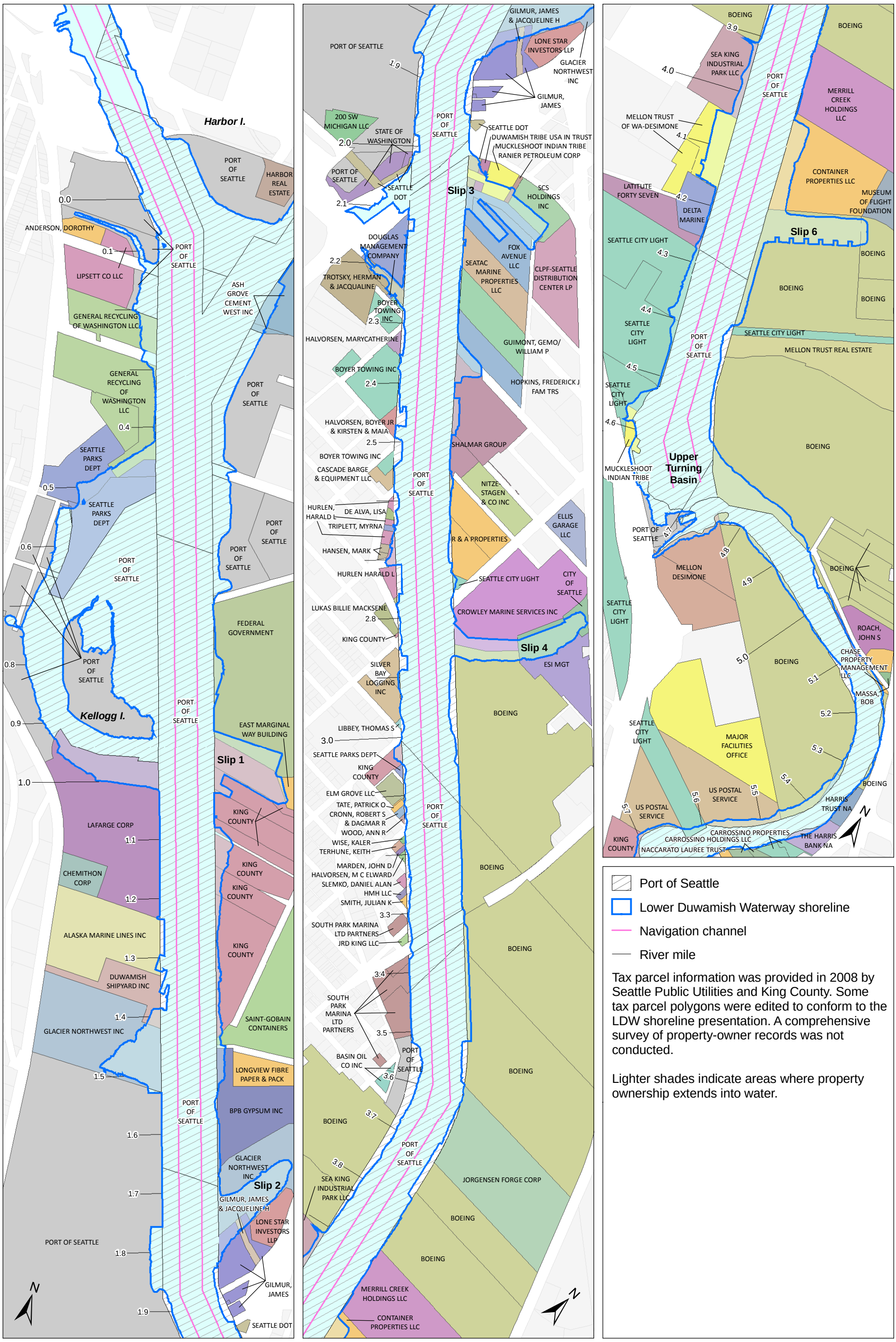
0 0.1 0.2 Miles

0 0.1 0.2 Kilometers

Scale is the same for each inset map

Map 2-11. SPI station successional stages with percent fines using Thiessen polygons

Prepared by CEH, 06/28/2010, MAP #3757; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase 2 RI\Intro - Env Setting



Port of Seattle

Lower Duwamish Waterway shoreline

Navigation channel

River mile

Tax parcel information was provided in 2008 by Seattle Public Utilities and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property-owner records was not conducted.

Lighter shades indicate areas where property ownership extends into water.

Wind Ward environmental LLC

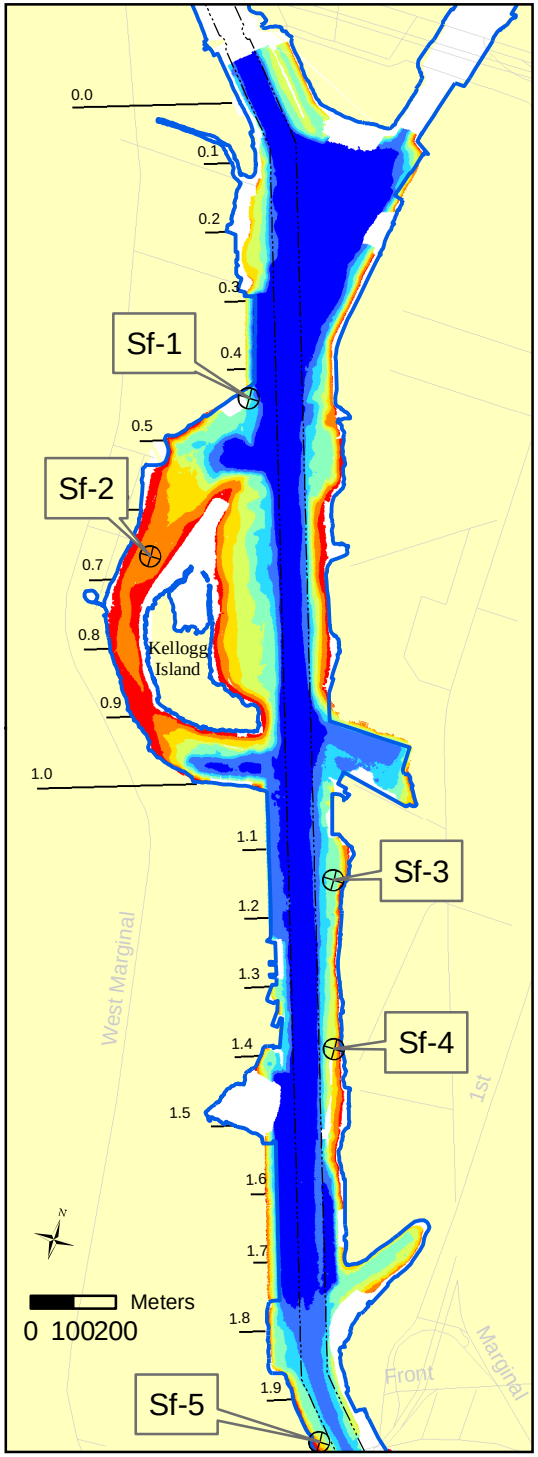
0 0.1 0.2 Miles

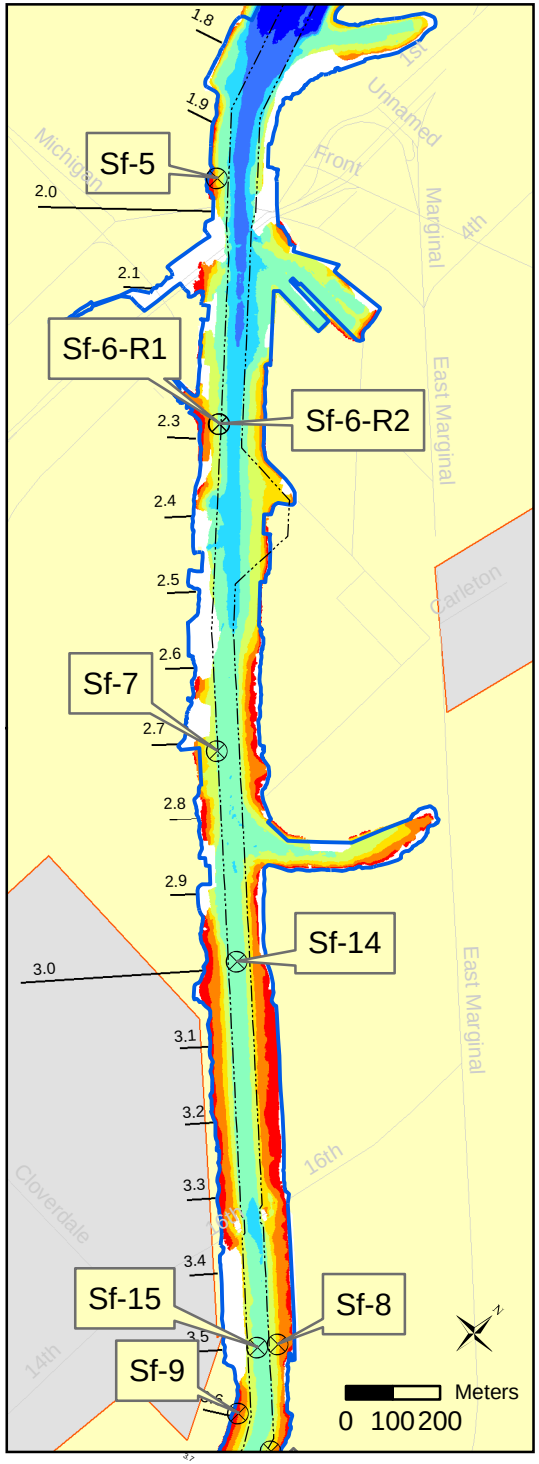
0 0.1 0.2 Kilometers

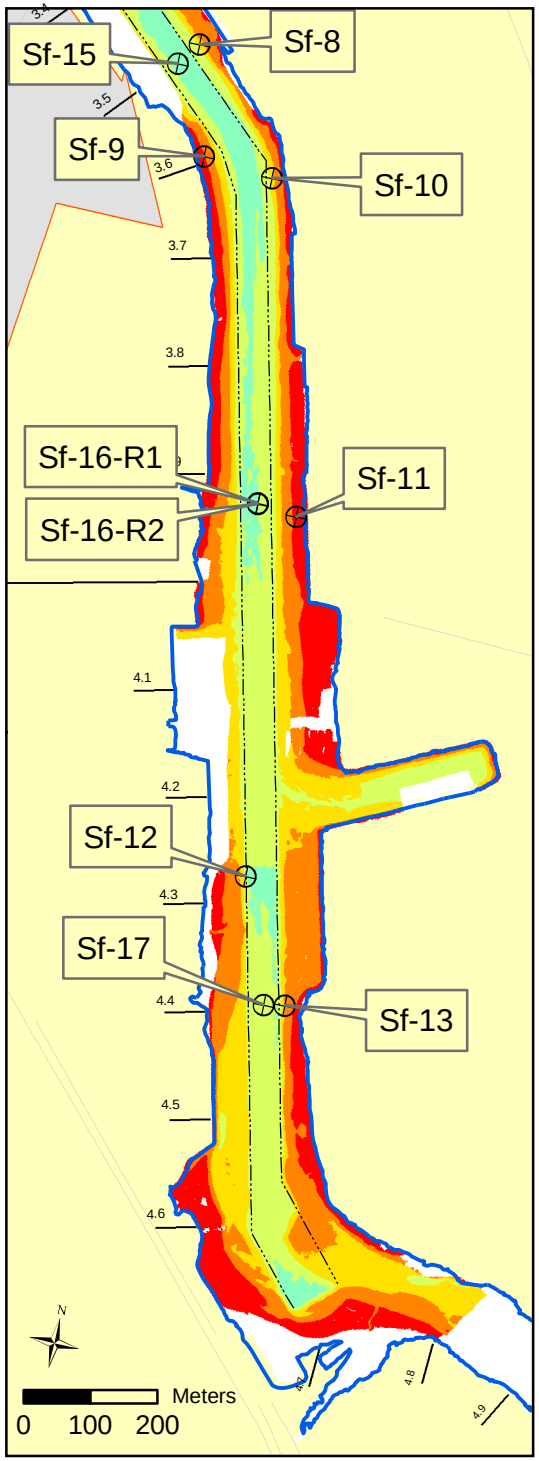
Scale is the same for each inset map

Map 2-12. Upland, intertidal, and subtidal land ownership

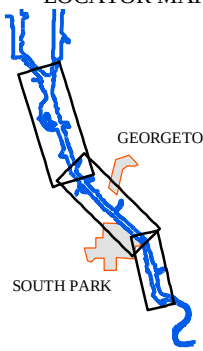
Prepared by CEH, 06/29/2010; MAP #2851; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Intro - Env Setting







LOCATOR MAP



Legend

- Shoreline
- Roads
- Neighborhoods

Sediment Elevation (ft MLLW)

- > 0
- -5 - 0
- -10 - -5
- -15 - -10
- -20 - -15
- -25 - -20
- -30 - -25
- < -30
- River Miles
- Navigation Channel
- Sedflume Locations

LOWER DUWAMISH WATERWAY STUDY AREA SEATTLE, WA

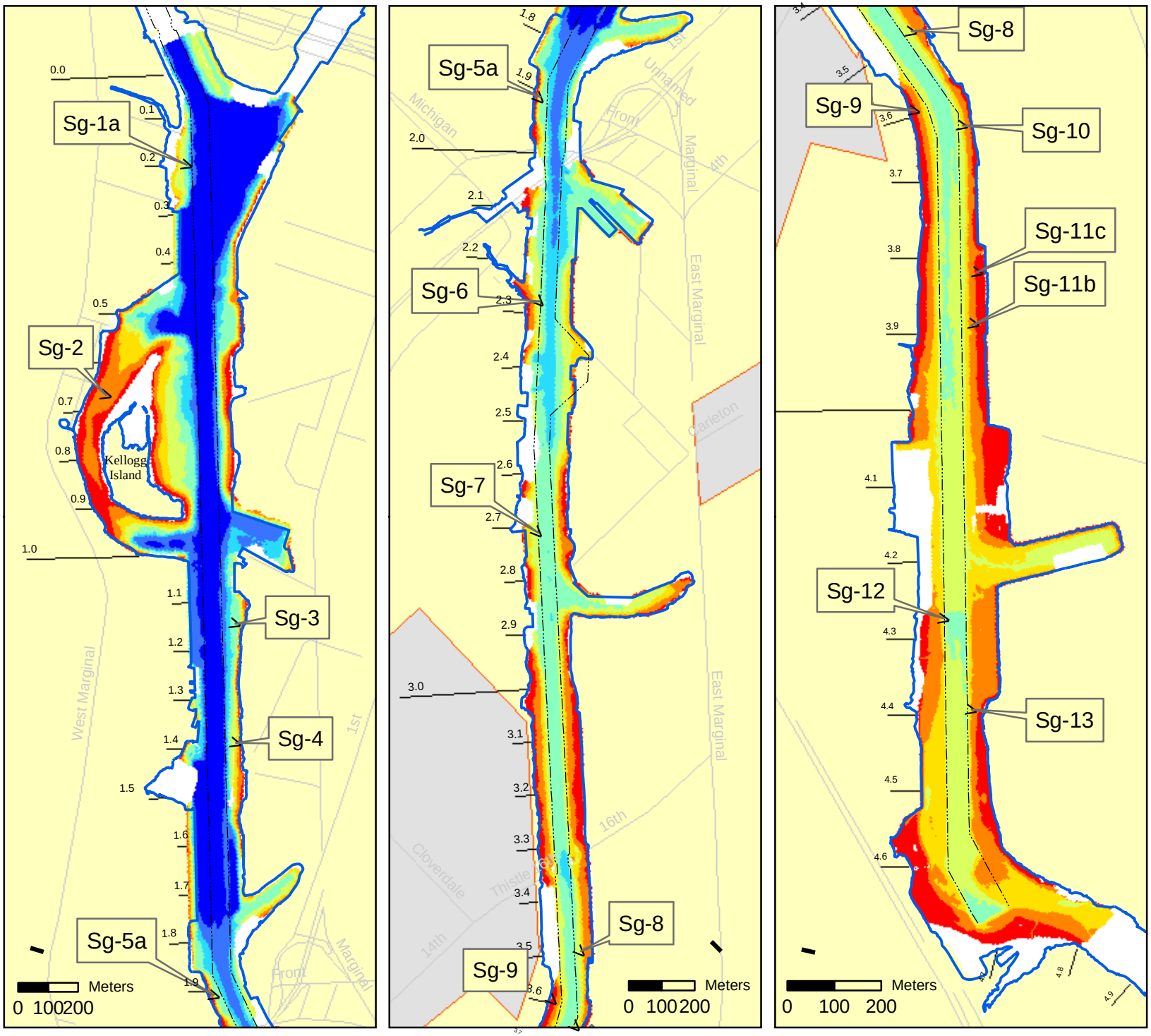
Map 3-1.
Sedflume core sampling locations

WINldw:130 October 2005

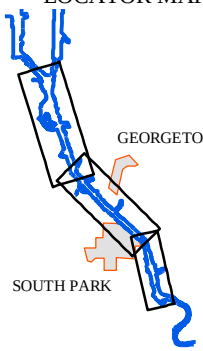
QEA Quantitative Environmental Analysis, LLC

DN - \\Daleel\D_DRIVE\WINldw\Analysis\Model_Inputs\GEOCHRON_SEDFLUME\sedflume_051013_rpt.mxd

SF



LOCATOR MAP



Legend

- Shoreline
- Roads
- Neighborhoods

Sediment Elevation (ft MLLW)

- > 0
- -5 - 0
- -10 - -5
- -15 - -10
- -20 - -15
- -25 - -20
- -30 - -25
- < -30
- River Miles
- Navigation Channel
- Geochron Locations

LOWER DUWAMISH WATERWAY STUDY AREA SEATTLE, WA

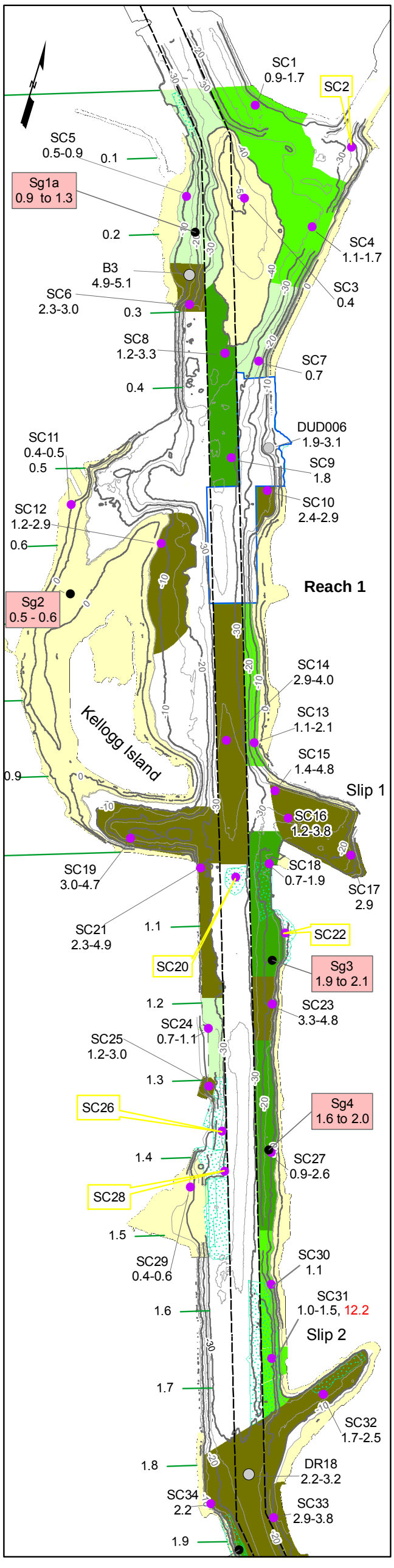
Map 3-2.
Geochronology core sampling locations

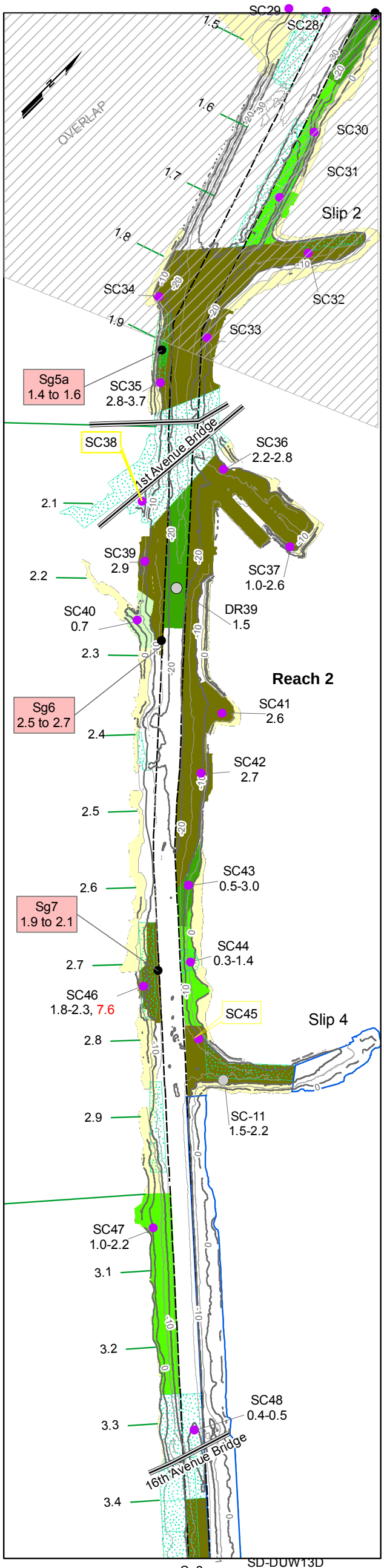
WINldw:121 May 2005

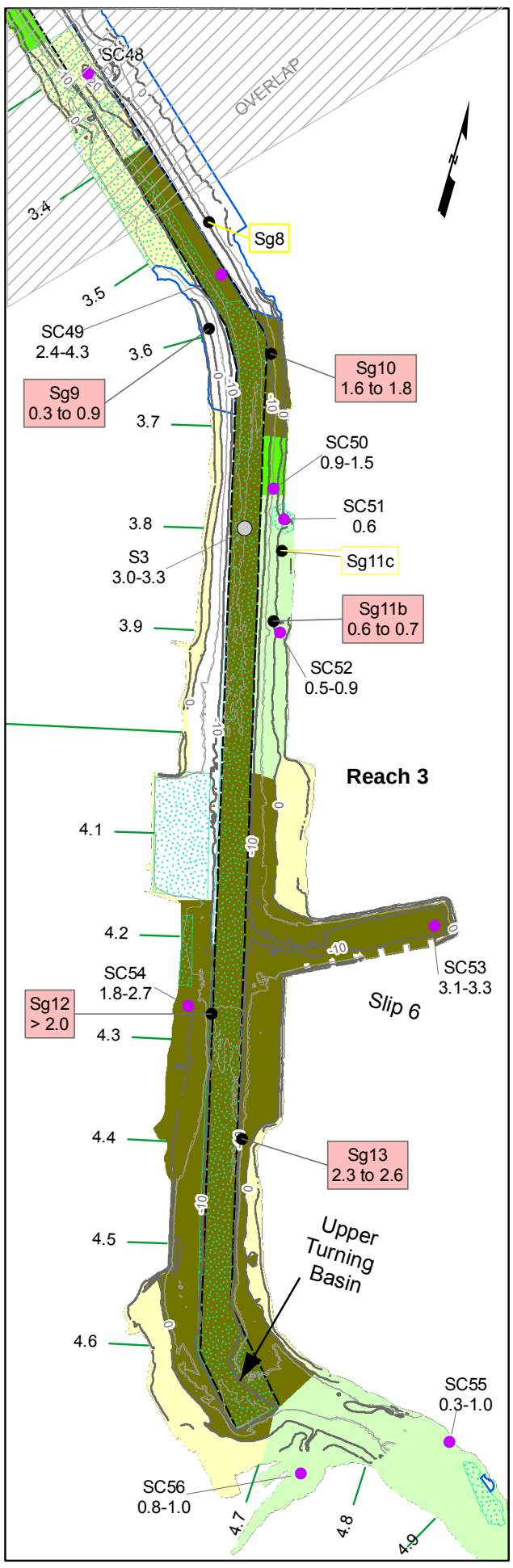
QEA Quantitative Environmental Analysis, LLC

DN - \\Daleel\D_DRIVE\WINldw\Analysis\Model_Inputs\GEOCHRON_SEDFLUME\geochron_051013_rpt.mxd

SF







LEGEND

- River Mile Marker
- Navigation Channel
- -10 Bathymetric Contour (ft MLLW)
- SC8 2006 Core
- Sg1a 2004 Radioisotope Core
- B3 Historical Core
- SC20 No Rate Calculated for Core
- In-water Dredged/Potentially Disturbed Area[6]
- Early Action Area

Estimated Net Sedimentation Rate (cm/yr)

- < 0.5
- ≥0.5 and <1.0
- ≥1.0 and <1.5
- ≥1.5 and <2.0
- ≥ 2.0
- No Data/Atypical Trends

Core Number
SC46
1.8-2.3,7.6[7]
Net Sedimentation Rate (cm/yr)

0 400 800 Feet

Notes:
1. Bathymetry data provided by Windward Environmental LLC based on waterway-wide October 2003 survey.
2. Estimated net sedimentation rates calculated from radioisotope core data provided by QEA LLC; 2006 core chemistry data and historical core data provided by Windward Environmental LLC; and historical dredge event data provided by USACE.
3. Numerous time markers used to calculate estimated net sedimentation rates are from radioisotope, physical, and chemical geochronology profiles.
4. Areas generally delineated within Reaches 1, 2, and 3; the east and west bench areas; and the navigation channel. Water depth, grain size, and distance to other cores also considered.
5. Ranges shown are calculated from recovered depths.
6. Potentially disturbed areas include documented dredge events after 1980, notes from USACE bathymetry surveys, or in-water debris/disturbances evident in the core logs.
7. Red font represents rate from dredge event marker outside range of other rates.

ENSR | AECOM
Merged with ENSR in 2007 RETEC
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

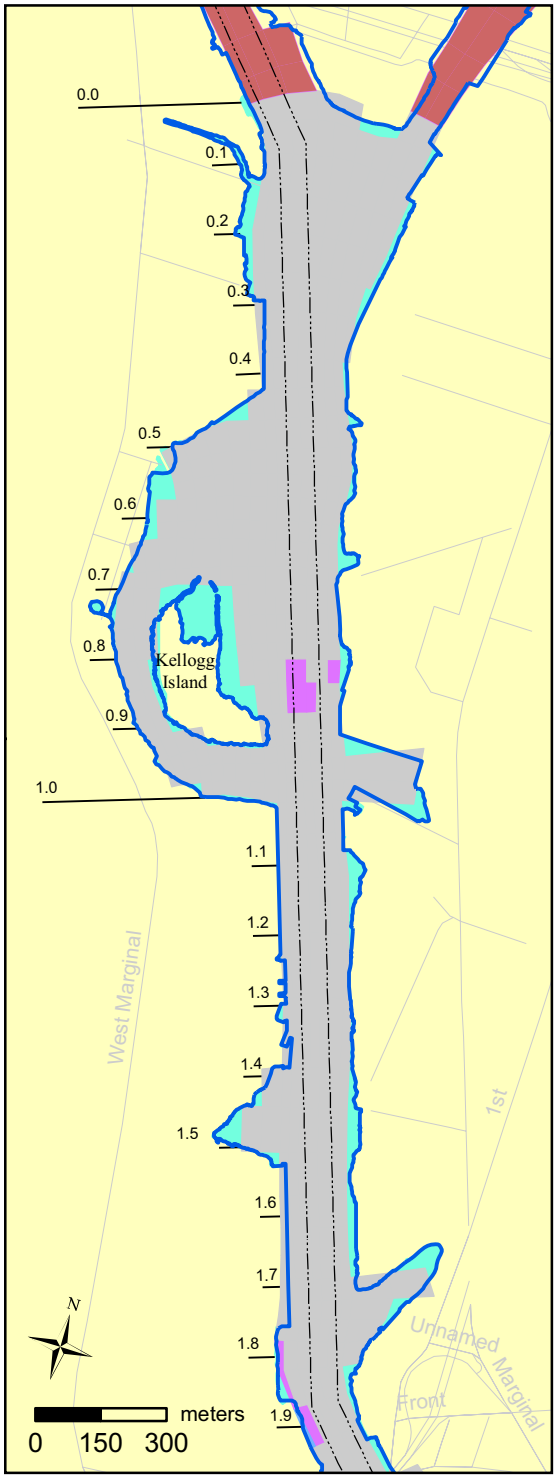
LOWER DUWAMISH WATERWAY
SEDIMENT TRANSPORT ANALYSIS REPORT
05482015-611

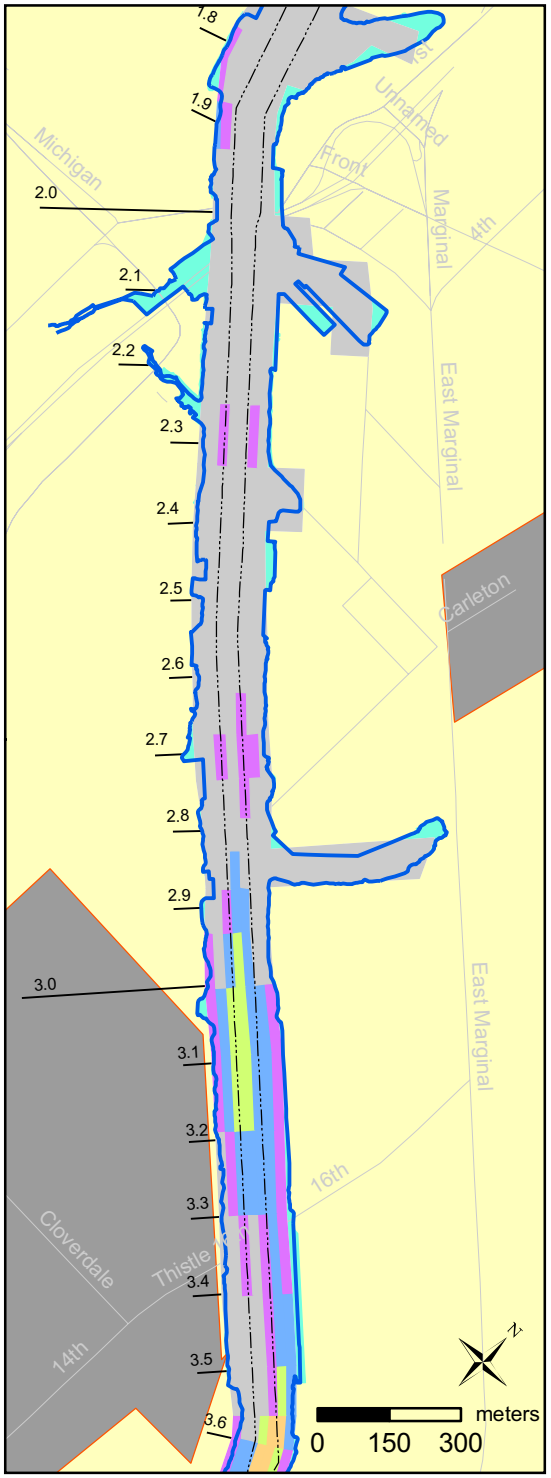
GENERALIZED ESTIMATES OF
NET SEDIMENTATION
RATES IN THE LDW

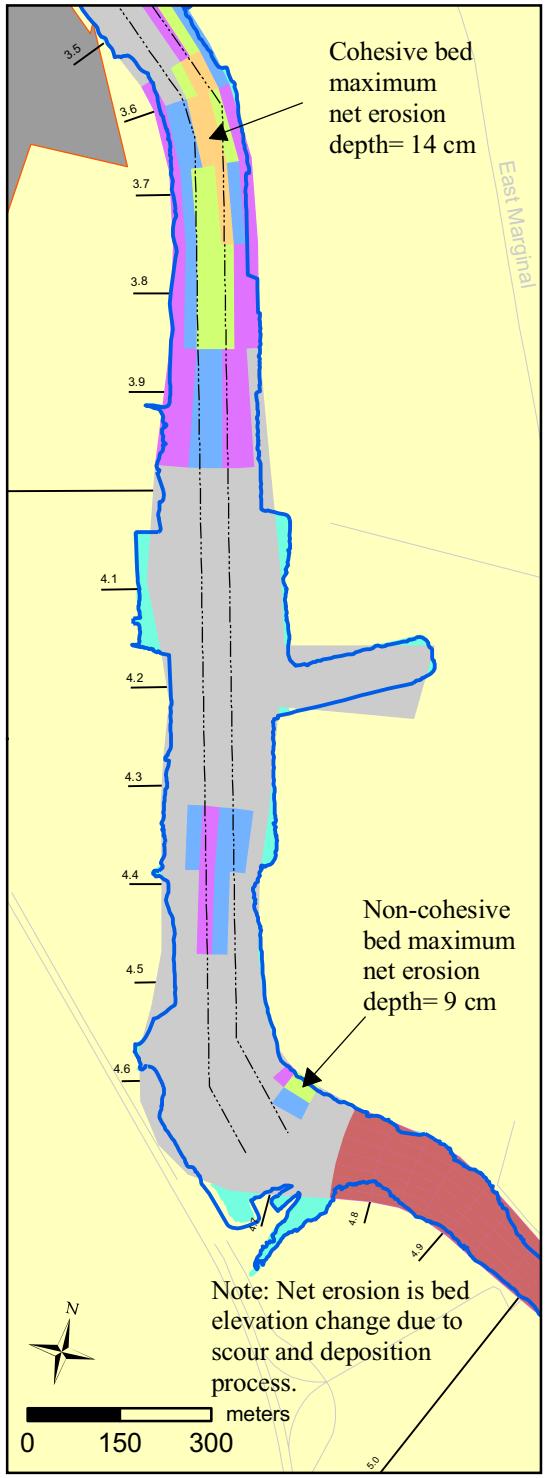
DATE: 10/15/08 | DWN. BY: MVI/sea

Map 3-3

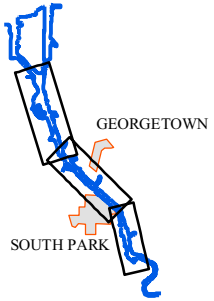
F:\PROJECTS\GIS\Lower Duwamish FS\Projects\Sediment Transport Model\SedimentTransAnalysisReport\Figure5.mxd : Created using ArcGIS 9.2







LOCATOR MAP



LEGEND

Net erosion depth (cm)

- > 10
- 6 - 10
- 2 - 6
- 0 - 2
- Net deposition
- Navigation channel
- Shore line
- River miles
- Roads
- Neighborhoods
- Outside model domain
- Hard bottom area

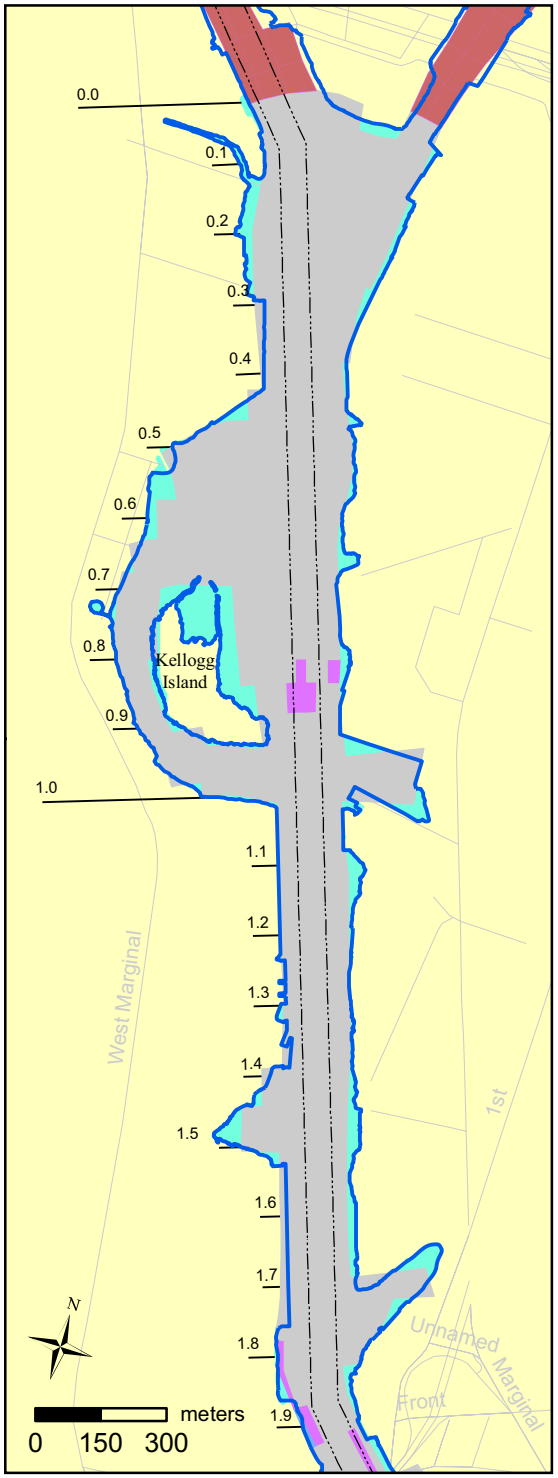
LOWER DUWAMISH WATERWAY STUDY AREA SEATTLE, WA

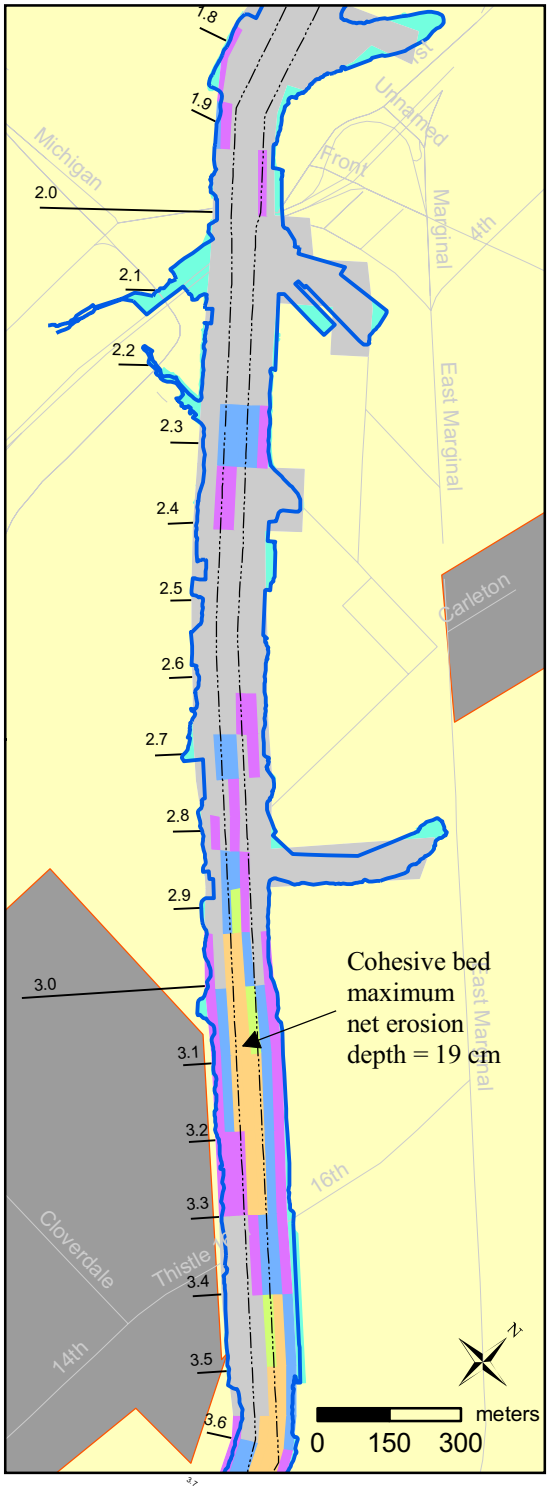
Map 3-4.
Spatial distribution of predicted net erosion during 2-year high-flow event.

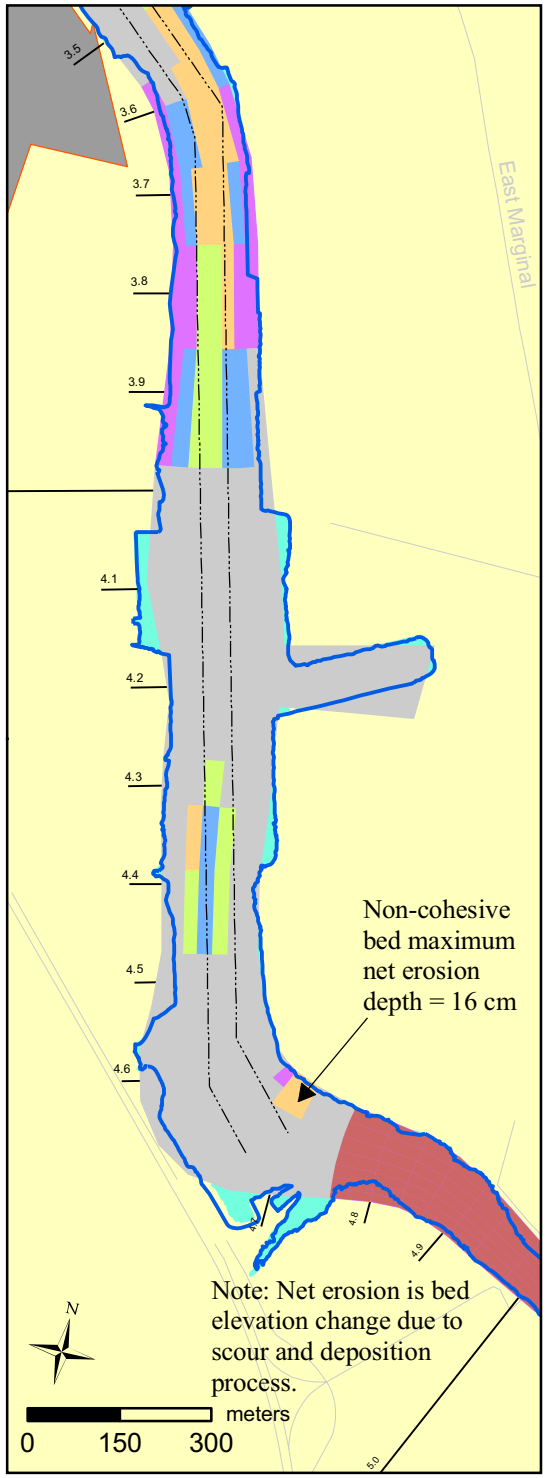
June 2008

QEA
Quantitative Environmental Analysis, LLC

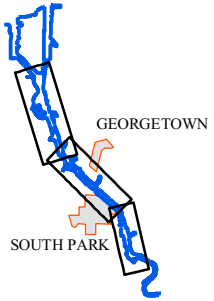
FC/AC - \\gis_station\d_drive\Private\RETldw\GIS_plot\sensitivity_plot_04102008.mxd







LOCATOR MAP



LEGEND

Net erosion depth (cm)

- > 10
- 6 - 10
- 2 - 6
- 0 - 2
- Net deposition
- Navigation channel
- Shore line
- River miles
- Roads
- Neighborhoods
- Outside model domain
- Hard bottom area

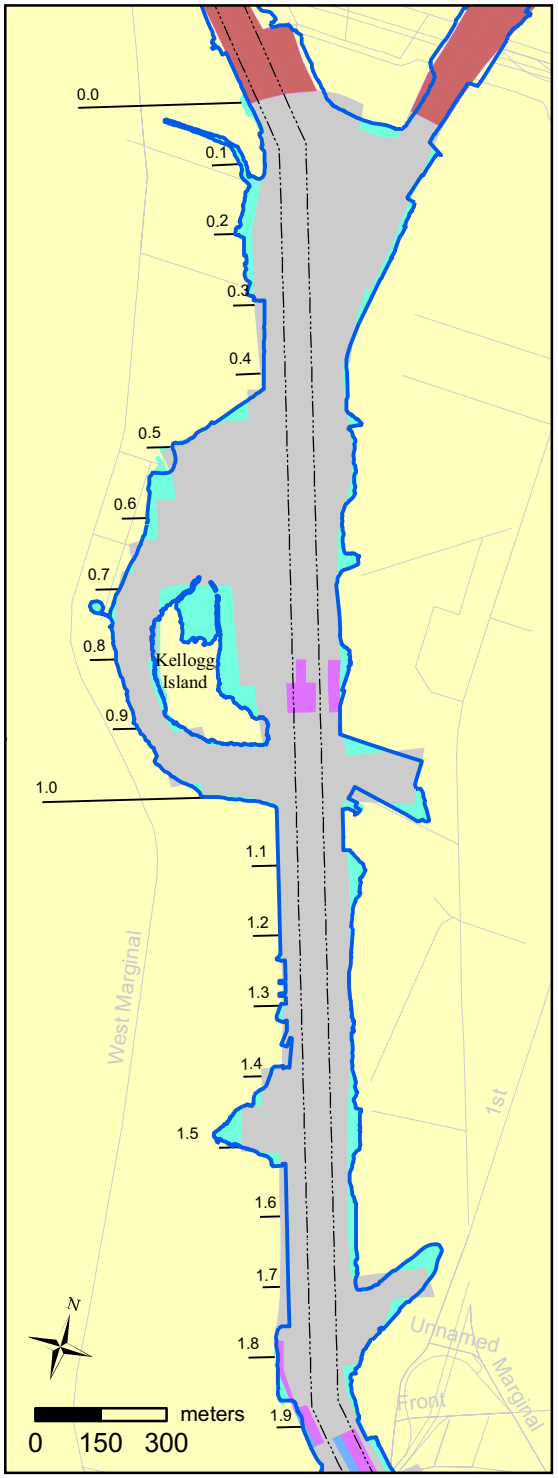
LOWER DUWAMISH WATERWAY STUDY AREA SEATTLE, WA

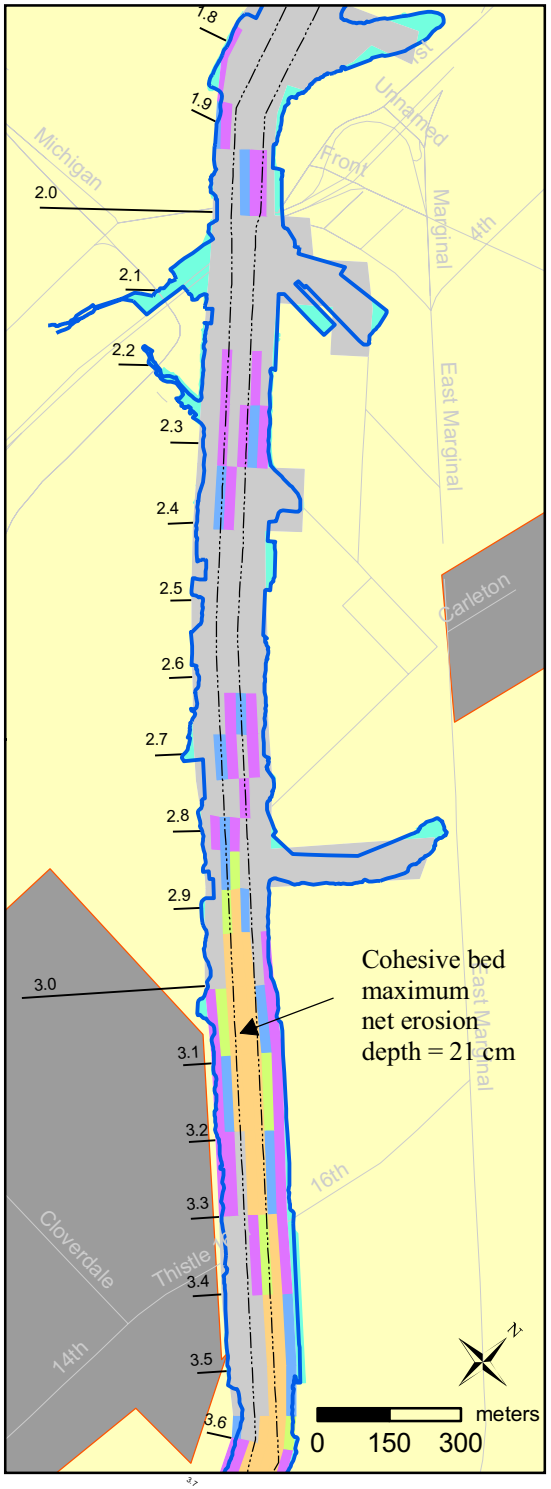
Map 3-5.
Spatial distribution of predicted net erosion during 10-year high-flow event.

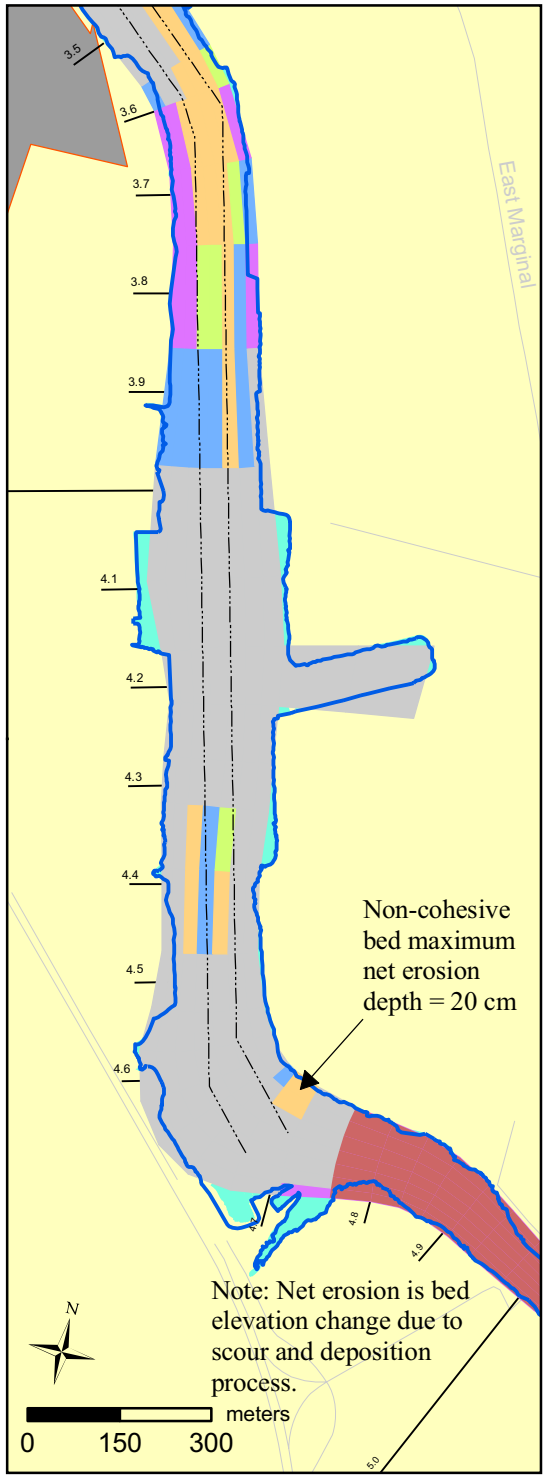
June 2008

QEA
Quantitative Environmental Analysis, LLC

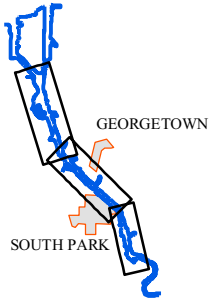
FC/AC - \\gis_station\d_drive\Private\RETldw\GIS_plot\sensitivity_plot_04102008.mxd







LOCATOR MAP



LEGEND

Net erosion depth (cm)

- > 10
- 6 - 10
- 2 - 6
- 0 - 2
- Net deposition
- Navigation channel
- Shore line
- River miles
- Roads
- Neighborhoods
- Outside model domain
- Hard bottom area

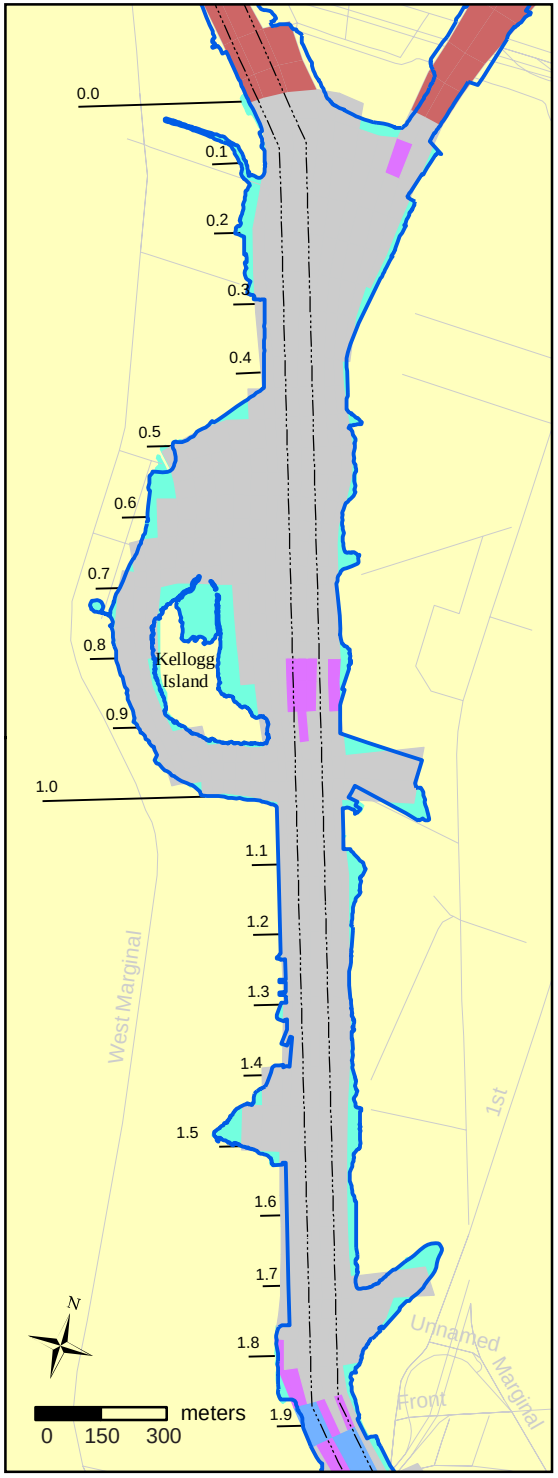
LOWER DUWAMISH WATERWAY STUDY AREA SEATTLE, WA

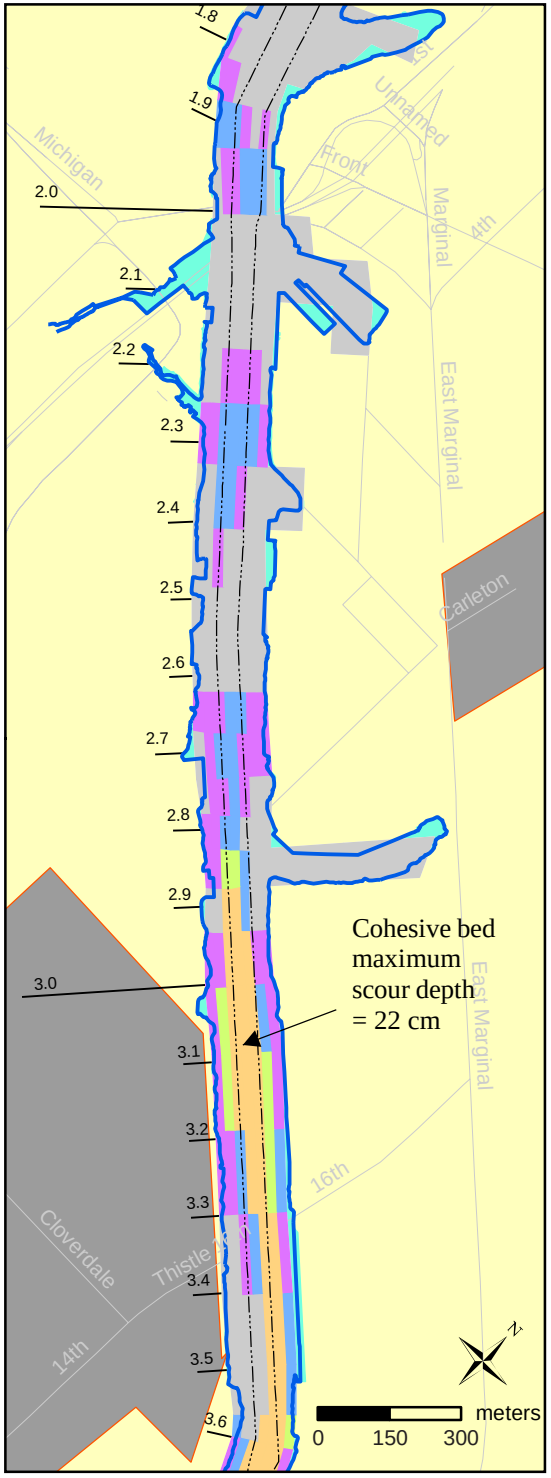
Map 3-6.
Spatial distribution of predicted net erosion during 100-year high-flow event.

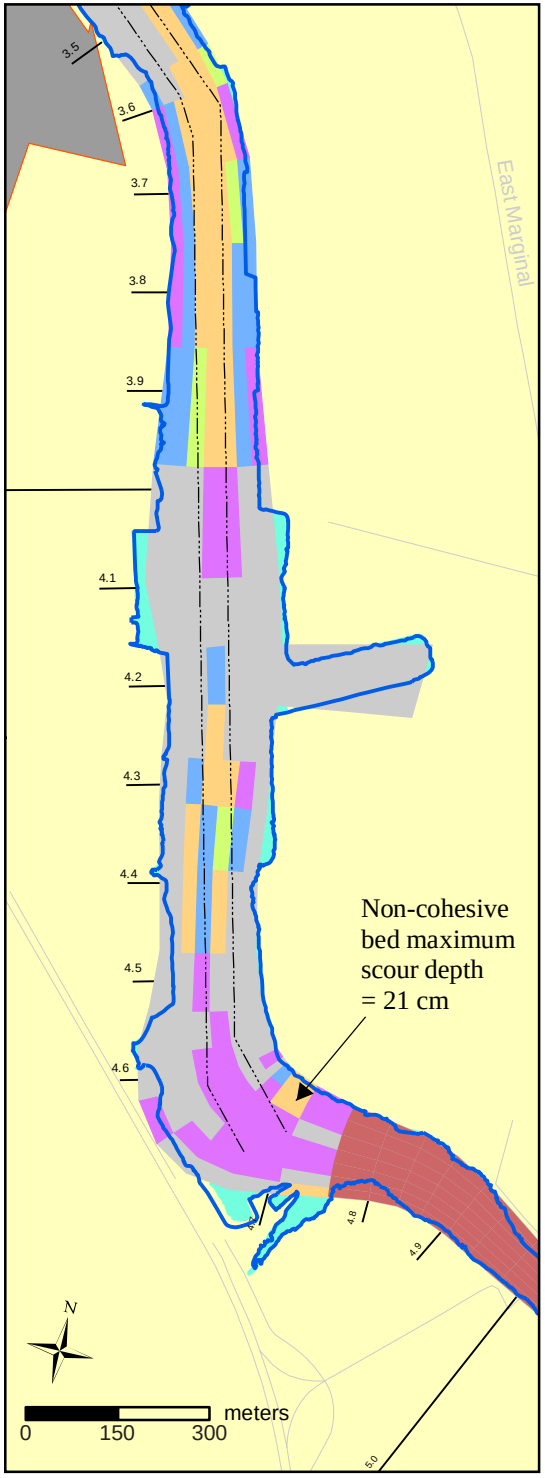
June 2008

QEA
Quantitative Environmental Analysis, LLC

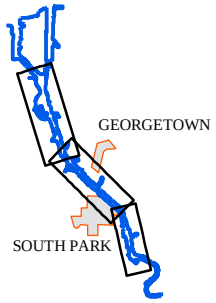
FC/AC - \\gis_station\d_drive\Private\RETldw\GIS_plot\sensitivity_plot_04102008.mxd







LOCATOR MAP



LEGEND

Maximum scour depth (cm)

- > 10
- 6 - 10
- 2 - 6
- 0 - 2
- 0
- Navigation channel
- Shore line
- River mile
- Roads
- Neighborhoods
- Outside model domain
- Hard bottom area

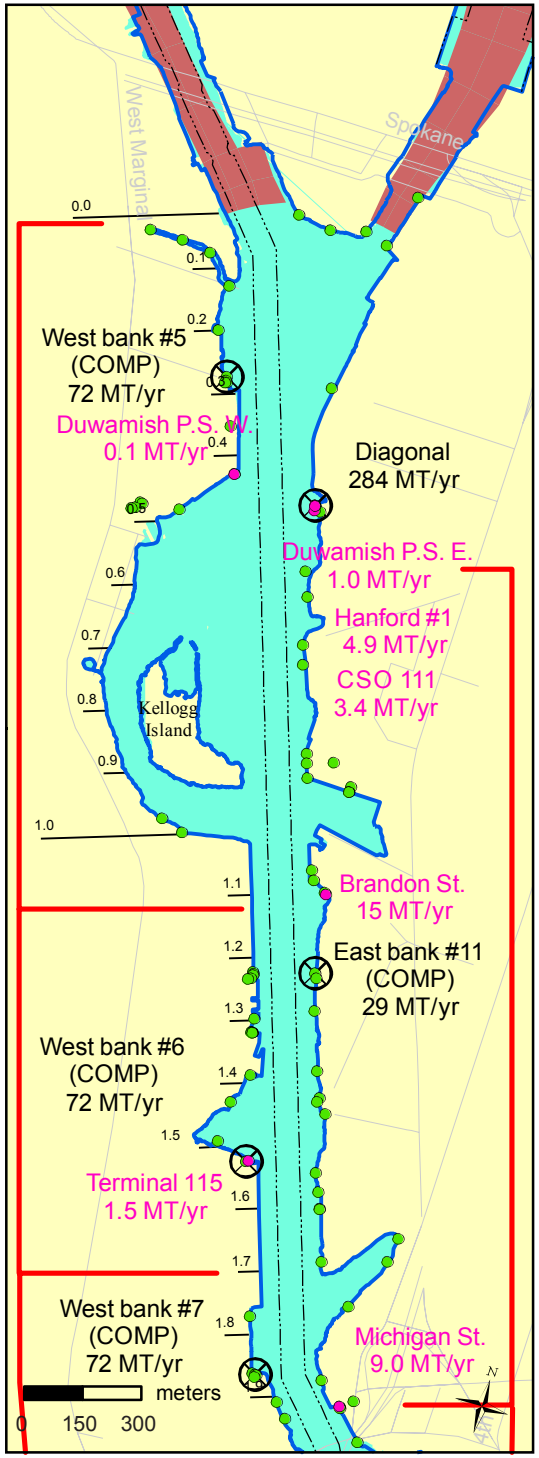
LOWER DUWAMISH WATERWAY STUDY AREA SEATTLE, WA

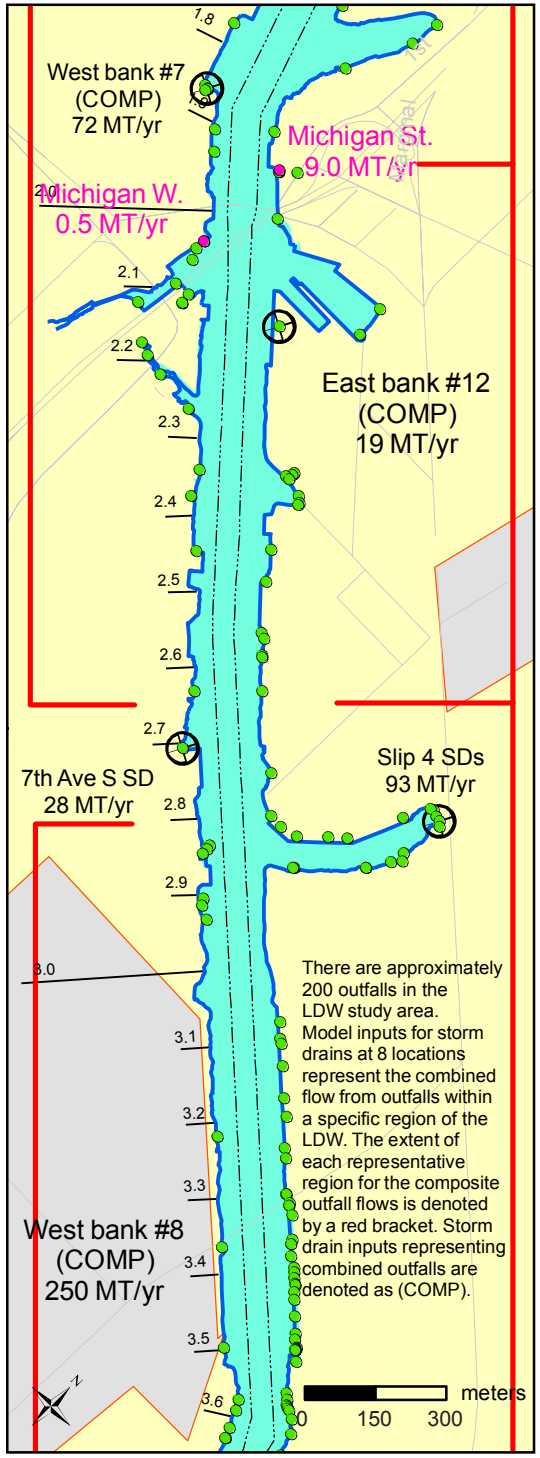
Map 3-7.
Spatial distribution of predicted maximum bed scour depth during 100-year high-flow event.

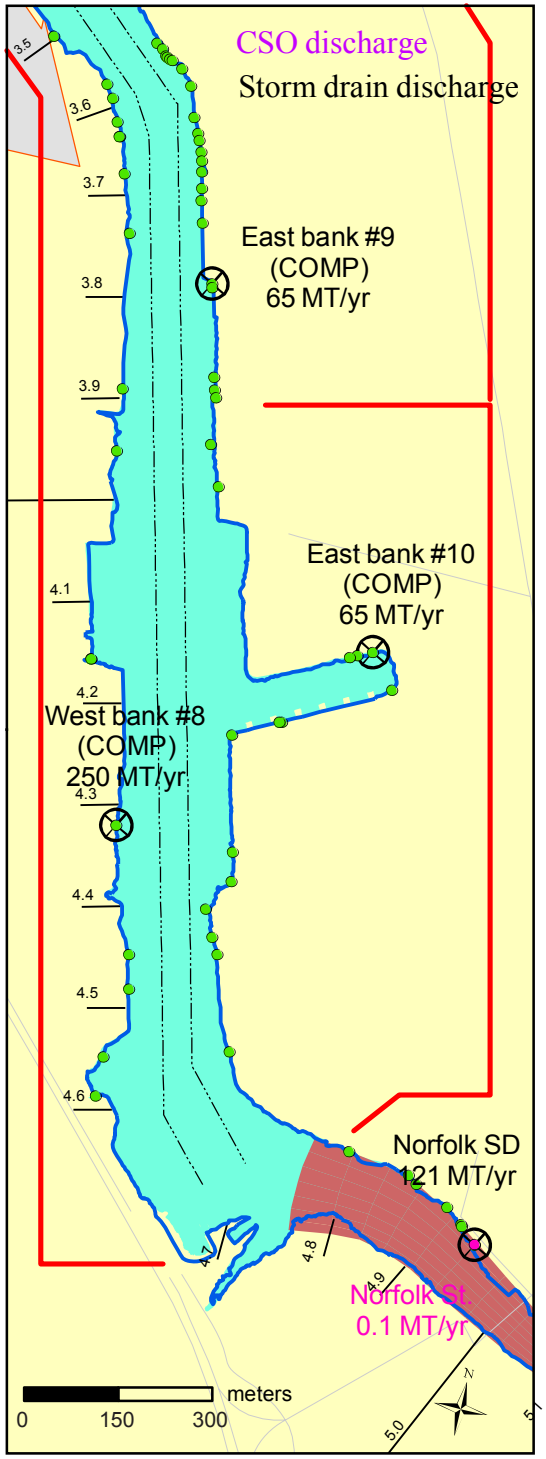
June 2008

QEA
Quantitative Environmental Analysis, LLC

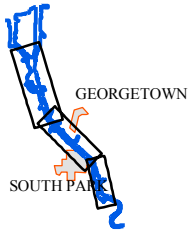
FC/AC - \\gis_station\d_drive\Private\RETldw\GIS_plot\sensitivity_plot_04102008.mxd







LOCATOR MAP



LEGEND

- CSO Locations
- Outfall Locations
- Storm Drain Locations
- Navigation Channel
- Shore Line
- River Mile
- Roads
- Neighborhoods
- MT metric tons

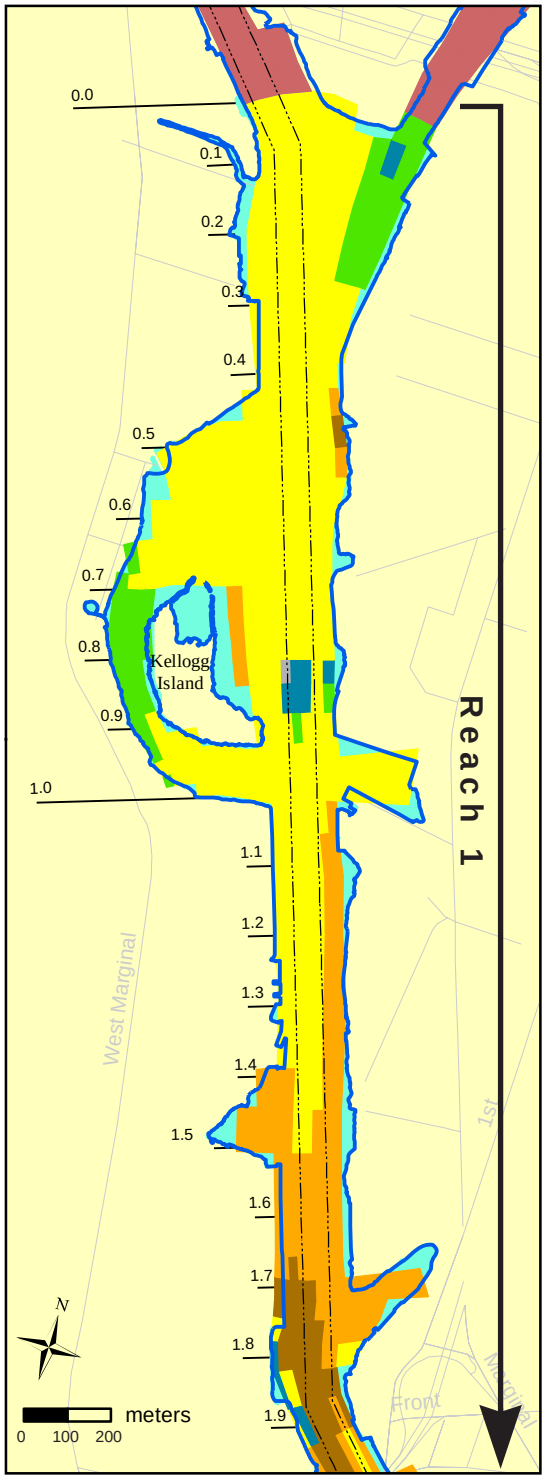
LOWER DUWAMISH WATERWAY STUDY AREA SEATTLE, WA

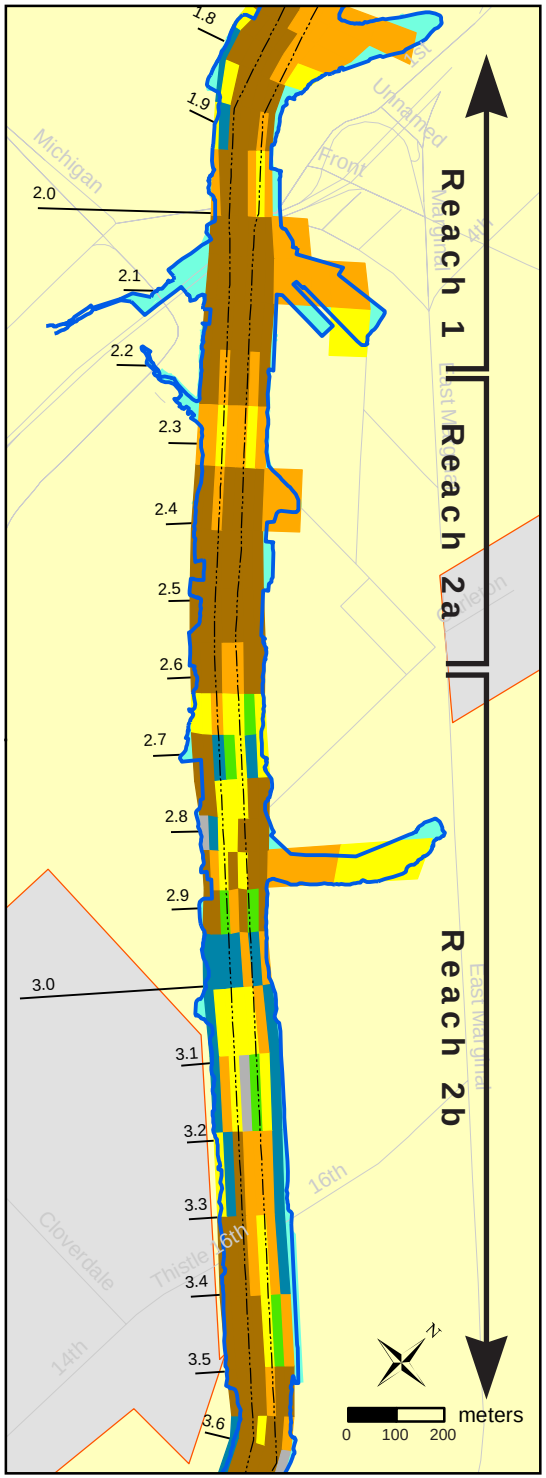
Map 3-8.
Representative locations of and annual loads for lateral sediment sources.

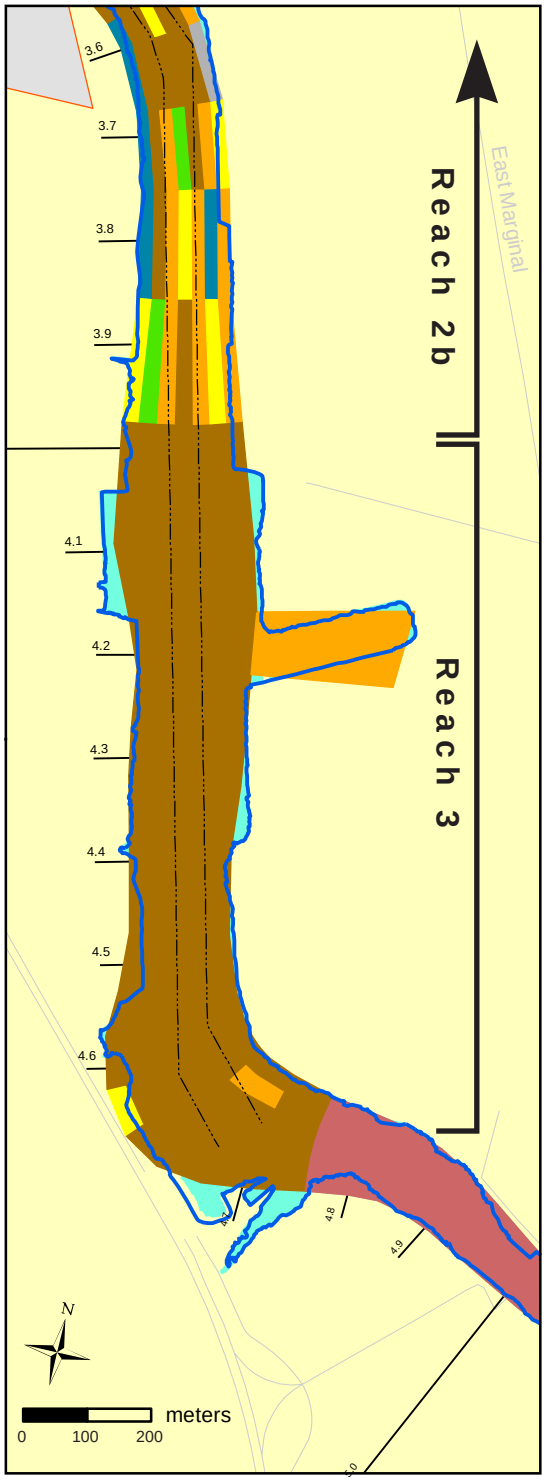
April 2008

QEA
Quantitative Environmental Analysis, LLC

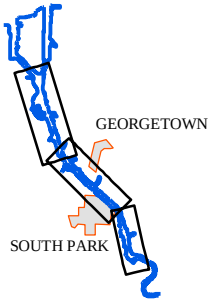
FC - \\Gis_station\D_DRIVE\Private\RETldw\GIS_plot\LatSourcePlot.mxd







LOCATOR MAP



LEGEND

- Navigation Channel
- Shore Line
- River Miles
- Roads
- Hard Bottom
- Neighborhoods
- Outside model domain

Model Predicted NSR (cm/yr)

- 0 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- > 3.0
- Net Erosion

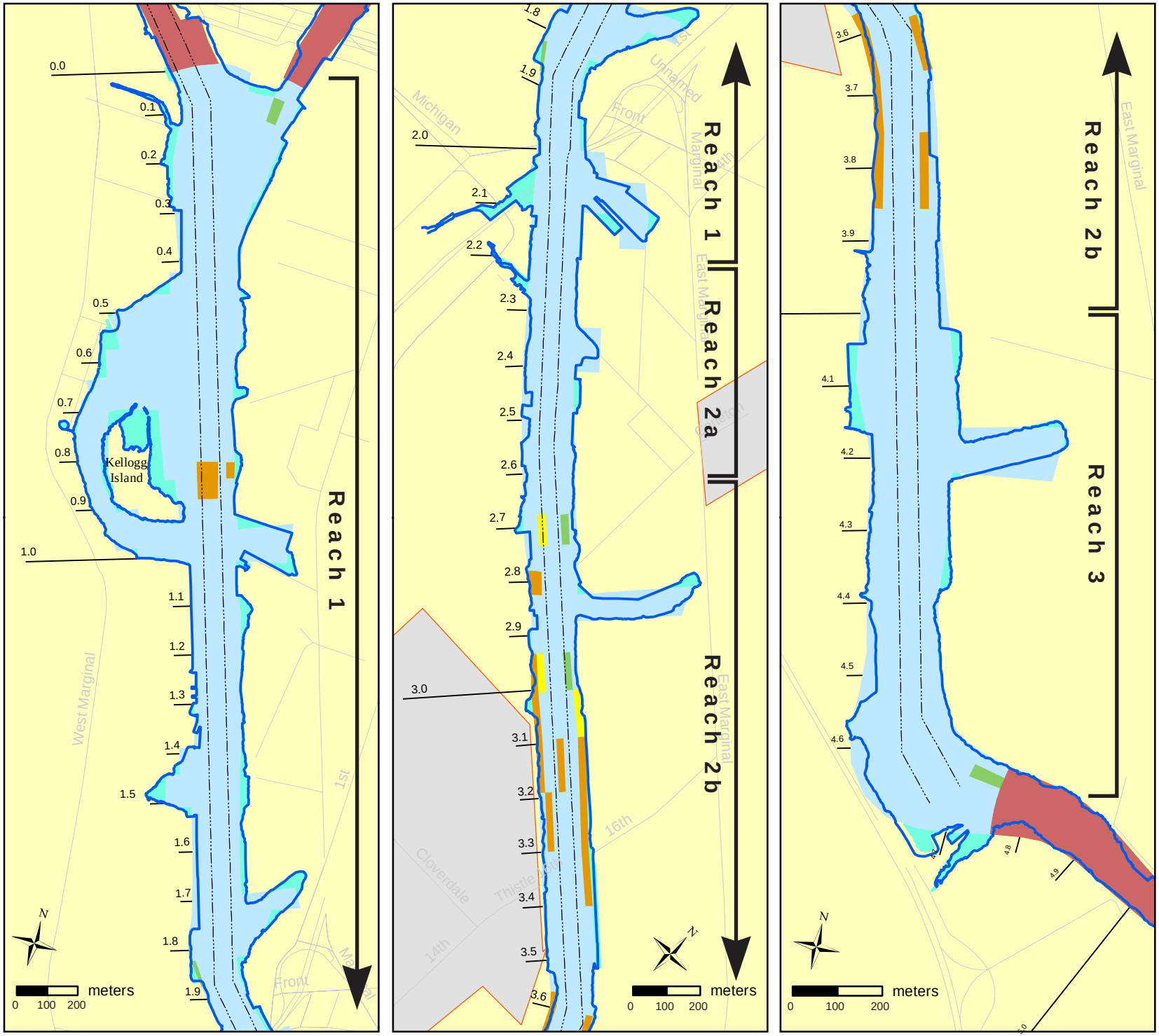
LOWER DUWAMISH WATERWAY STUDY AREA SEATTLE, WA

Map 3-9.
Spatial distribution of predicted net sedimentation rate (NSR) for 30-year period.

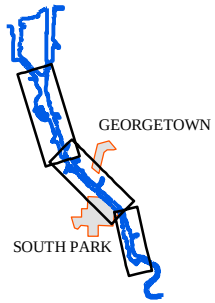
June 2008

QEA Quantitative Environmental Analysis, LLC

FC- \\Gis_station\D_DRIVE\Private\RETldw\GIS_plot\layout_bed_elv_chg_070205.mxd



LOCATOR MAP



LEGEND

Bed source content (%)

- 0 - 25
- 25 - 50
- 50 - 75
- 75 - 100
- Navigation channel
- Shore line
- River miles
- Roads
- Neighborhoods
- Outside model domain
- Hard bottom

LOWER DUWAMISH WATERWAY STUDY AREA SEATTLE, WA

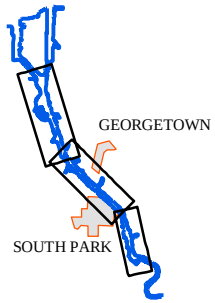
Map 3-10.
Spatial distribution of predicted bed-source content in surface layer (0-10 cm) of the bed at the end of 30-year period.

April 2008

QEA
Quantitative Environmental Analysis, LLC

FC- \\Gis_station\D_DRIVE\Private\RETldw\GIS_plot\layout_bed_elv_chg_070205.mxd

LOCATOR MAP



LEGEND

Upstream source content (%)

- 0 - 25
- 25 - 50
- 50 - 75
- 75 - 100
- Navigation channel
- Shore line
- River miles
- Roads
- Neighborhoods
- Outside model domain
- Hard bottom

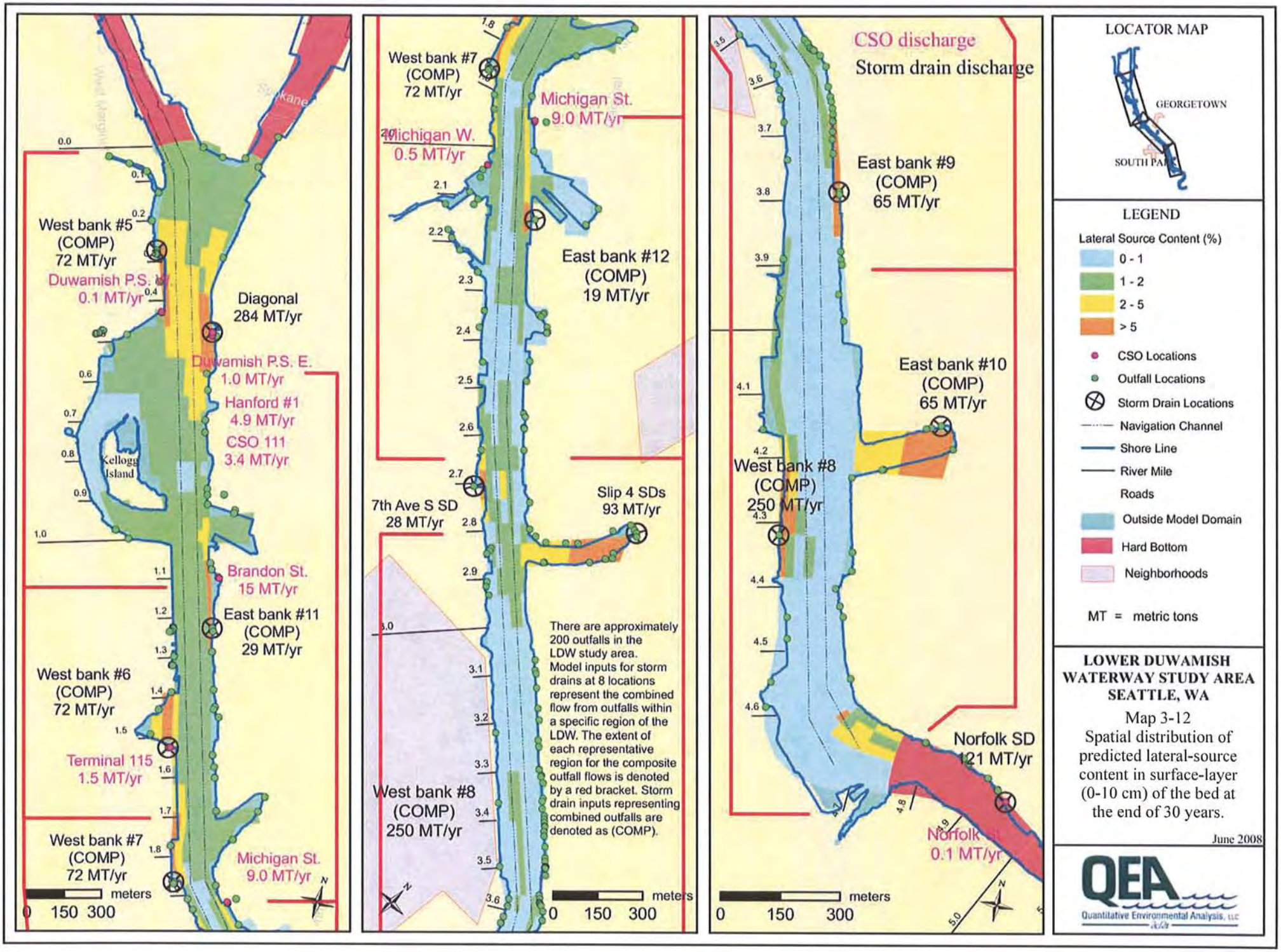
LOWER DUWAMISH WATERWAY STUDY AREA SEATTLE, WA

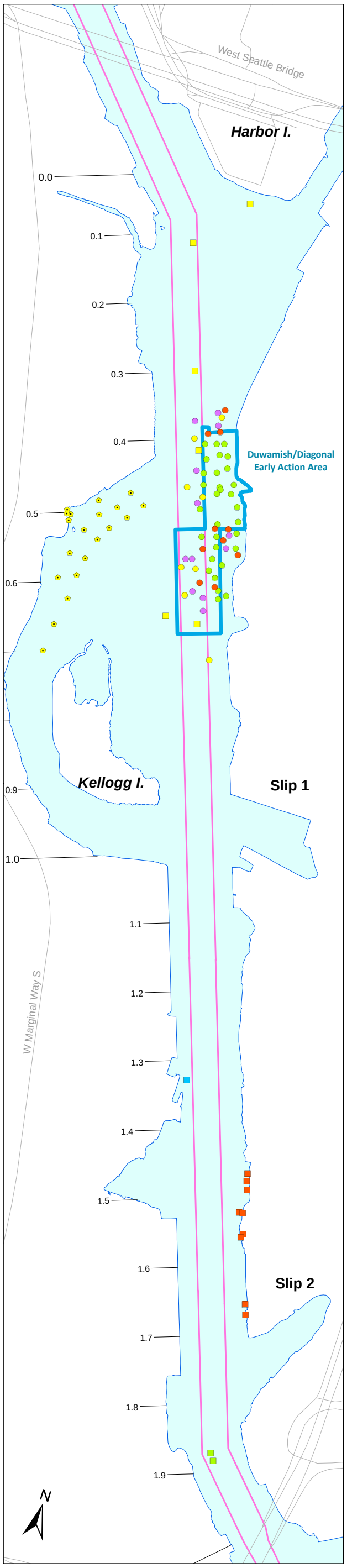
Map 3-11.
Spatial distribution of predicted upstream-source content in surface layer (0-10 cm) of the bed at the end of 30-year period.

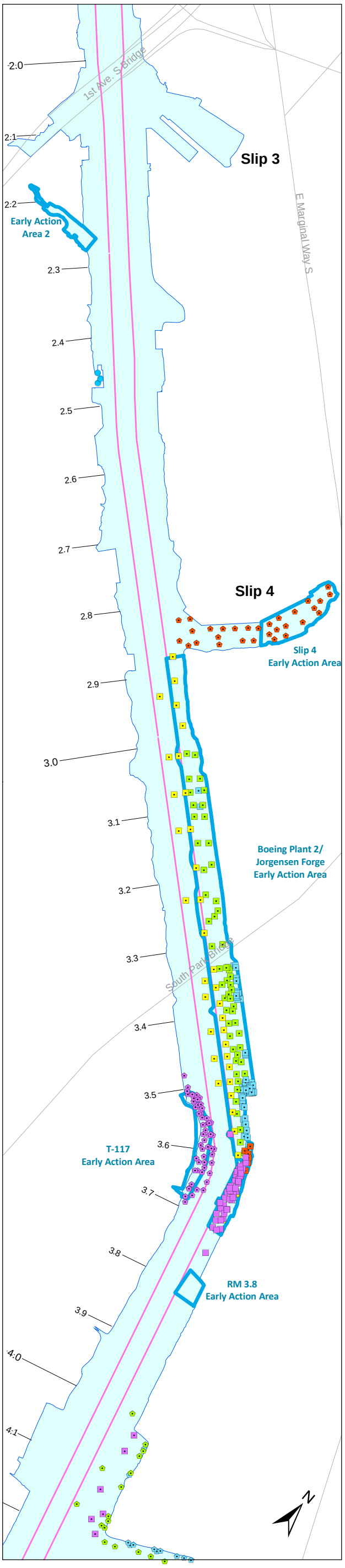
April 2008

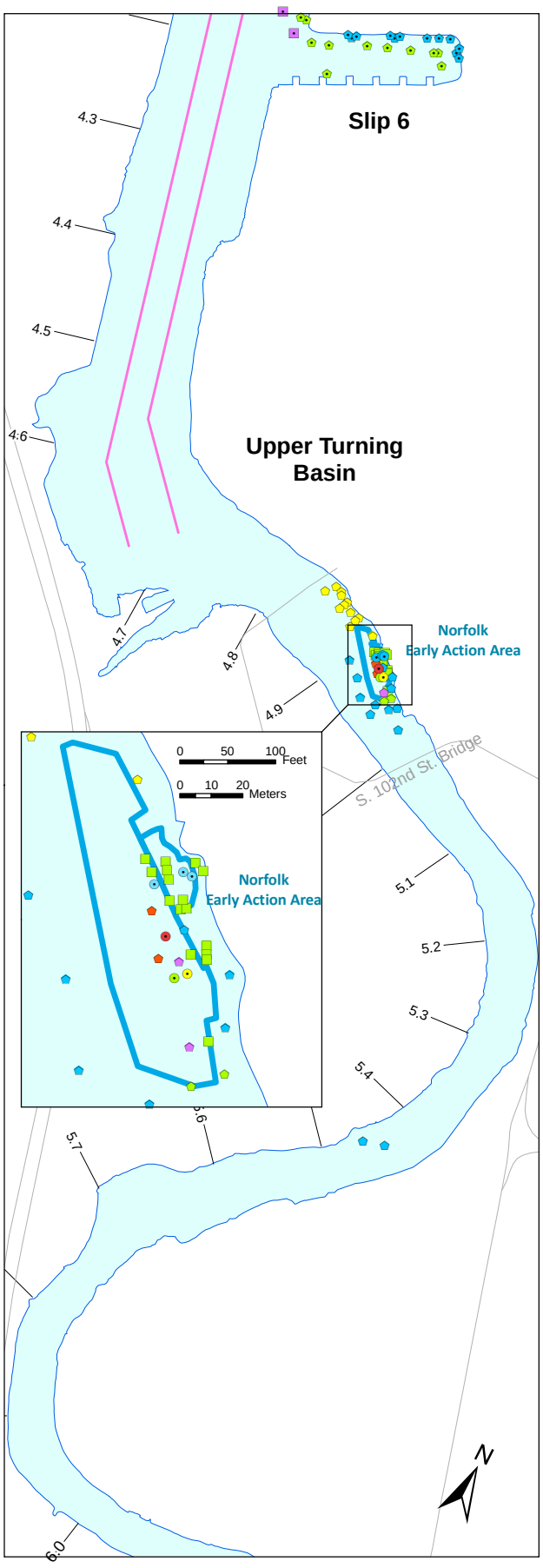
QEA
Quantitative Environmental Analysis, LLC

FC- \\Gis_station\D_DRIVE\Private\RETldw\GIS_plot\layout_bed_elv_chg_070205.mxd


West bank #5
(COMP)
72 MT/yr
Duwamish P.S. W.
0.1 MT/yr
Diagonal
284 MT/yr
Duwamish P.S. E.
1.0 MT/yr
Hanford #1
4.9 MT/yr
CSO 111
3.4 MT/yr
Kellogg Island
Brandon St.
15 MT/yr
East bank #11
(COMP)
29 MT/yr
West bank #6
(COMP)
72 MT/yr
Terminal 115
1.5 MT/yr
West bank #7
(COMP)
72 MT/yr
Michigan St.
9.0 MT/yr
meters
0 150 300
West bank #7
(COMP)
72 MT/yr
Michigan St.
9.0 MT/yr
Michigan W.
0.5 MT/yr
East bank #12
(COMP)
19 MT/yr
Slip 4 SDs
93 MT/yr
7th Ave S SD
28 MT/yr
West bank #8
(COMP)
250 MT/yr
There are approximately 200 outfalls in the LDW study area. Model inputs for storm drains at 8 locations represent the combined flow from outfalls within a specific region of the LDW. The extent of each representative region for the composite outfall flows is denoted by a red bracket. Storm drain inputs representing combined outfalls are denoted as (COMP).
meters
0 150 300
CSO discharge
Storm drain discharge
East bank #9
(COMP)
65 MT/yr
East bank #10
(COMP)
65 MT/yr
West bank #8
(COMP)
250 MT/yr
Norfolk SD
121 MT/yr
Norfolk
0.1 MT/yr
meters
0 150 300
LOCATOR MAP
GEORGETOWN
SOUTH PARK
LEGEND
Lateral Source Content (%)
0 - 1
1 - 2
2 - 5
> 5
CSO Locations
Outfall Locations
Storm Drain Locations
Navigation Channel
Shore Line
River Mile
Roads
Outside Model Domain
Hard Bottom
Neighborhoods
MT = metric tons
LOWER DUWAMISH WATERWAY STUDY AREA
SEATTLE, WA
Map 3-12
Spatial distribution of predicted lateral-source content in surface-layer (0-10 cm) of the bed at the end of 30 years.
June 2008
QEA
Quantitative Environmental Analysis, LLC







Surface sediment sampling event

- BoyerTowing (2004)
- Duw/Diag-1 (1994)
- Duw/Diag-1.5 (1995)
- Duw/Diag-2 (1996)
- DuwDiagonal (2003)
- DuwamishShipyard (1993)
- Ecology-Norfolk (2002)
- Harbor Island RI (1991)
- JamesHardieOutfall (2000)
- Jorgensen (2004)
- Norfolk-cleanup1 (1994)
- Norfolk-cleanup2 (1995)
- Norfolk-cleanup3 (1995)
- Norfolk-monit1 (1999)
- Norfolk-monit2a (1999)
- Norfolk-monit2b (2000)
- Norfolk-monit3 (2000)
- Norfolk-monit4 (2001)
- Norfolk-monit5 (2002)
- Plant 2 RFI-1 (1995)
- Plant 2 RFI-2a (1995)
- Plant 2 RFI-2b (1996)
- Plant 2-Transformer-Phase1 (2003)
- Rhône-Poulenc RFI-2 (1994)
- Rhône-Poulenc RFI-3 (1996)
- Rhône-Poulenc (2004)
- Seaboard-Ph2 (1996)
- Slip4-EarlyAction (2004)
- T117Boundary-Definition (2003)
- Early Action Area[a]
- Road
- Navigation channel
- River mile

[a] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2. For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer capping in 2003 to 2005. For the Norfolk Early Action Area, surface sediment data represent samples collected after dredging and capping at the Boeing Developmental Center south storm drain in 2003.

Wind Ward environmental LLC

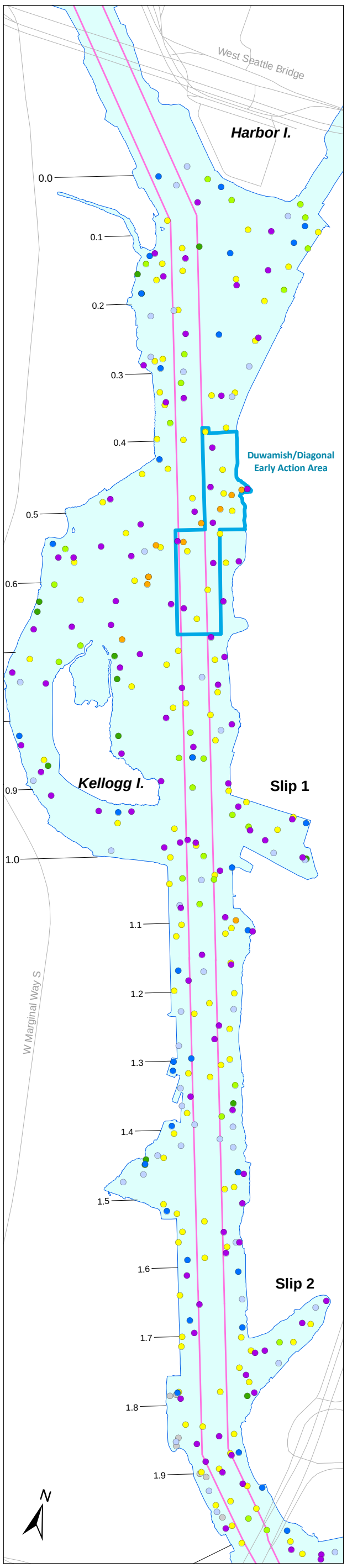
0 0.1 0.2 Miles

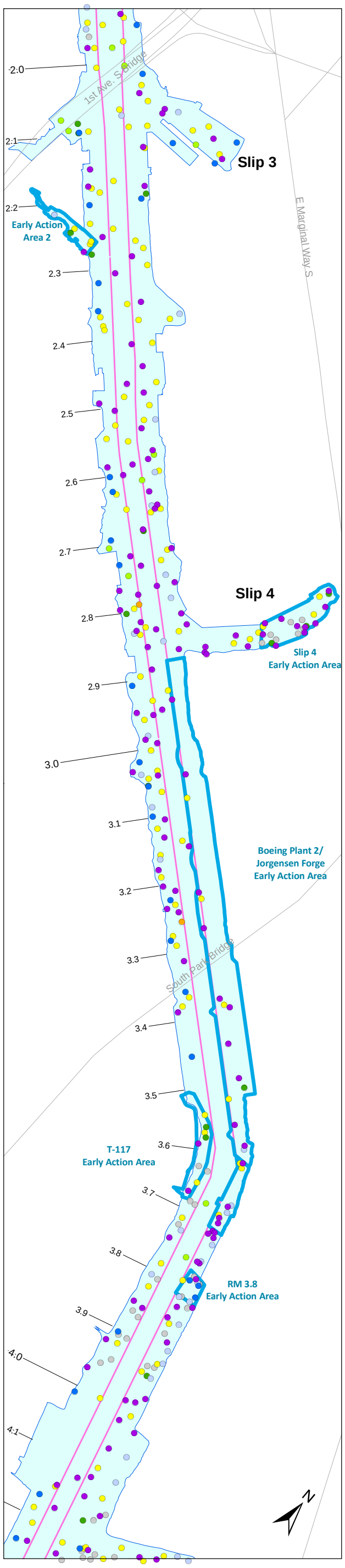
0 0.1 0.2 Kilometers

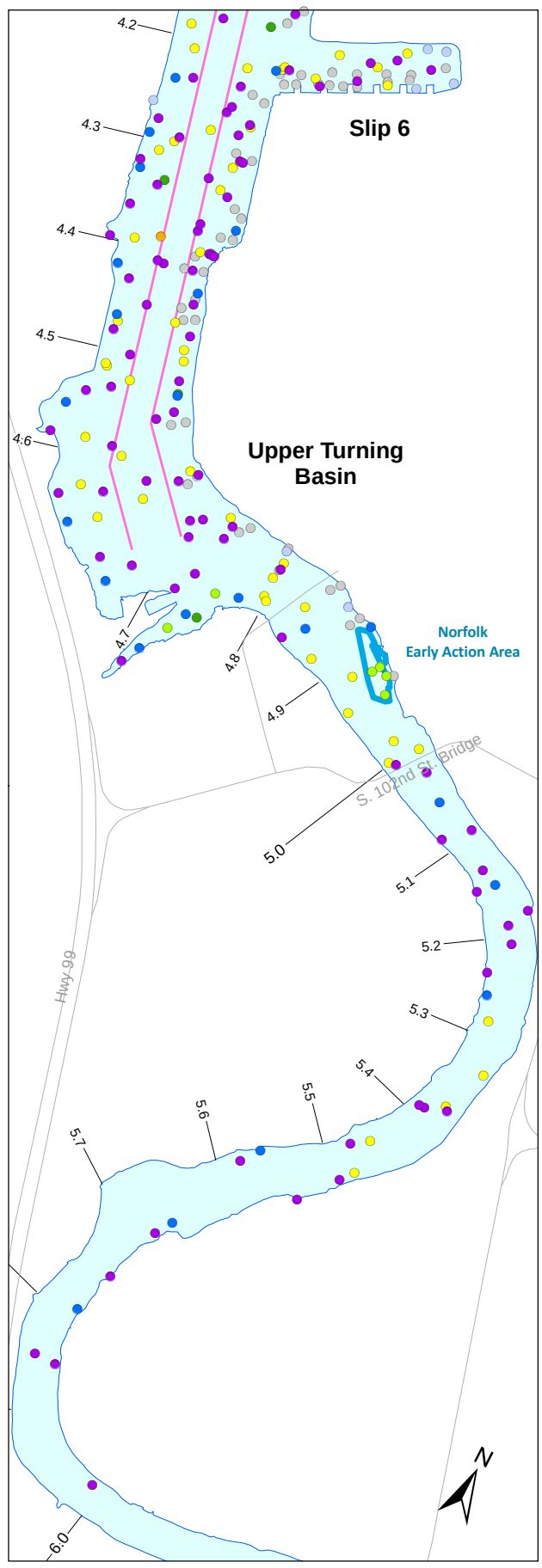
Scale is the same for each inset map

Map 4-1. Locations of surface sediment samples analyzed as part of discrete events

Prepared by CEH 07/13/2010; MAP #2674; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\Baseline Locations







Surface sediment sampling event

- Boeing SiteChar (1997)
- EPA SI (1998)
- KC WQA (1997)
- LDWRI-Benthic (2004)
- LDWRI-SurfaceSedimentRound1 (2005)
- LDWRI-SurfaceSedimentRound2 (2005)
- LDWRI-SurfaceSedimentRound3 (2006)
- NOAA SiteChar (1997)
- Early Action Area[a]
- Road
- River mile
- Navigation channel

[a] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2. For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer capping in 2003 to 2005. For the Norfolk Early Action Area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

Wind Ward environmental LLC

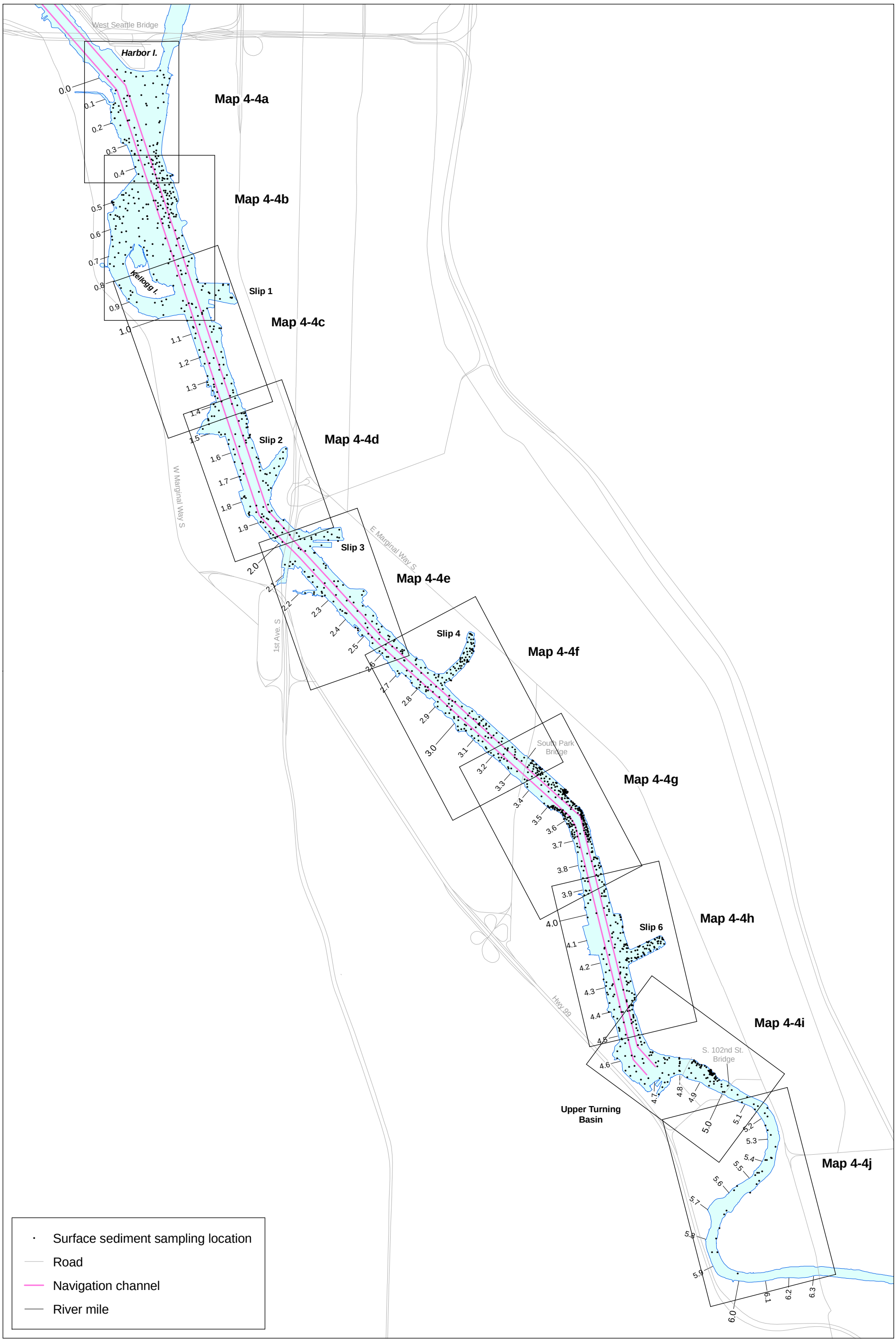
0 0.1 0.2 Miles

0 0.1 0.2 Kilometers

Scale is the same for each inset map

Map 4-2. Locations of surface sediment samples analyzed as part of LDW-wide events

Prepared by CEH, 07/13/2010; MAP 2685; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\Baseline Locations



Wind Ward environmental LLC

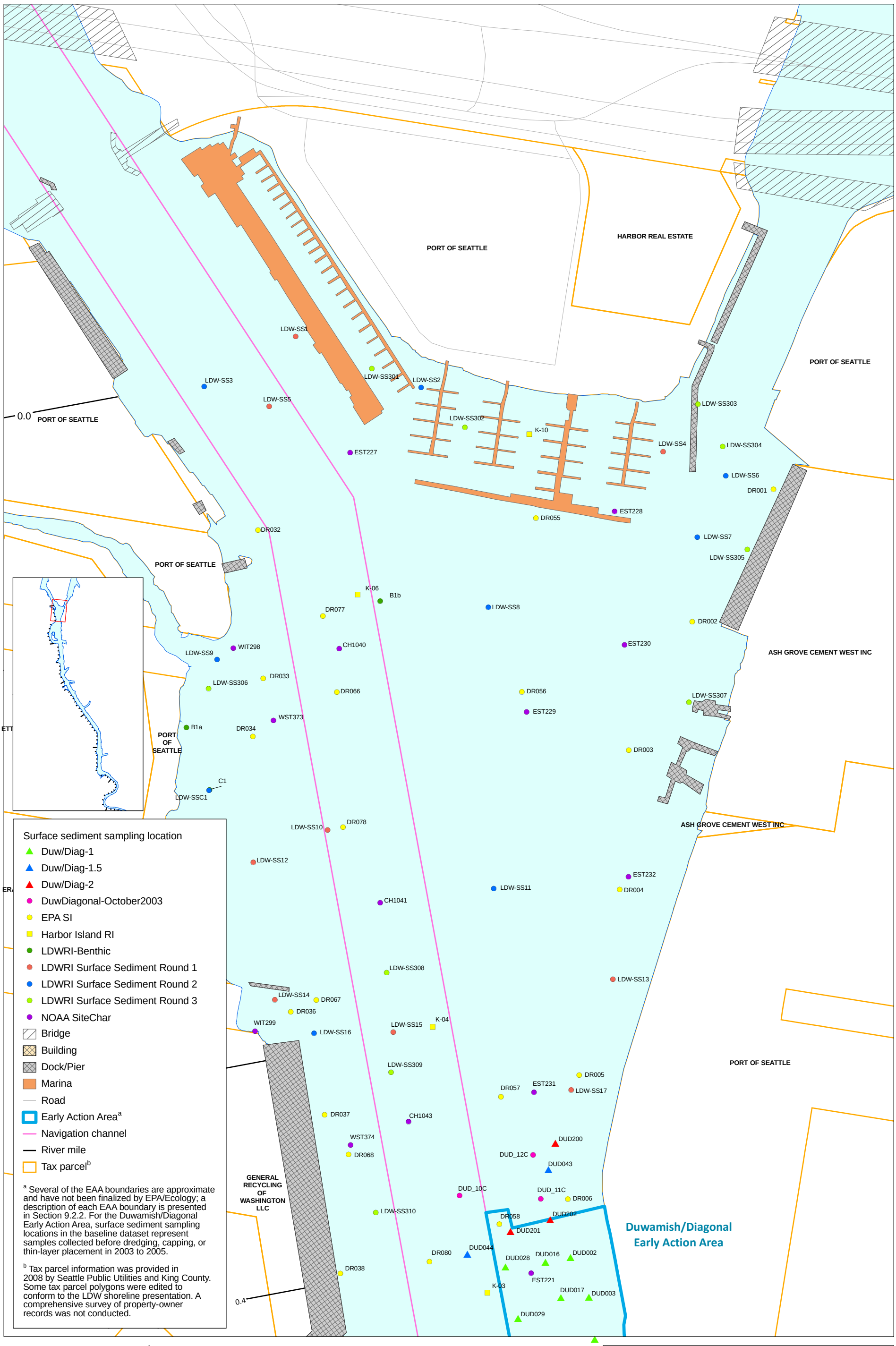
N

0 0.25 0.5 Miles

0 0.25 0.5 Kilometers

Map 4-3. Surface sediment sampling location reference map

Prepared by CEH, 07/13/2010; W:\Projects\09-08-06_Duwamish_RI\data\gis\Phase 2 RI\Nature and Extent\Surface Sediment\Baseline Locations



Wind Ward environmental LLC

N

0 200 400 Feet

0 50 100 Meters

Map 4-4a. Surface sediment sampling locations, RM 0.0 to RM 0.4

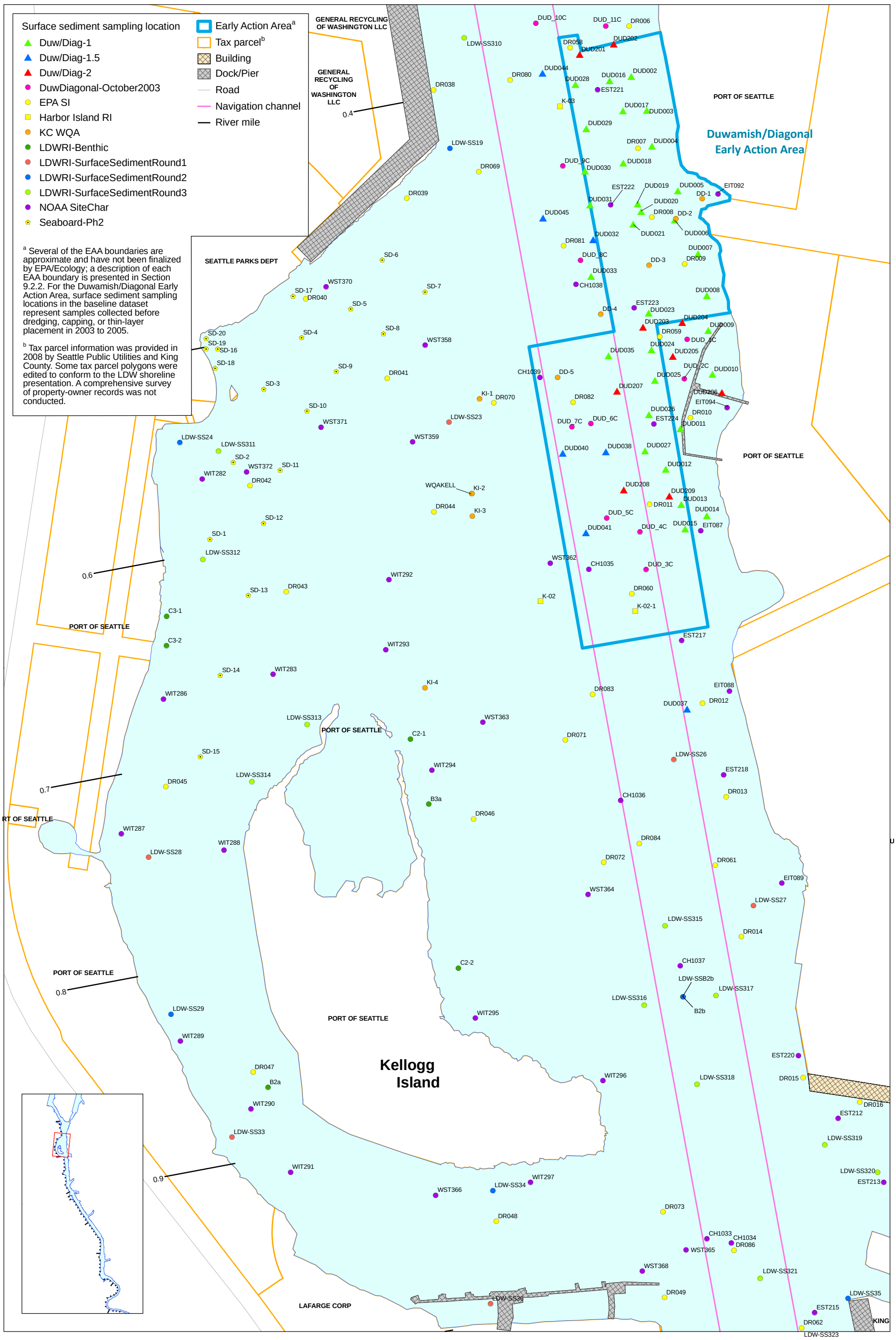
Prepared by CEH 07/13/2010; MAP 2619; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\Baseline Locations

Surface sediment sampling location
- Duw/Diag-1
- Duw/Diag-1.5
- Duw/Diag-2
- DuwDiagonal-October2003
- EPA SI
- Harbor Island RI
- KC WQA
- LDWRI-Benthic
- LDWRI-SurfaceSedimentRound1
- LDWRI-SurfaceSedimentRound2
- LDWRI-SurfaceSedimentRound3
- NOAA SiteChar
- Seaboard-Ph2

- Early Action Area[a]
- Tax parcel[b]
- Building
- Dock/Pier
- Road
- Navigation channel
- River mile

[a] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2. For the Duwamish/Diagonal Early Action Area, surface sediment sampling locations in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005.

[b] Tax parcel information was provided in 2008 by Seattle Public Utilities and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property-owner records was not conducted.



Prepared by CEH, 07/13/2010; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase 2 RI\Nature and Extent\Surface Sediment\Baseline Locations

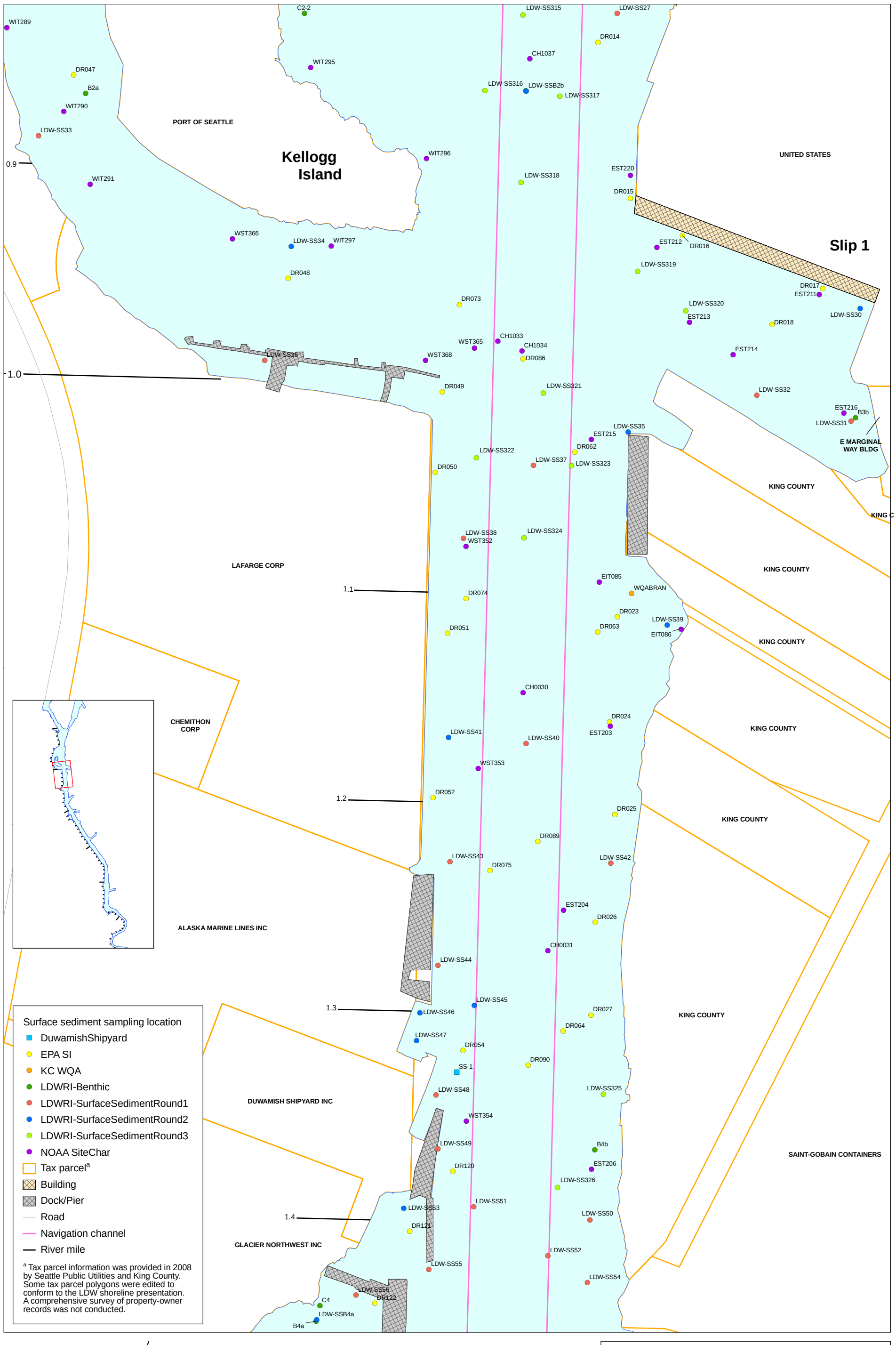
Wind Ward environmental LLC

N

0 200 400 Feet

0 50 100 Meters

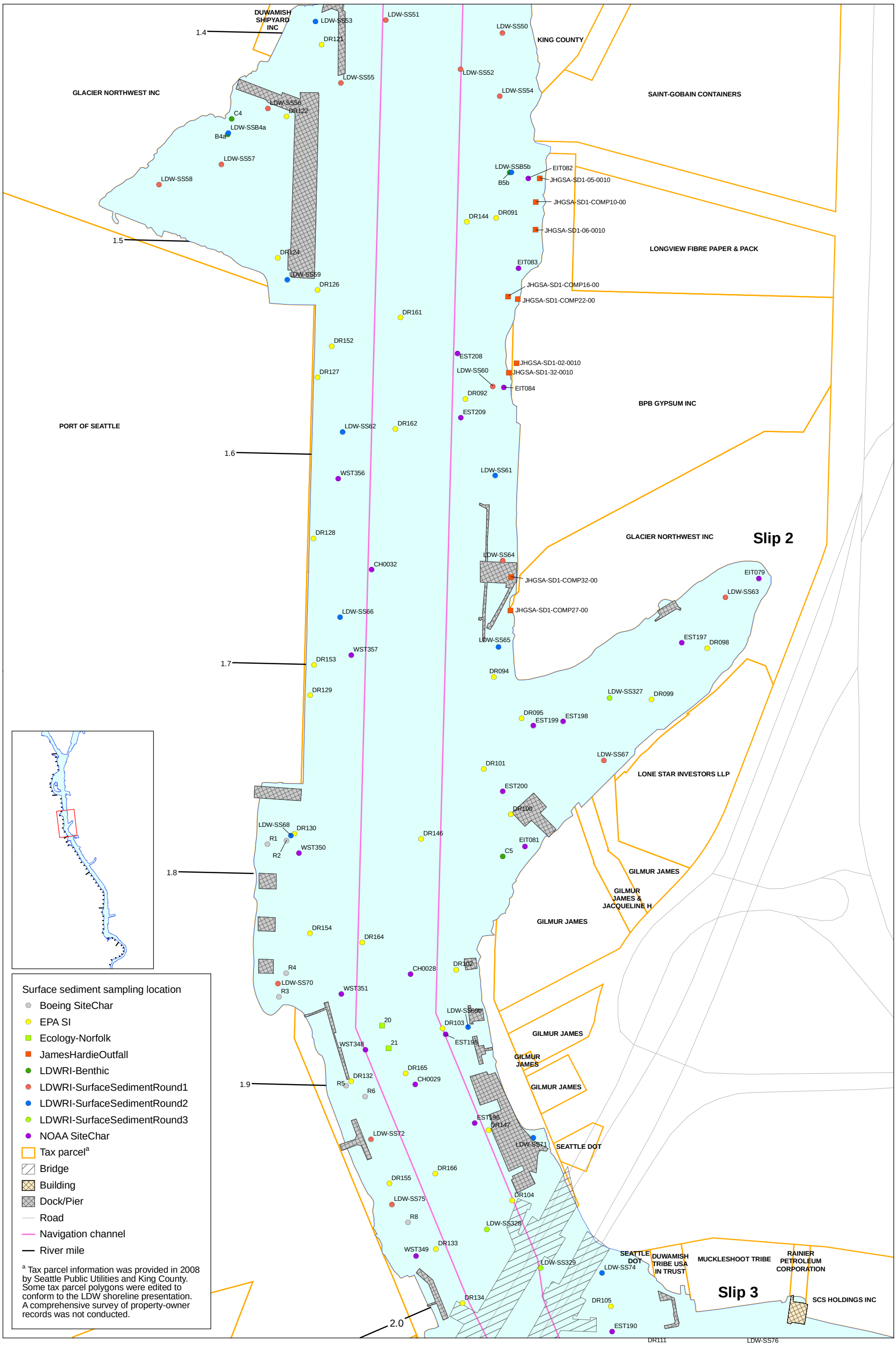
Map 4-4b. Surface sediment sampling locations, RM 0.4 to RM 0.9



Wind Ward environmental LLC

Map 4-4c. Surface sediment sampling locations, RM 0.9 to RM 1.4

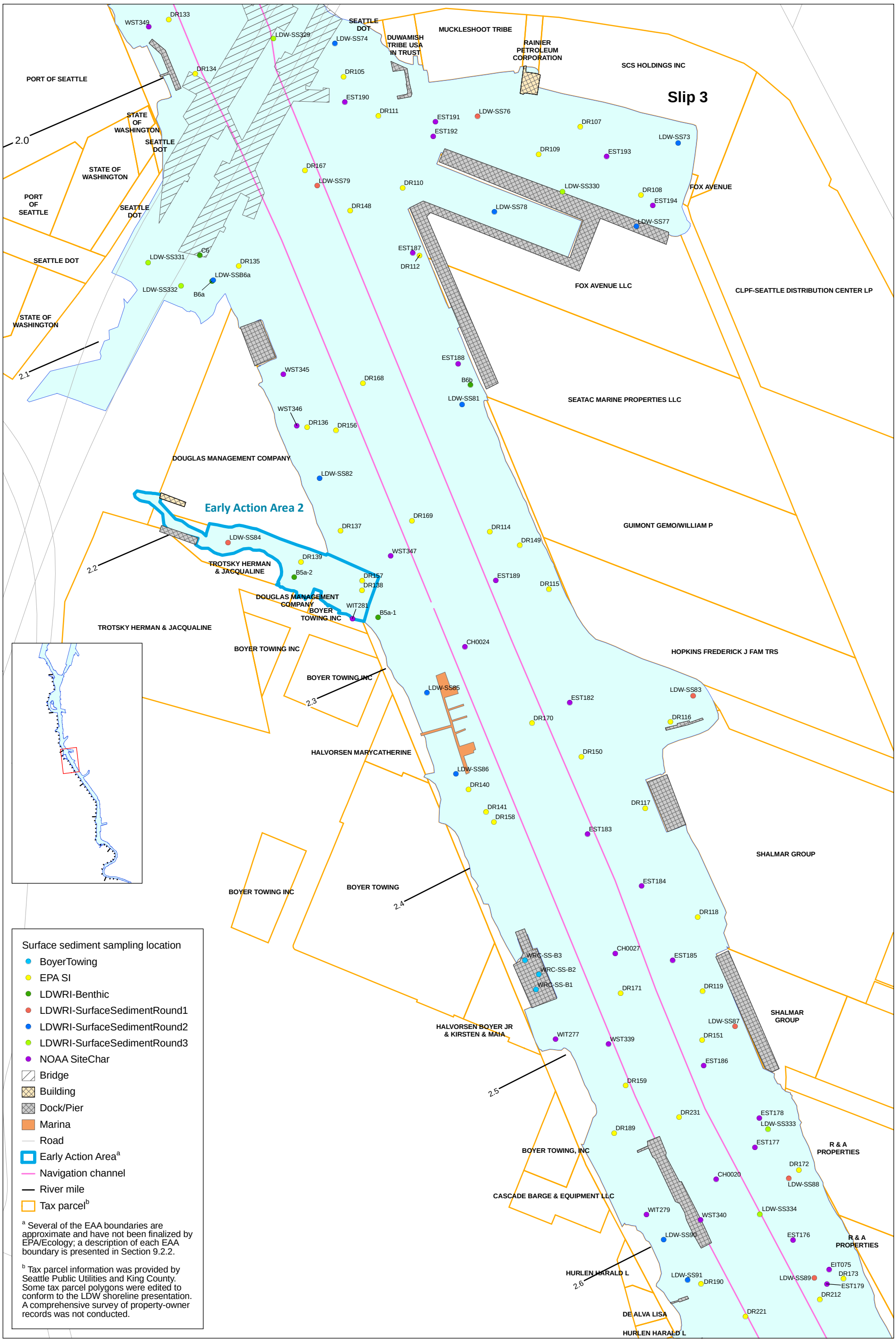
Prepared by CEH, 07/13/2010; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\Baseline Locations



Wind Ward environmental LLC

Map 4-4d. Surface sediment sampling locations, RM 1.4 to RM 2.0

Prepared by CEH, 07/13/2010; W:\Projects\03-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\Baseline Locations



Wind Ward environmental LLC

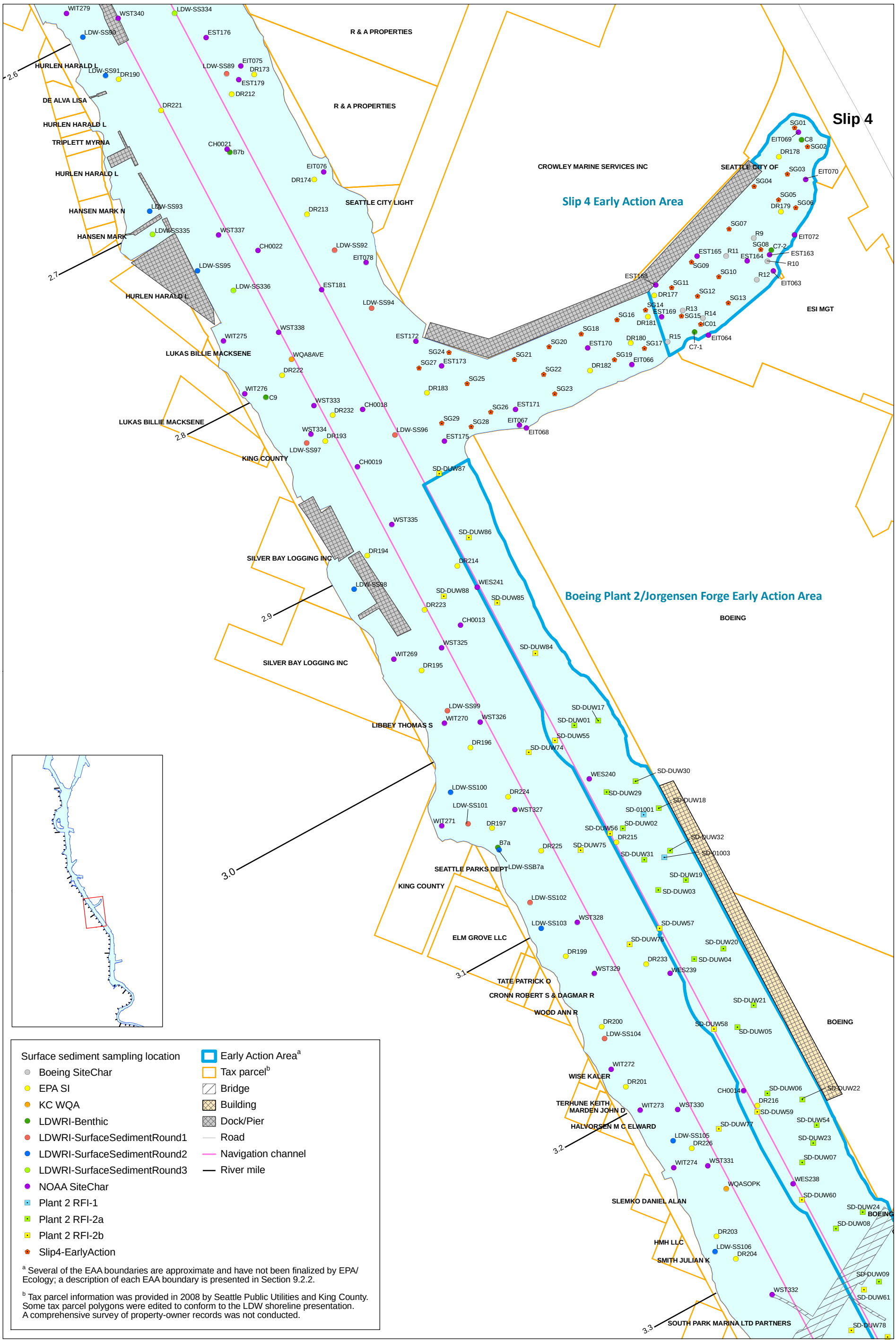
N

0 200 400 Feet

0 50 100 Meters

Map 4-4e. Surface sediment sampling locations, RM 2.0 to RM 2.6

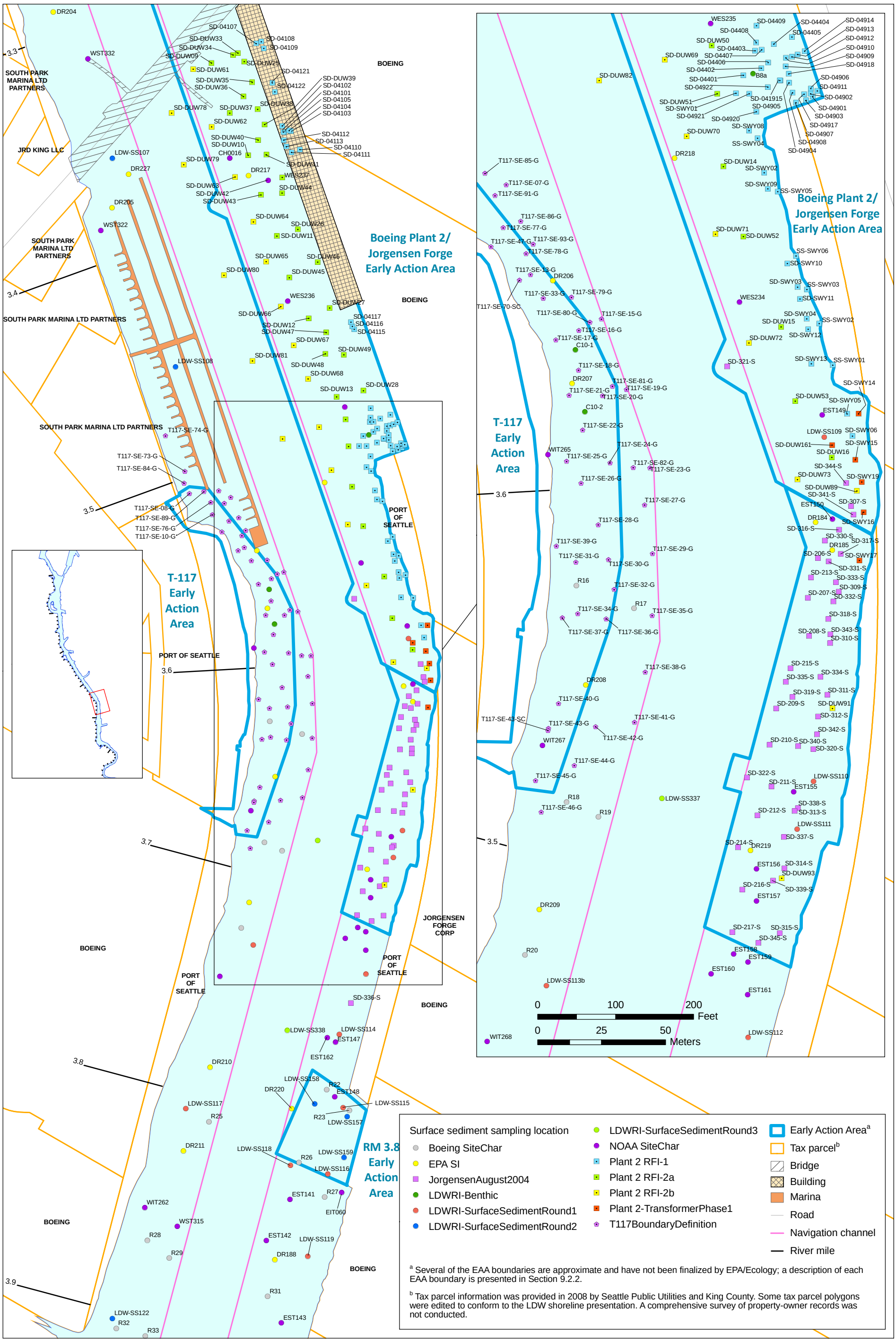
Prepared by CEH, 07/13/2010; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\Baseline Locations



Wind Ward environmental LLC

Map 4-4f. Surface sediment sampling locations, RM 2.6 to RM 3.3

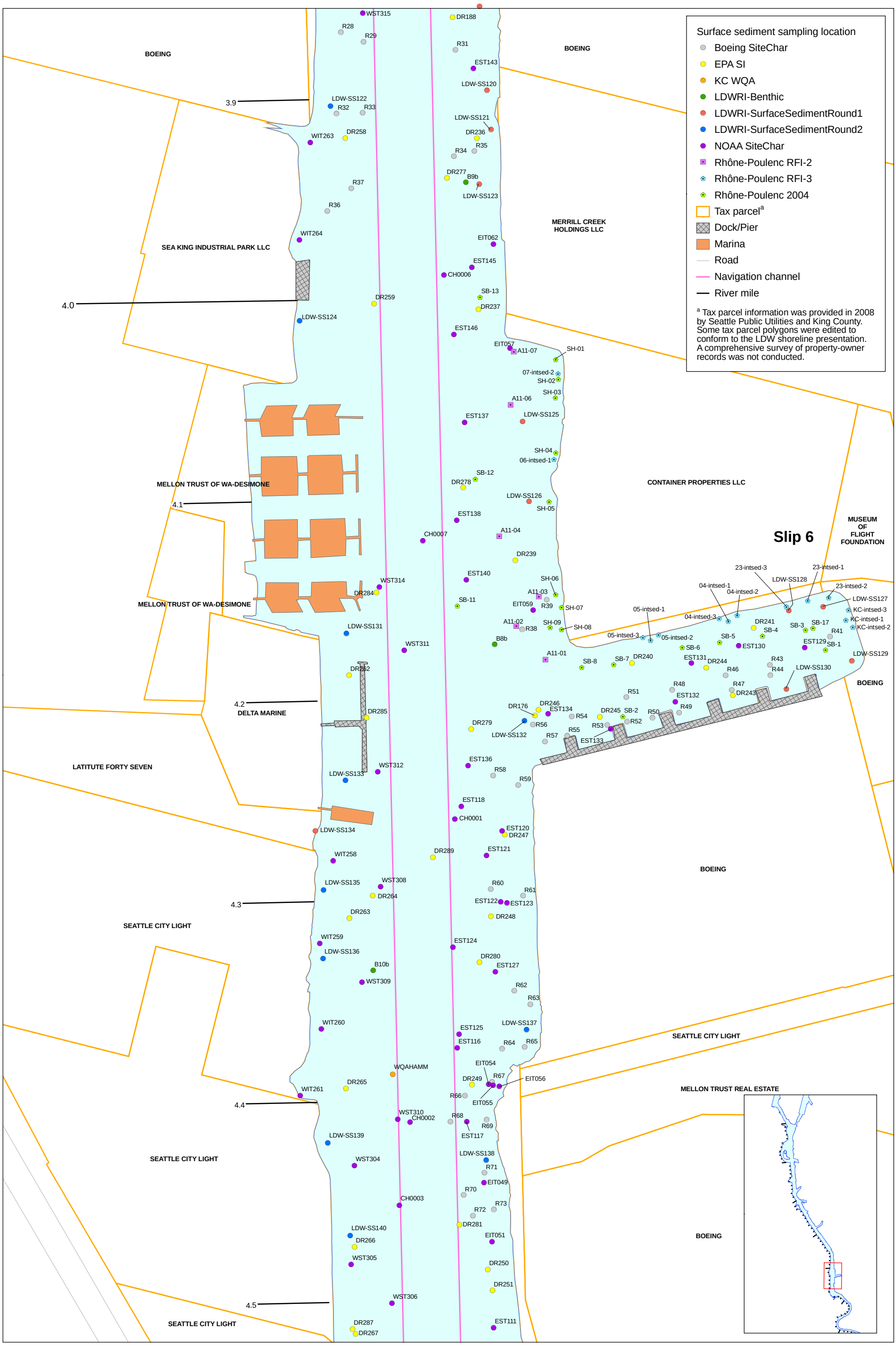
Prepared by CEH, 07/13/2010; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\Baseline Locations



Wind Ward environmental LLC

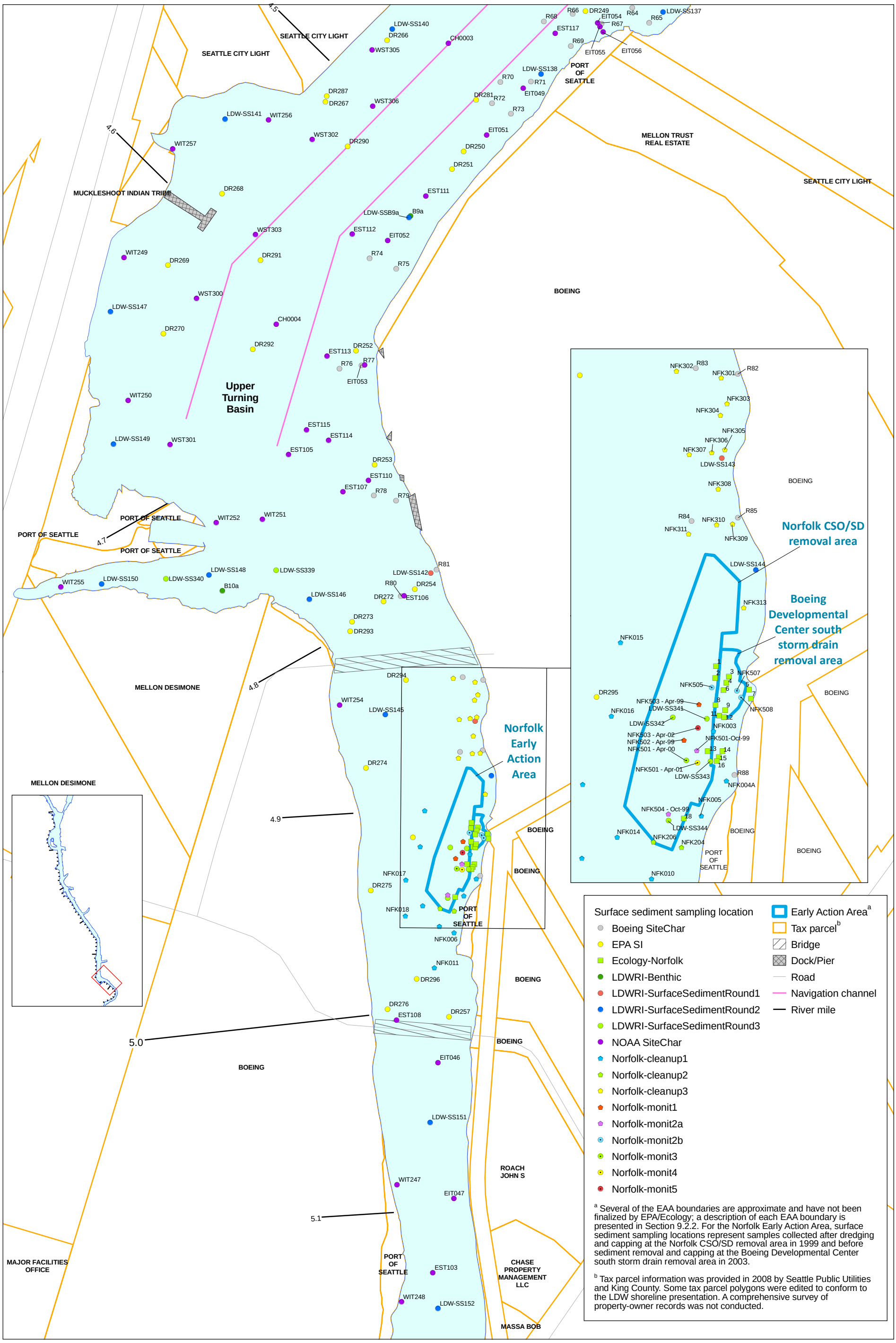
Map 4-4g. Surface sediment sampling locations, RM 3.3 to RM 3.9

Prepared by CEH, 07/13/2010; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\Baseline Locations



Map 4-4h. Surface sediment sampling locations, RM 3.9 to RM 4.5

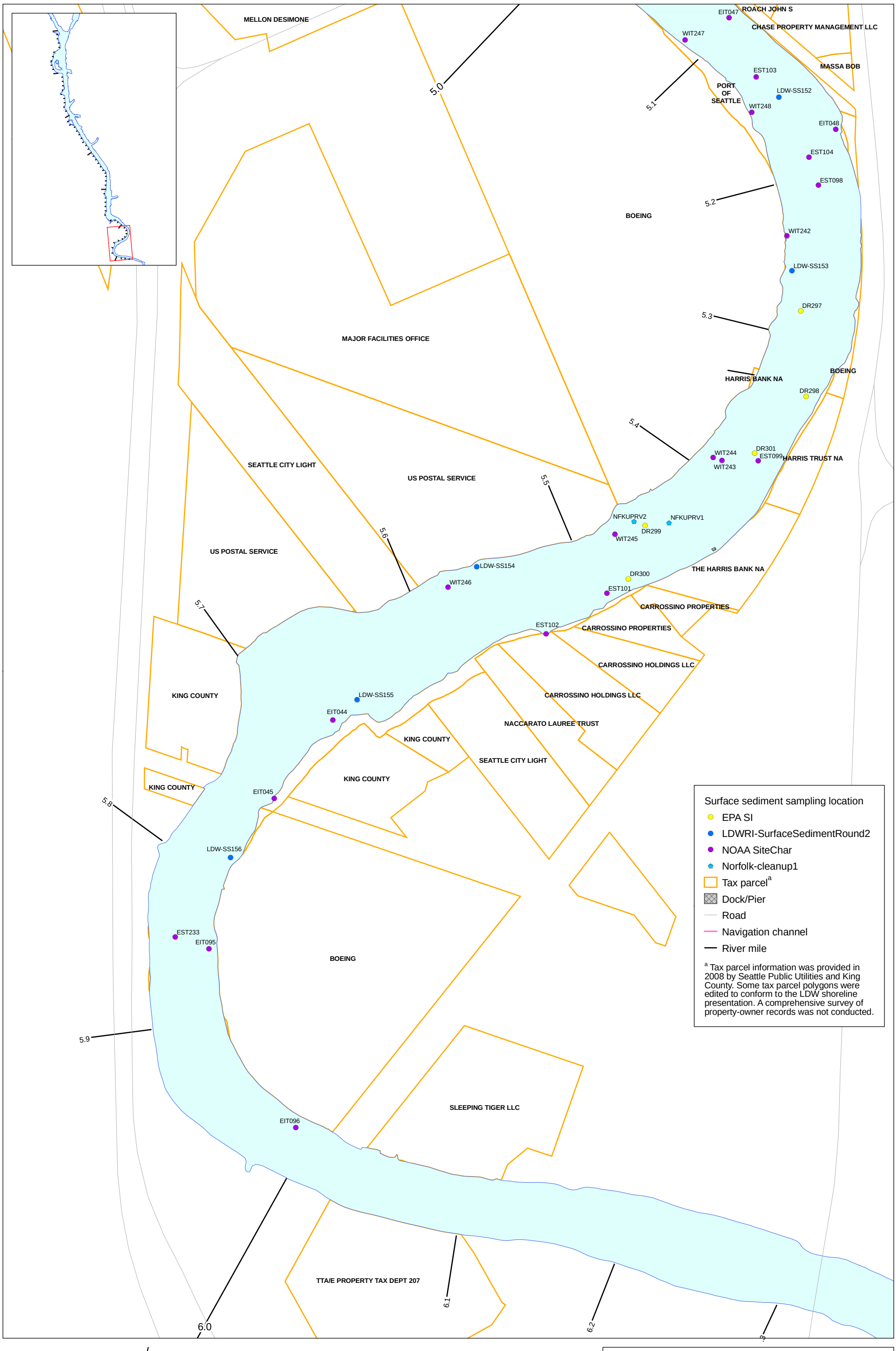
Prepared by CEH, 07/13/2010; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\Baseline Locations



Wind Ward environmental LLC

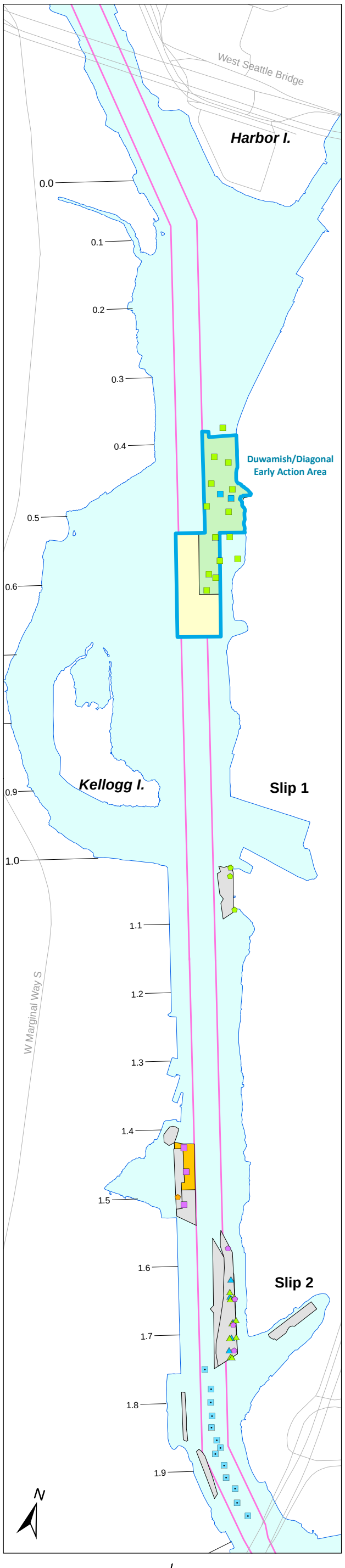
Map 4-4i. Surface sediment sampling locations, RM 4.5 to RM 5.0

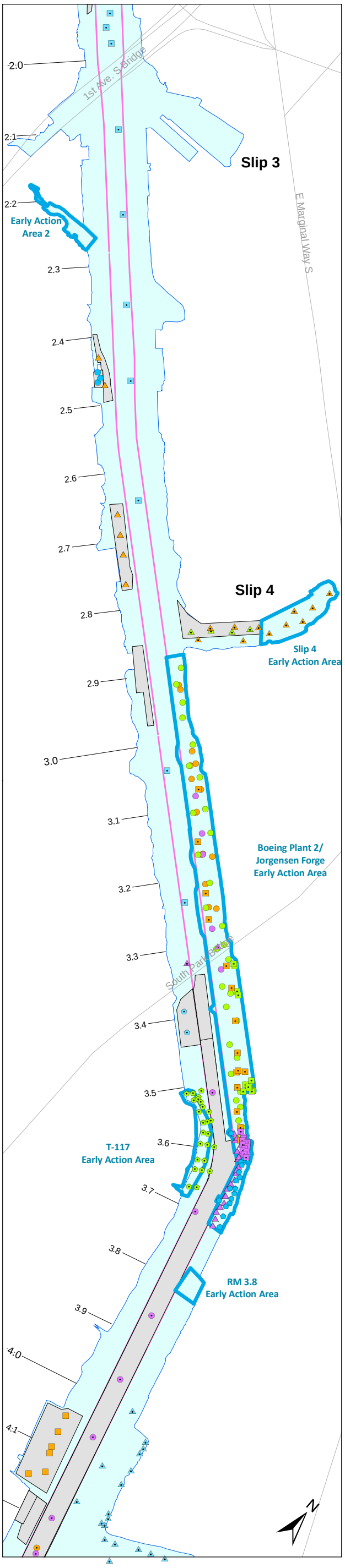
Prepared by CEH, 07/13/2010, W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase 2 RI\Nature and Extent\Surface Sediment\Baseline Locations

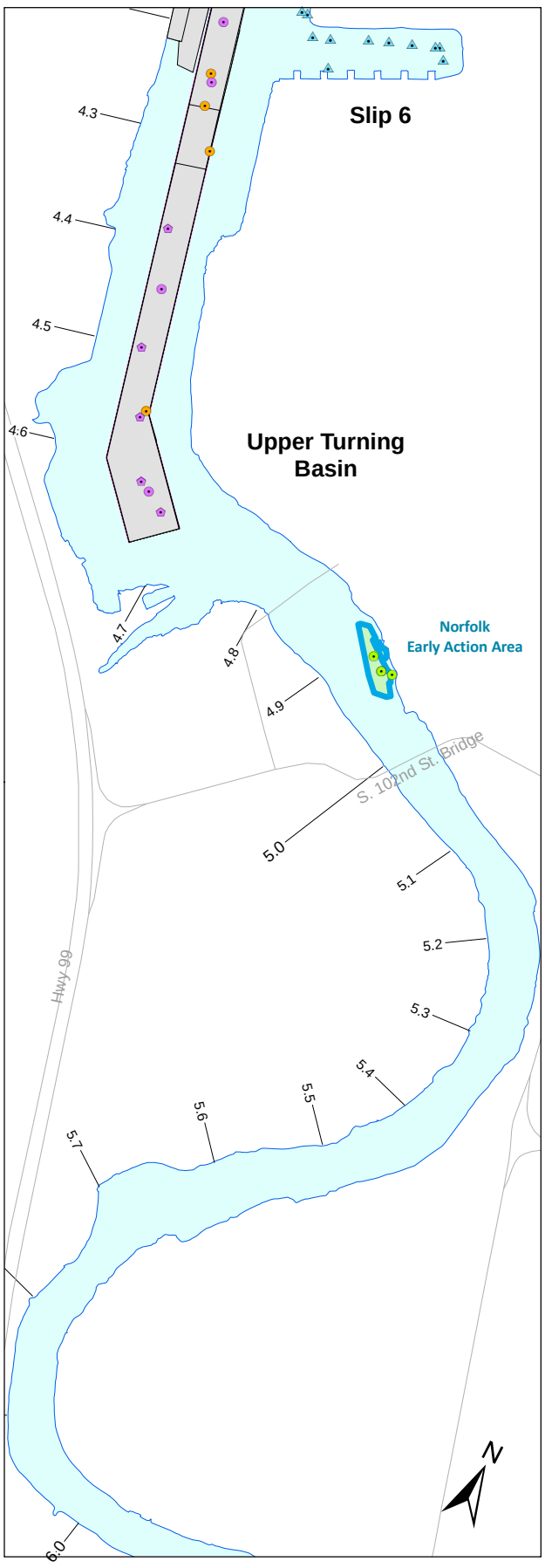


Map 4-4j. Surface sediment sampling locations, RM 5.1 to RM 6.0

Prepared by CEH, 07/13/2010, W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase 2 RI\Nature and Extent\Surface Sediment\Baseline Locations







Subsurface sediment sampling event

- BoyerTowing (2004)
- DSOAvertchar (2001)
- DSOAvertchar2 (2003)
- DSOAvertchar3 (2004)
- Duw/Diag-1 (1994)
- Duw/Diag-2 (1996)
- DuwamYachtClub (1999)
- Glacier NW (2002)
- Hardie Gypsum-1 (1998)
- Hardie Gypsum-2 (1999)
- Hurlen-Boyer (1999)
- Jorgensen (2004)
- Jorgensen (2004)
- Lehigh NW (2003)
- Lone Star 92 (1992)
- Lone Star-Hardie Gypsum (1995)
- Norfolk-cleanup1 (1994)
- Norfolk-cleanup2 (1995)
- PSDDA96 (1996)
- PSDDA98 (1998)
- PSDDA99 (1999)
- Plant 2 RFI-1 (1994, 1995)
- Plant 2 RFI-2b (1996)
- Plant 2-TransformerPhase1 (2003)
- Rhône-Poulenc (2004)
- Slip4-Crowley (1995)
- Slip4-EarlyAction (2004)
- South Park Bridge (2003)
- SouthParkMarina (1994)
- T117BoundaryDefinition (2003, 2004)
- Terminal 105 (1985)
- Turning-basin (2003)
- Early Action Area[a]
- Dredged area[b]
- Dredged and capped area[b]
- Dredged and thin-layer placement[b]
- Thin-layer placement
- Road
- Navigation channel
- River mile

[a] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[b] Subsurface sediment data at locations in dredged areas were collected prior to dredging.

Windward environmental LLC

0 0.1 0.2 Miles

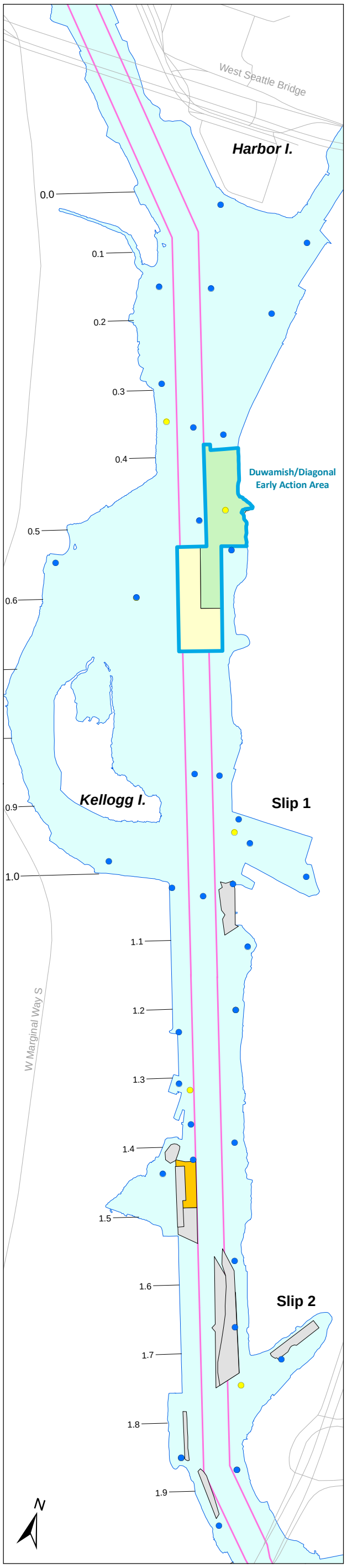
0 0.1 0.2 Kilometers

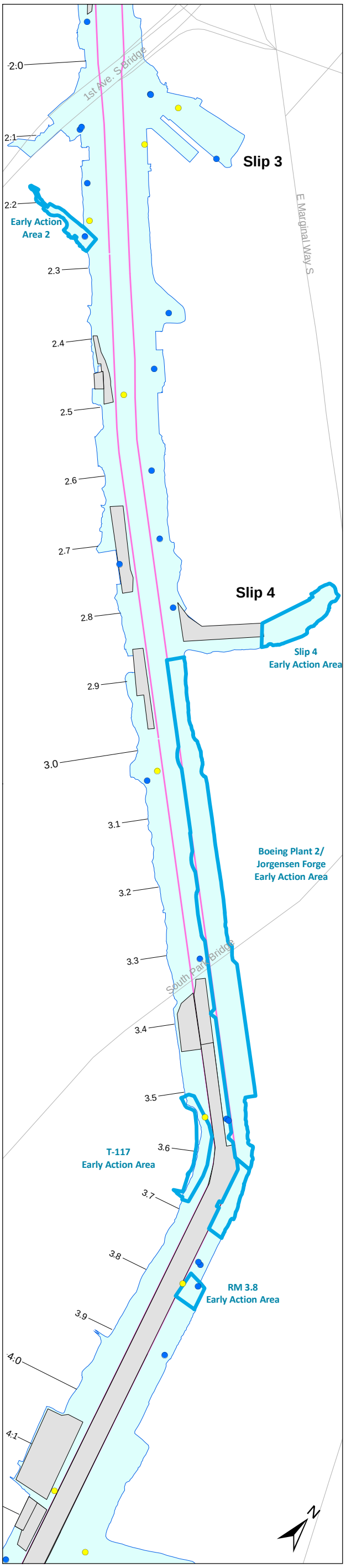
Scale is the same for each inset map

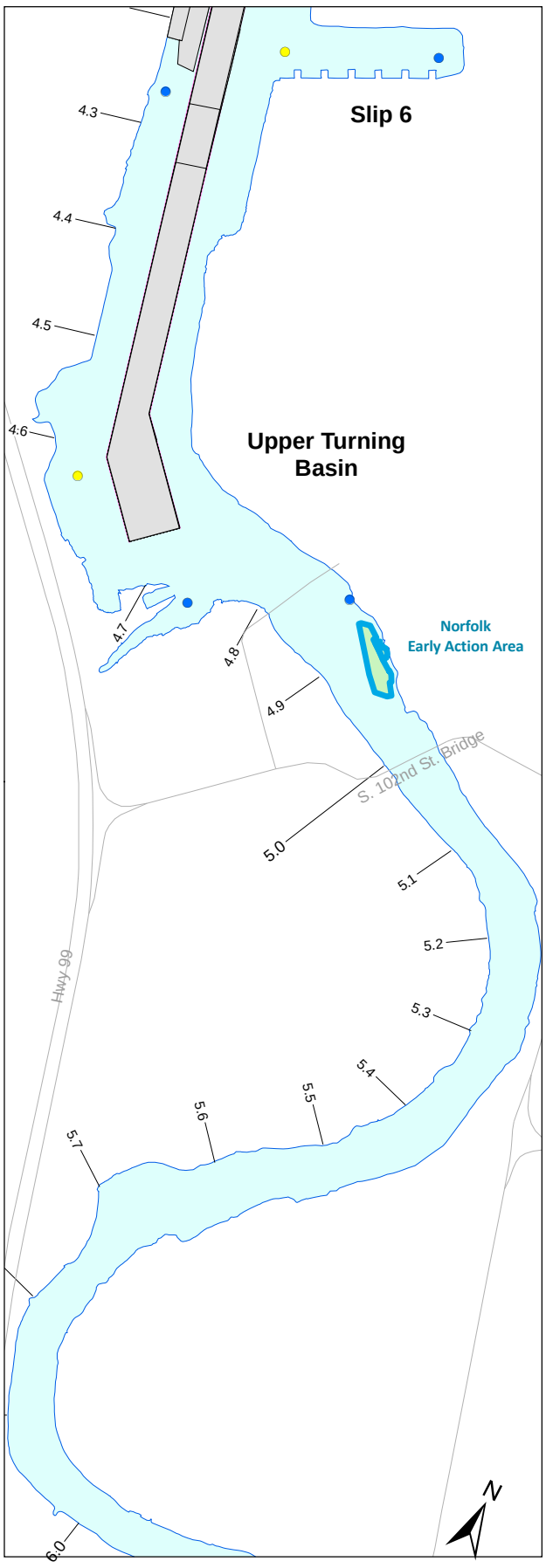
Map 4-5. Locations of subsurface sediment cores analyzed as part of discrete events

Prepared by CEH, 07/13/2010; MAP 2750; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface

Dredging information provided by AECOM.







Subsurface sediment sampling event

- EPA SI (1998)
- LDWRI- Subsurface Sediment (2006)
- Early Action Area[a]
- Dredged area[b]
- Dredged and capped area[b]
- Dredged and thin-layer placement[b]
- Thin-layer placement
- Road
- Navigation channel
- River mile

[a] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[b] Subsurface sediment data at locations in dredged areas were collected prior to dredging.

Wind Ward environmental LLC

0 0.1 0.2 Miles

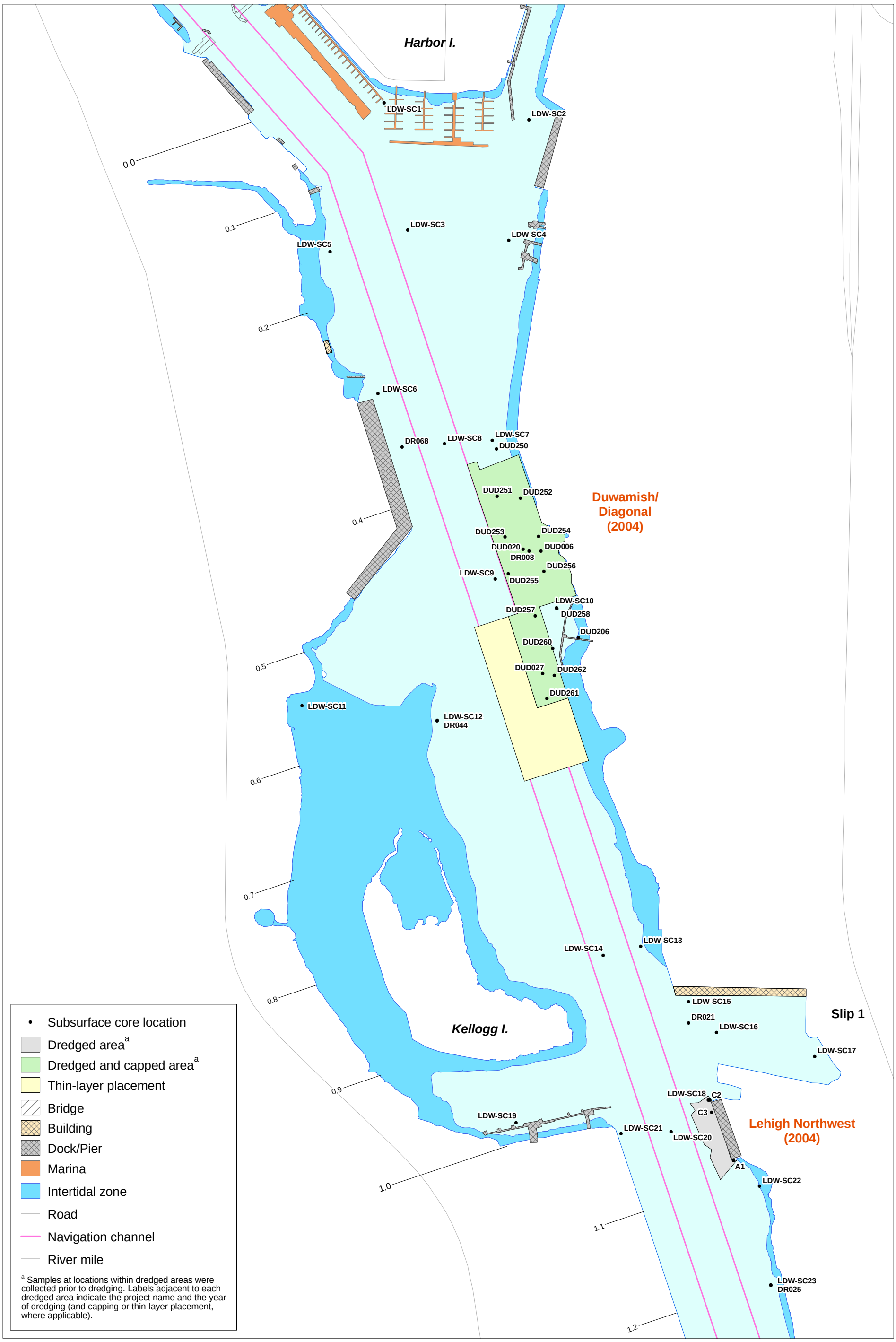
0 0.1 0.2 Kilometers

Scale is the same for each inset map

Map 4-6. Locations of subsurface sediment cores analyzed as part of LDW-wide events

Prepared by CEH, 07/13/2010; MAP 2749; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface

Dredging information provided by AECOM.

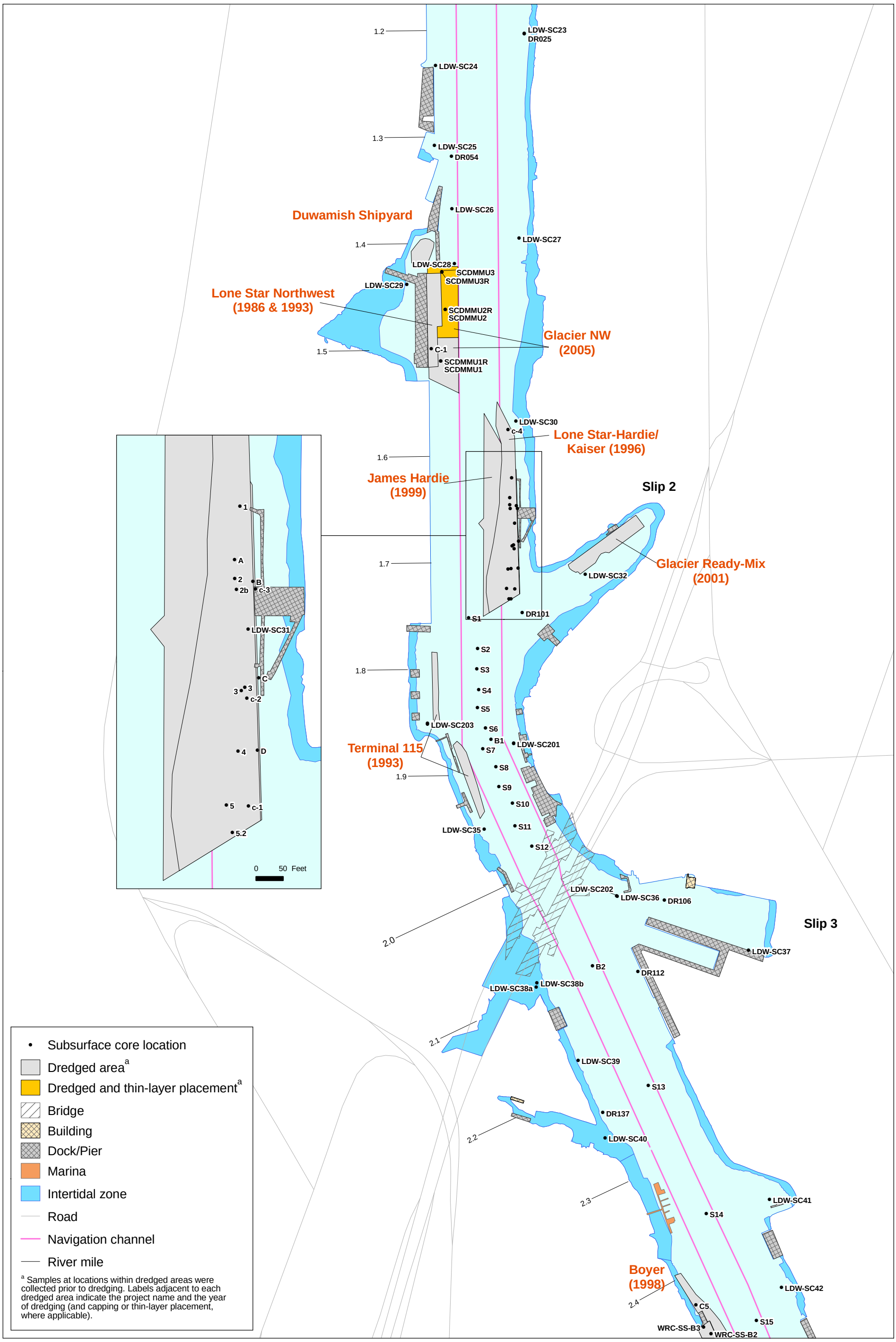


Wind Ward environmental LLC

Map 4-7a. Subsurface sediment core locations and dredging events, RM 0.0 to RM 1.2

Prepared by CEH 07/13/2010; MAP 2844; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Subsurface Locations

Dredging information provided by AECOM.

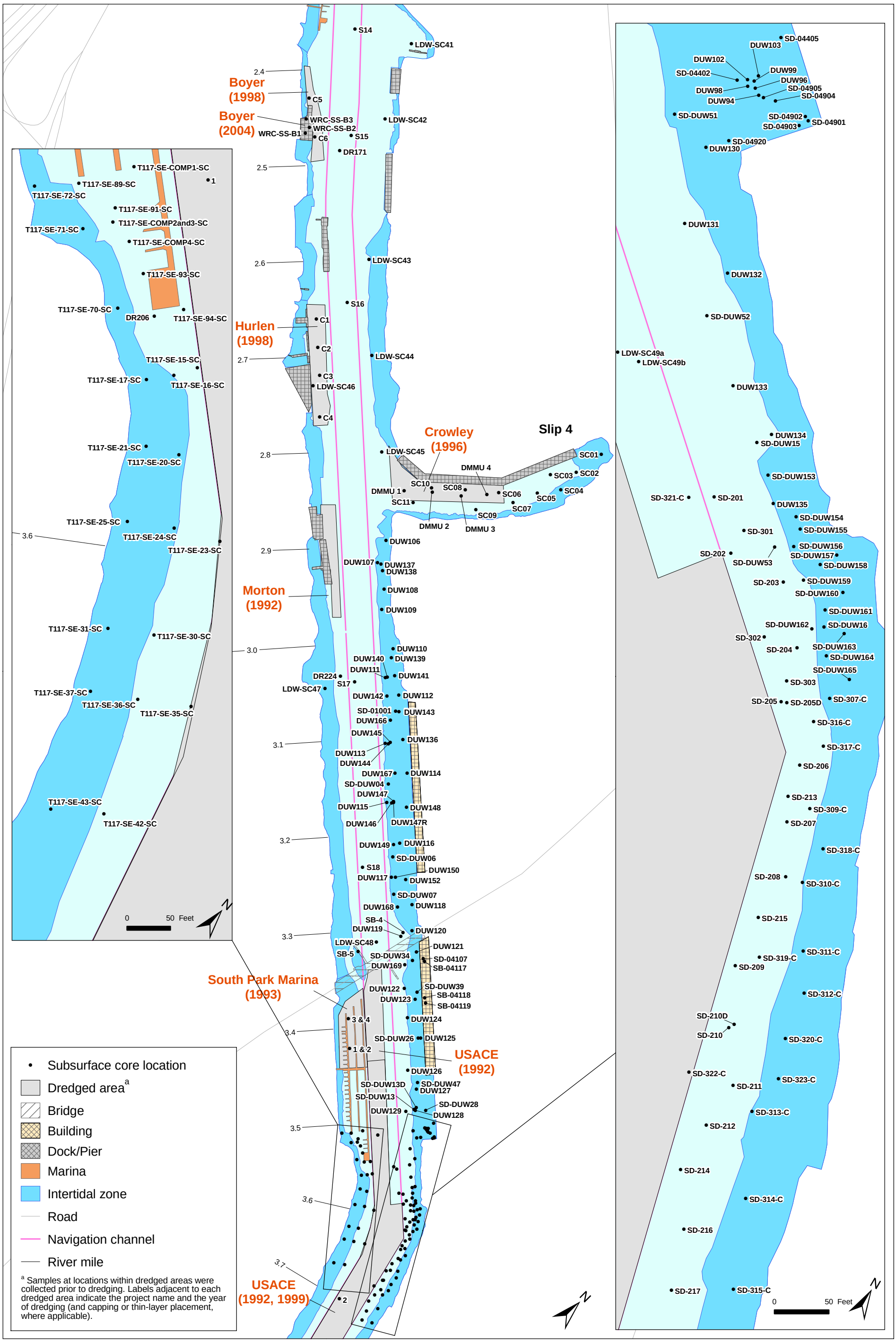


Wind Ward LLC environmental

Map 4-7b. Subsurface sediment core locations and dredging events, RM 1.2 to RM 2.4

Prepared by CEH, 07/13/2010, MAP 2844, W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Subsurface Locations

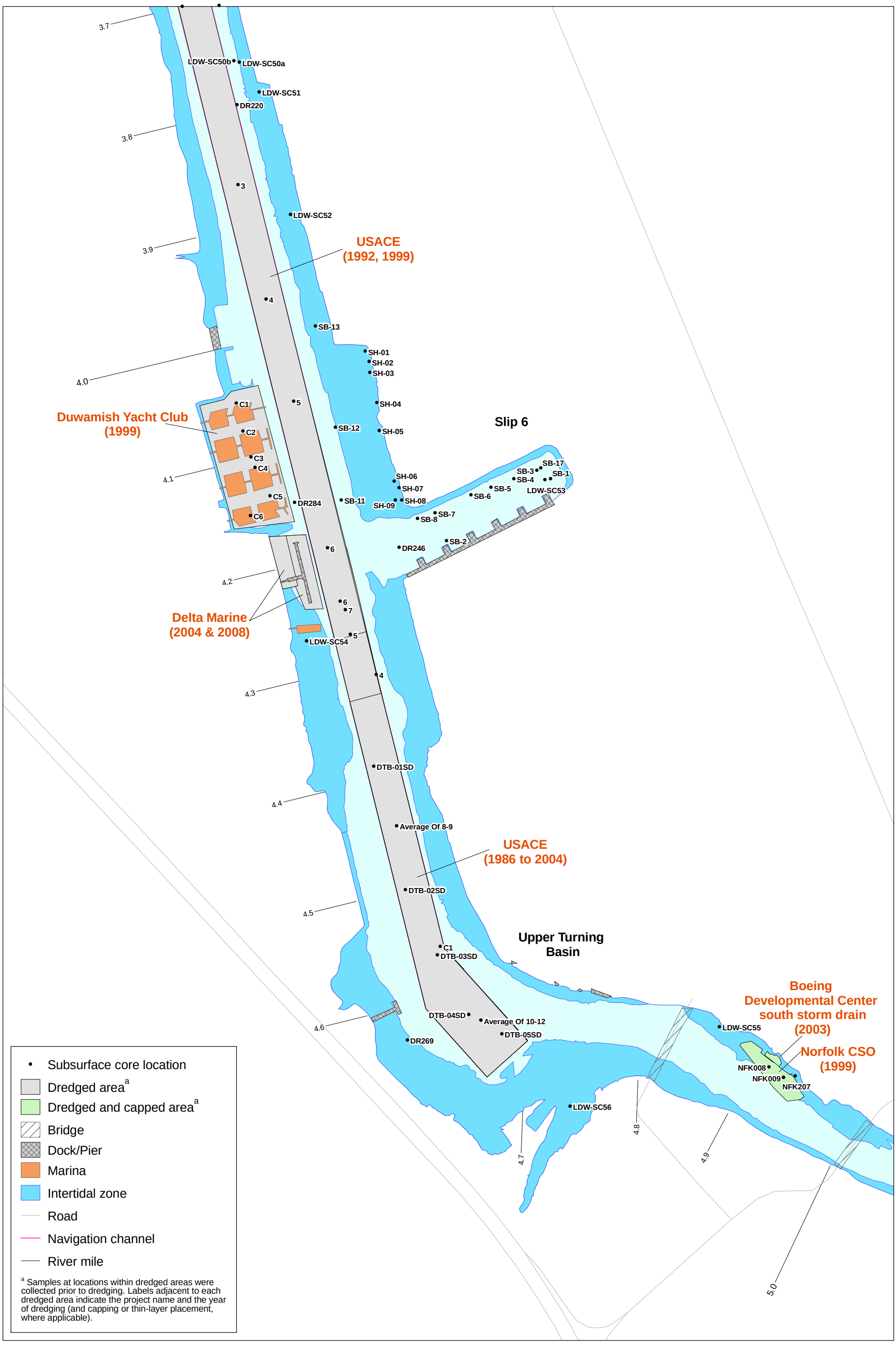
Dredging information provided by AECOM.



Map 4-7c. Subsurface sediment core locations and dredging events, RM 2.4 to RM 3.7

Prepared by CEH, 07/13/2010, MAP 2844, W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2_RI\Nature and Extent\Subsurface\Subsurface Locations

Dredging information provided by AECOM.



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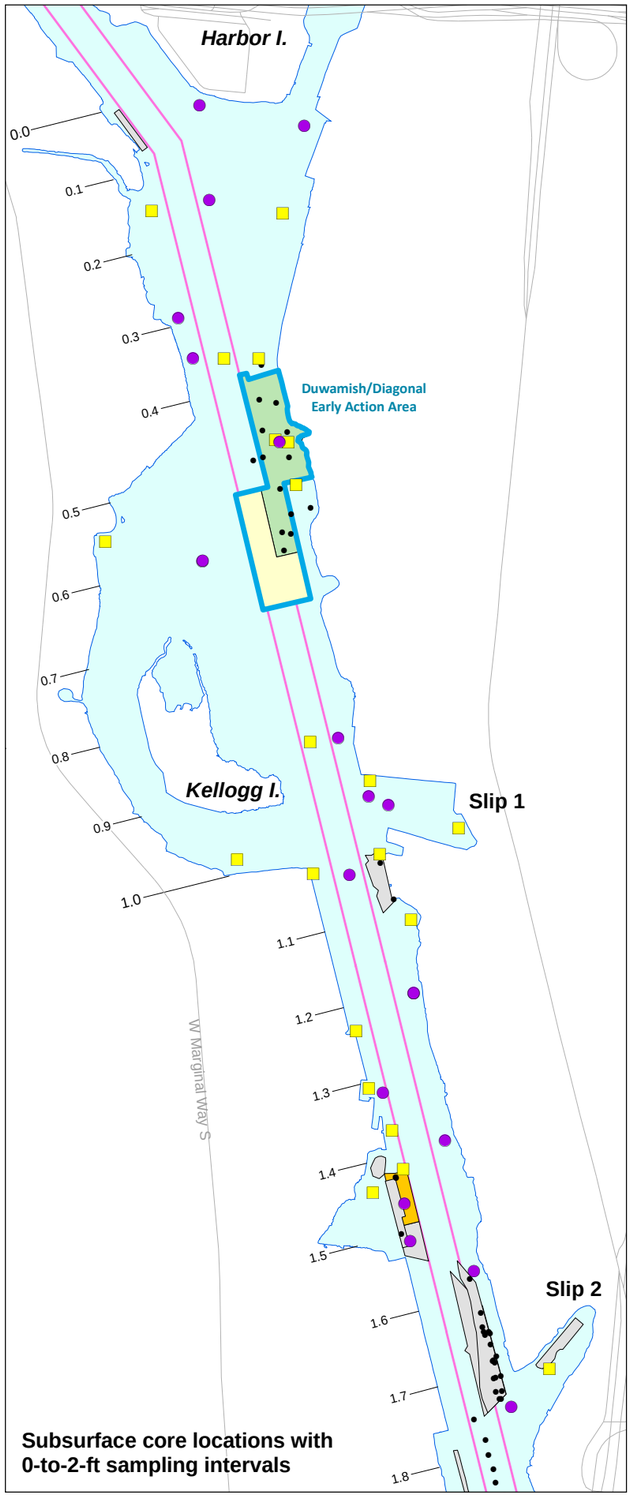
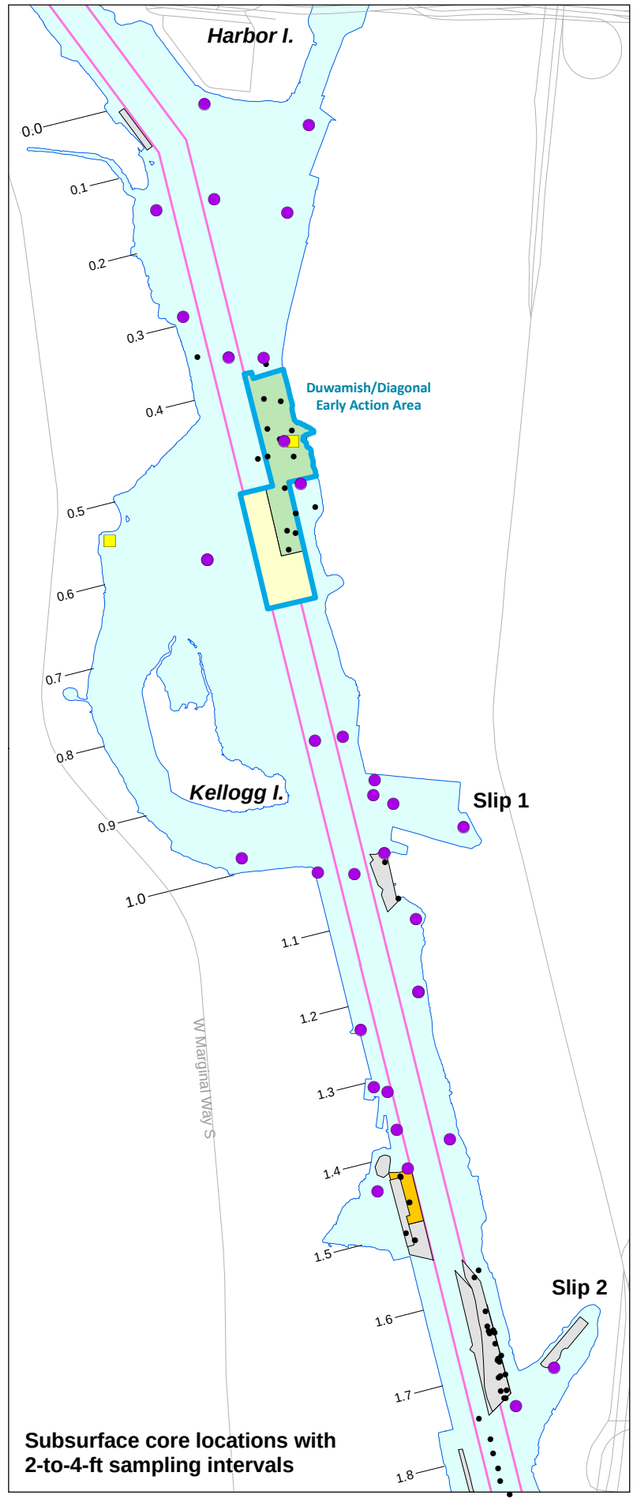
Map 4-7d. Subsurface sediment core locations and dredging events, RM 3.7 to RM 5.0

Prepared by CEH, 07/13/2010; Map 2844; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Subsurface Locations

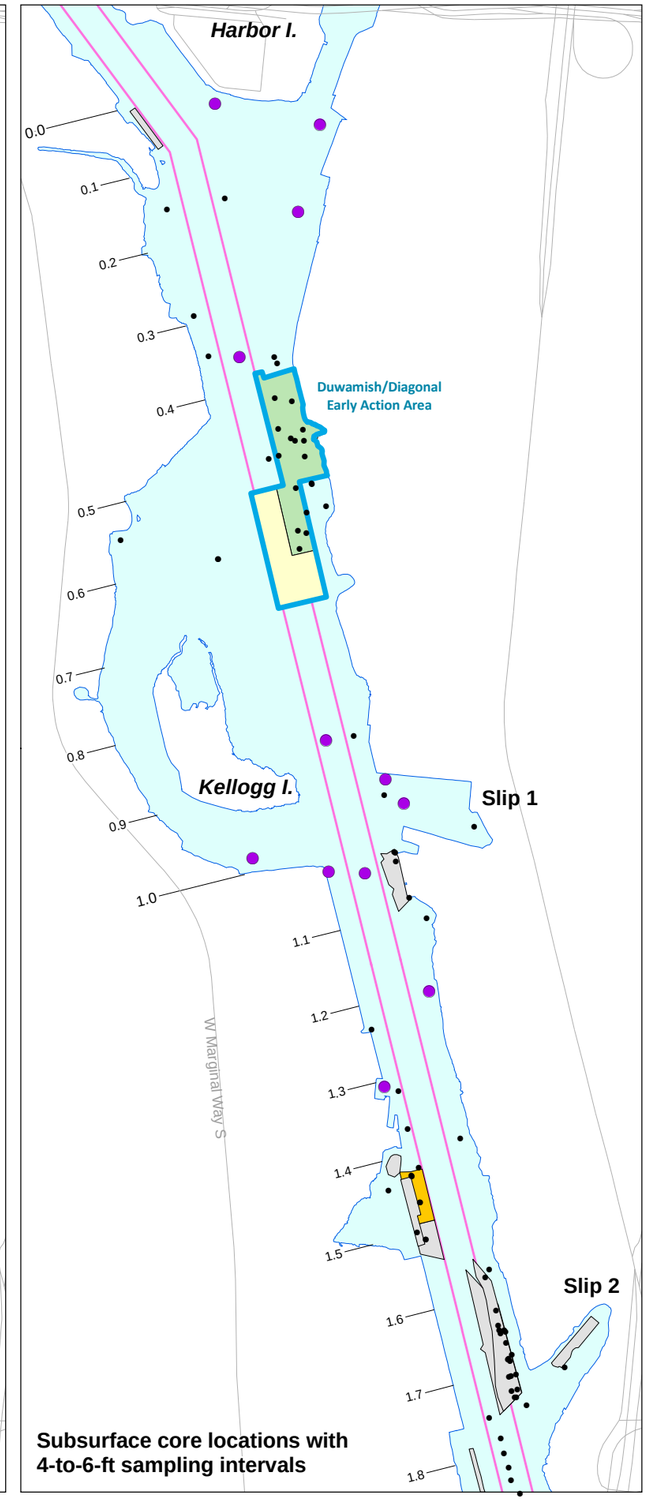
Dredging information provided by AECOM.



Subsurface core locations with 0-to-2-ft sampling intervals



Subsurface core locations with 2-to-4-ft sampling intervals



Subsurface core locations with 4-to-6-ft sampling intervals

- Subsurface core location with empirical data for specified core interval
- Subsurface core location with calculated data for specified core interval[a]
- Subsurface core location with no data for specified core interval
- Early Action Area[b]
- Dredged area[c]
- Dredged and capped area[c]
- Dredged and thin-layer placement[c]
- Thin-layer placement
- Road
- Navigation channel
- River mile

[a] If data were available for 1-foot intervals, concentrations were averaged for an estimated concentration in each 2-foot interval. The 0-to-2-foot interval was calculated from the 0-to-1-foot and 1-to-2-foot intervals, the 2-to-4-foot interval was calculated from the 2-to-3-foot and 3-to-4-foot intervals, and the 4-to-6-foot interval was calculated from the 4-to-5-foot and 5-to-6-foot intervals.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] Subsurface sediment data at locations in dredged areas were collected prior to dredging.

N

0 0.1 0.2 Kilometers

0 0.1 0.2 Miles

Scale is the same for each map frame

Map 4-8a. Locations with subsurface sediment data within the 0-to-2-ft, 2-to-4-ft, and 4-to-6-ft sampling intervals, RM 0.0 to RM 1.8

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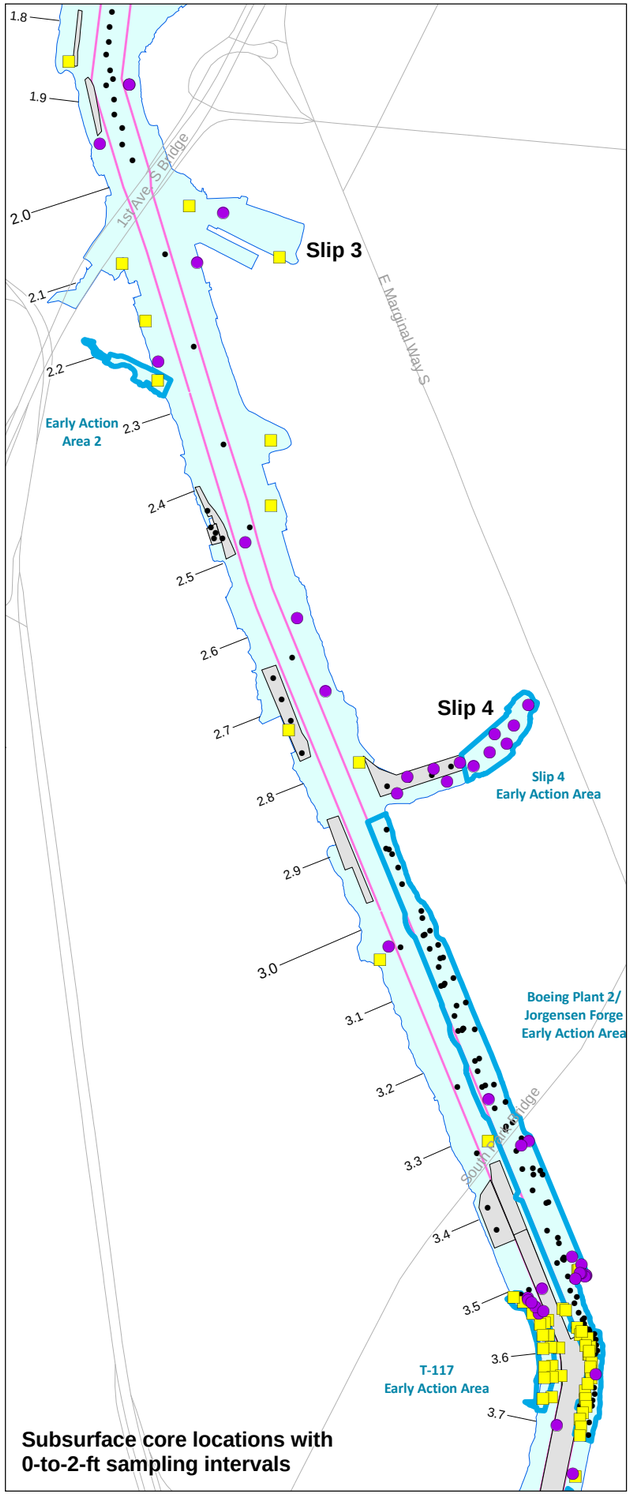
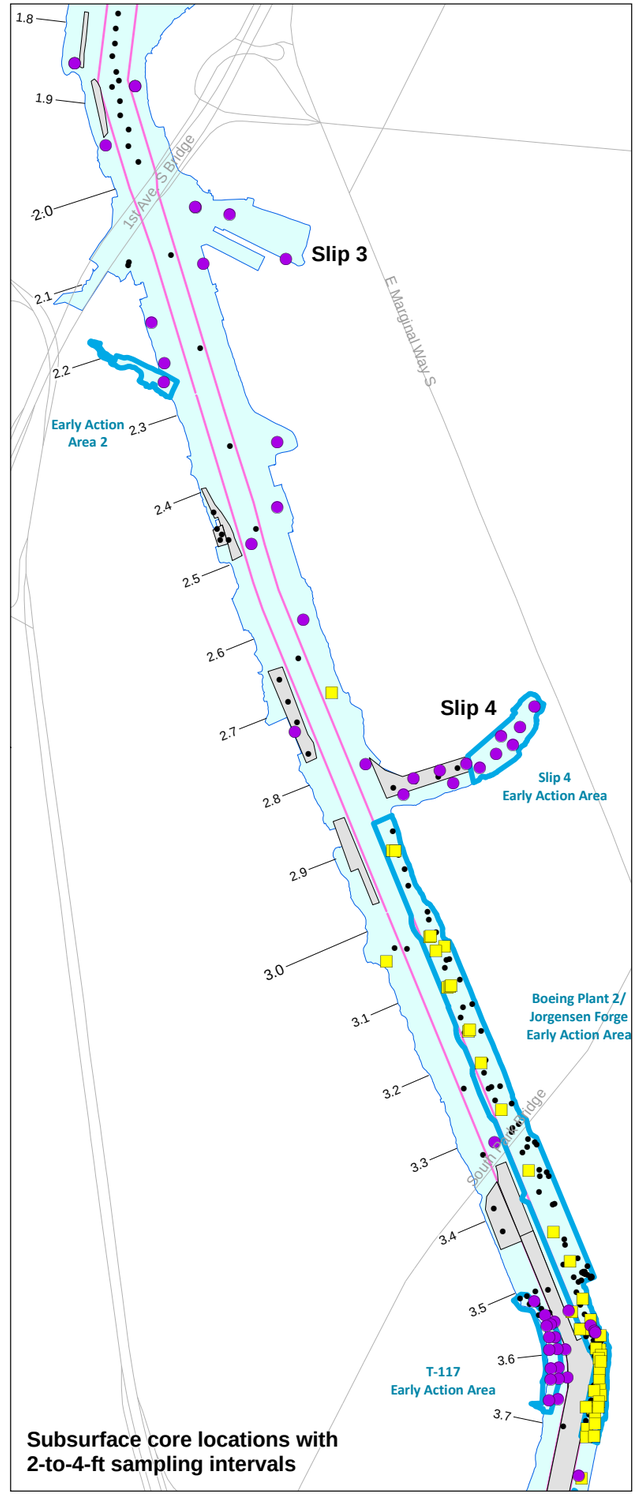
Prepared by CEH, 07/13/2010, MAP 2688; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Depth Interval\

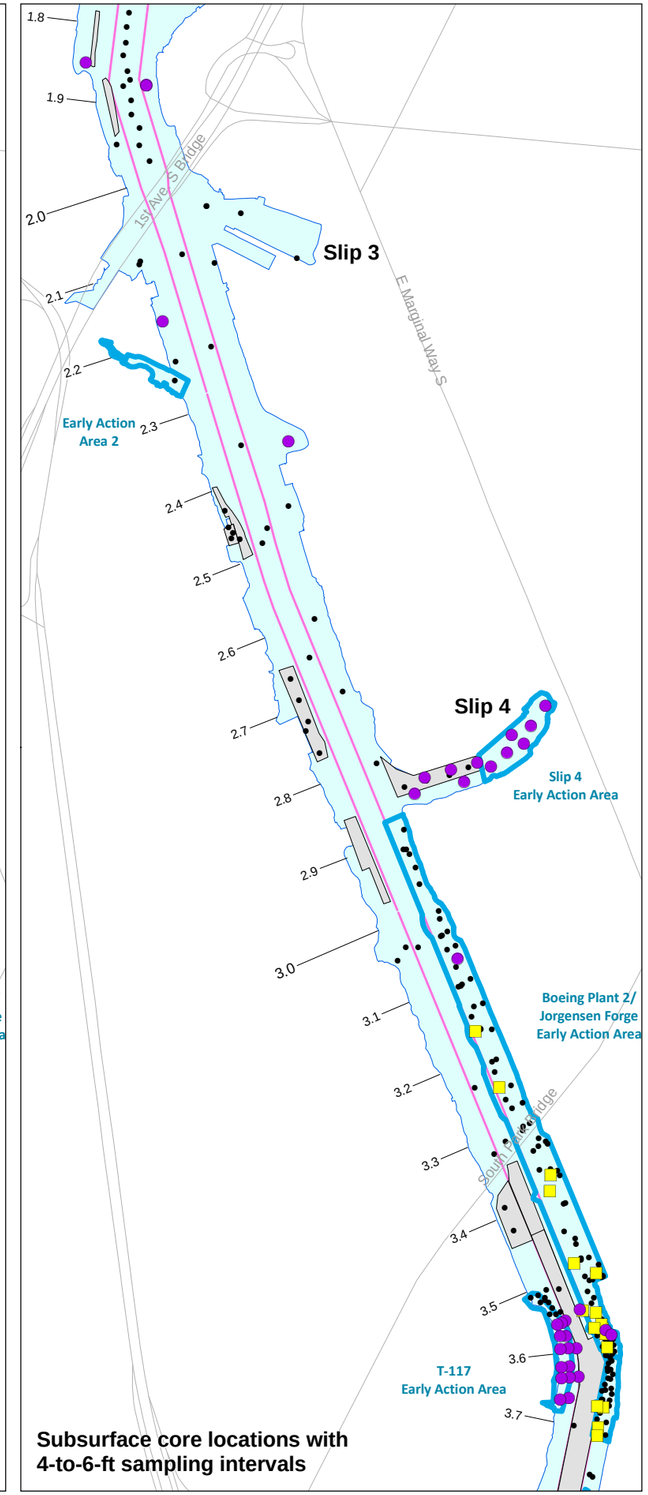
Dredging information provided by AECOM.



Subsurface core locations with 0-to-2-ft sampling intervals



Subsurface core locations with 2-to-4-ft sampling intervals



Subsurface core locations with 4-to-6-ft sampling intervals

- Subsurface core location with empirical data for specified core interval
- Subsurface core location with calculated data for specified core interval[a]
- Subsurface core location with no data for specified core interval
- Early Action Area[b]
- Dredged area[c]
- Road
- Navigation channel
- River mile

[a] If data were available for 1-foot intervals, concentrations were averaged for an estimated concentration in each 2-foot interval. The 0-to-2-foot interval was calculated from the 0-to-1-foot and 1-to-2-foot intervals, the 2-to-4-foot interval was calculated from the 2-to-3-foot and 3-to-4-foot intervals, and the 4-to-6-foot interval was calculated from the 4-to-5-foot and 5-to-6-foot intervals.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] Subsurface sediment data at locations in dredged areas were collected prior to dredging.

0 0.1 0.2 Kilometers

0 0.1 0.2 Miles

Scale is the same for each map frame

Map 4-8b. Locations with subsurface sediment data within the 0-to-2-ft, 2-to-4-ft, and 4-to-6-ft sampling intervals, RM 1.8 to RM 3.7

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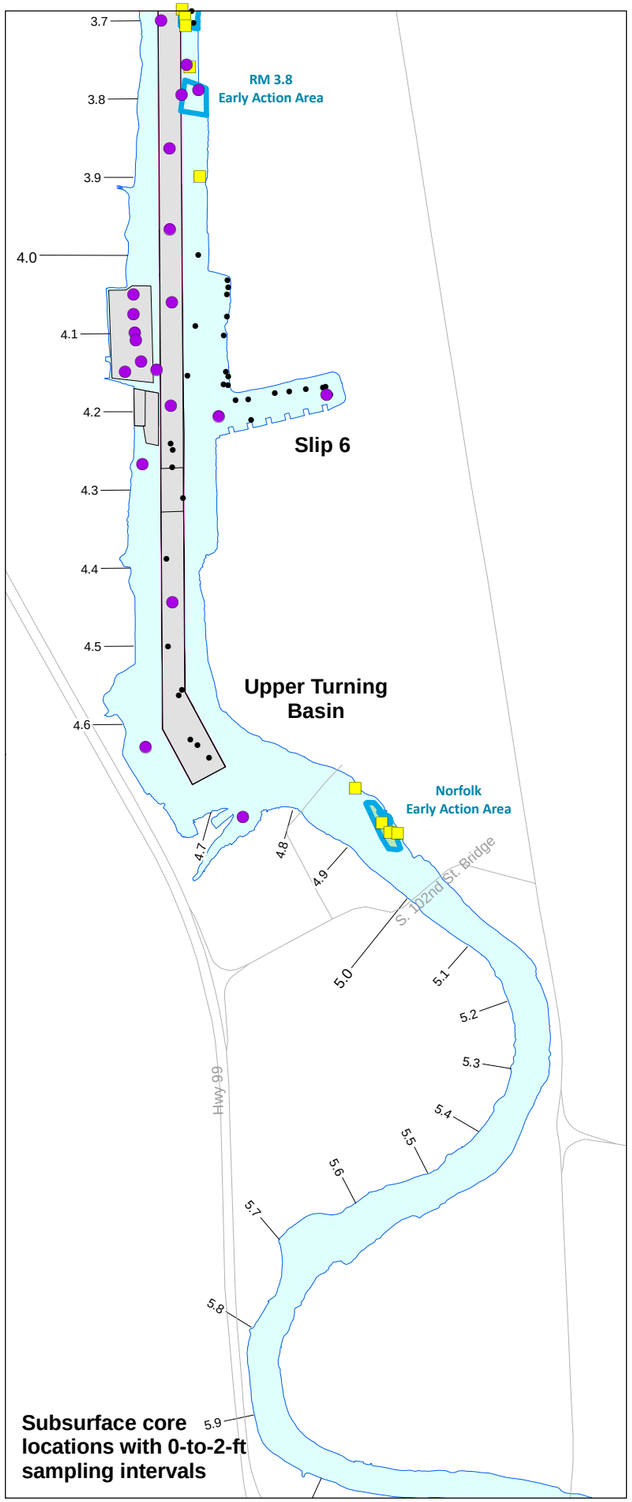
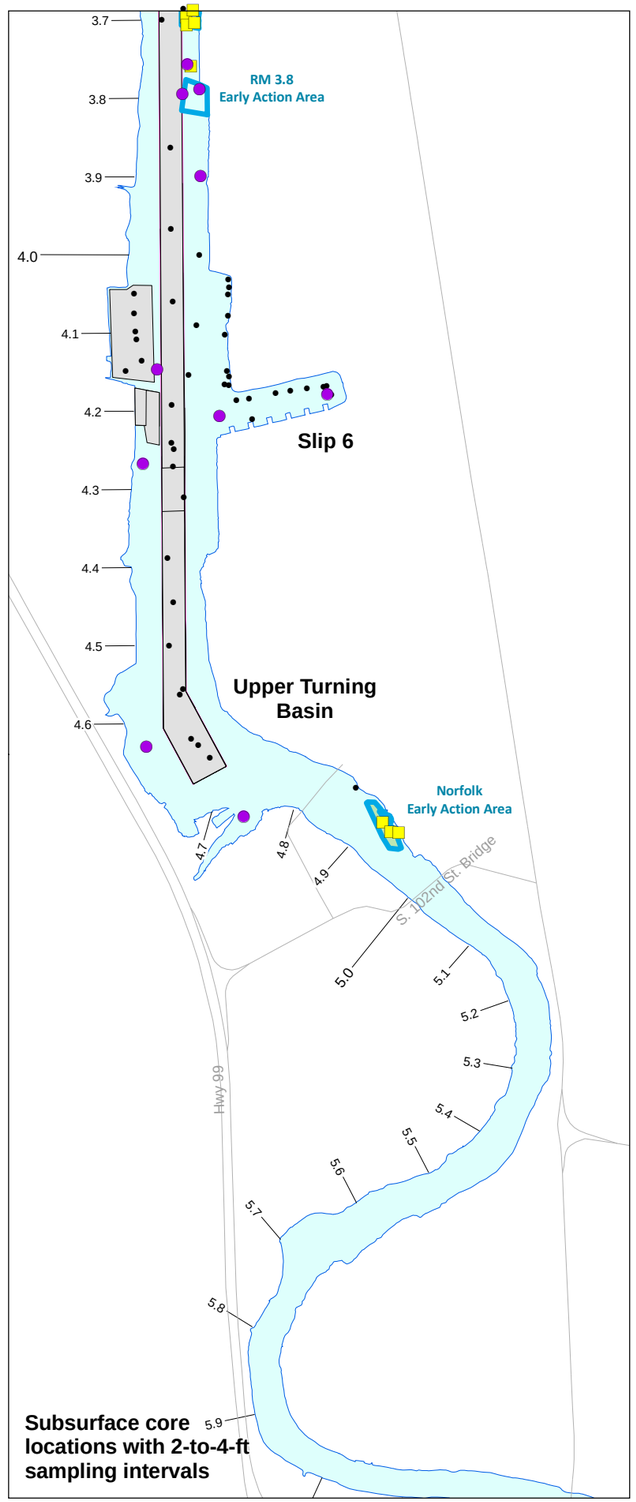
Prepared by CEH, 07/13/2010, MAP 2683, W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Depth Interval

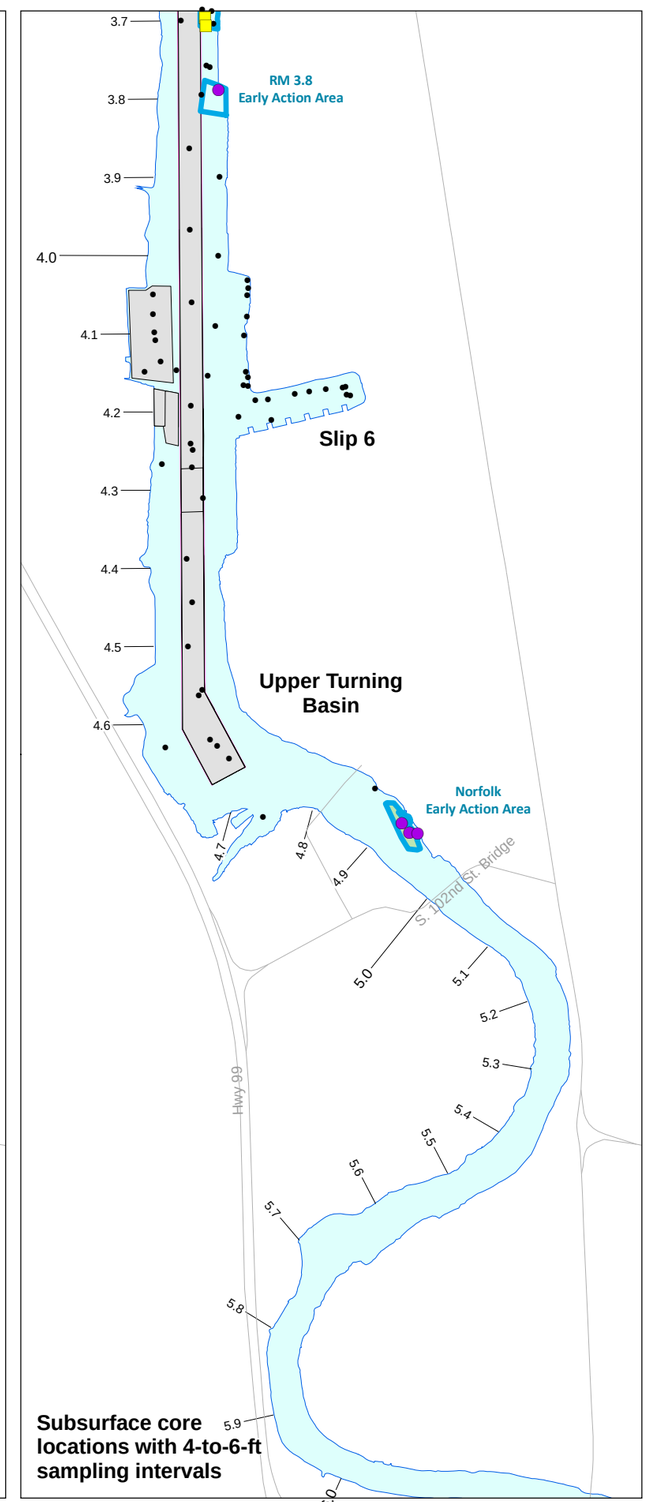
Dredging information provided by AECOM.



Subsurface core locations with 0-to-2-ft sampling intervals



Subsurface core locations with 2-to-4-ft sampling intervals



Subsurface core locations with 4-to-6-ft sampling intervals

- Subsurface core location with empirical data for specified core interval
- Subsurface core location with calculated data for specified core interval[a]
- Subsurface core location with no data for specified core interval
- Early Action Area[b]
- Dredged area[c]
- Dredged and capped area[c]
- Road
- Navigation channel
- River mile

[a] If data were available for 1-foot intervals, concentrations were averaged for an estimated concentration in each 2-foot interval. The 0-to-2-foot interval was calculated from the 0-to-1-foot and 1-to-2-foot intervals, the 2-to-4-foot interval was calculated from the 2-to-3-foot and 3-to-4-foot intervals, and the 4-to-6-foot interval was calculated from the 4-to-5-foot and 5-to-6-foot intervals.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] Subsurface sediment data at locations in dredged areas were collected prior to dredging.

N

0 0.1 0.2 Kilometers

0 0.1 0.2 Miles

Scale is the same for each map frame

Map 4-8c. Locations with subsurface sediment data within the 0-to-2-ft, 2-to-4-ft, and 4-to-6-ft sampling intervals, RM 3.7 to RM 6.0

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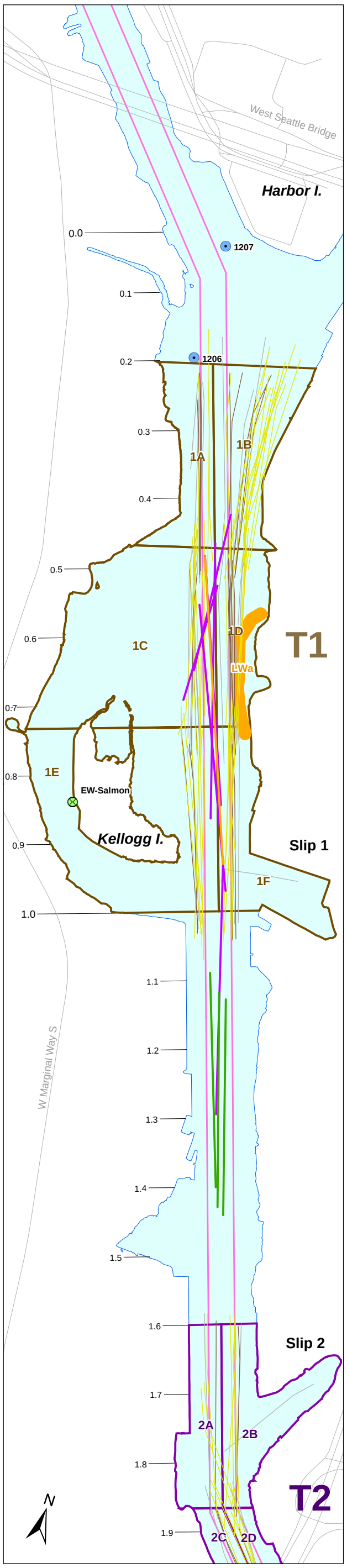
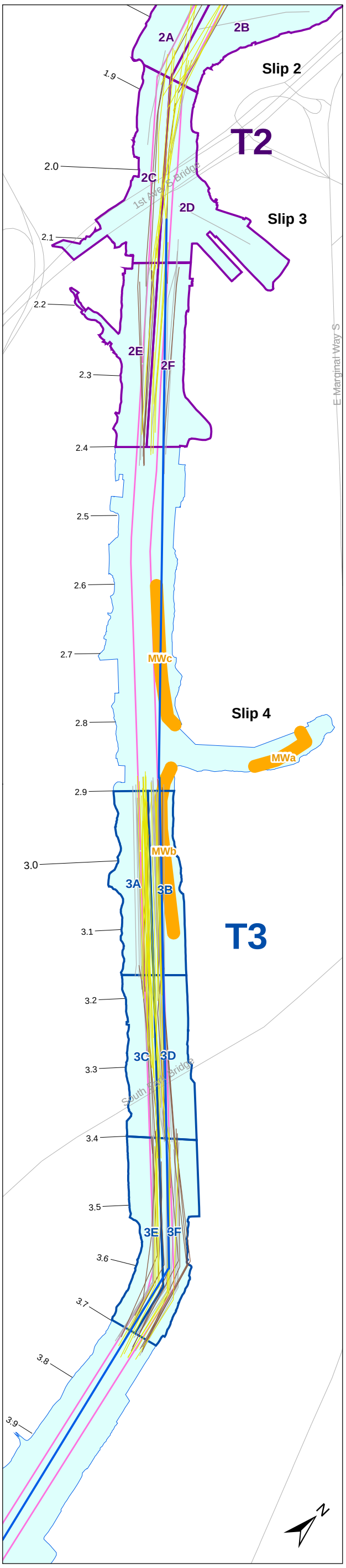
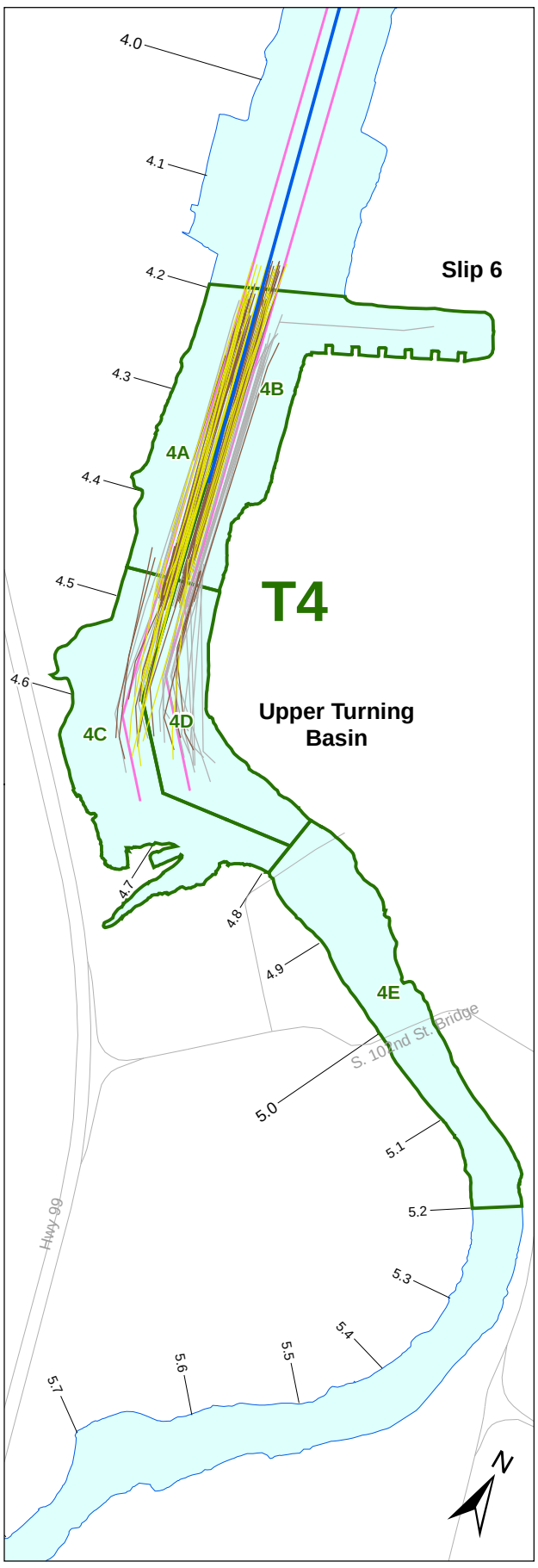
Prepared by CEH, 07/13/2010, MAP 2683, W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Depth Interval

Dredging information provided by AECOM.







Tissue sample locations by sampling event

LDWG trawl lines for starry flounder, perch, Pacific staghorn sculpin[a], and English sole

- 2007
- 2005
- 2004
- Juvenile chinook salmon beach seine location (2003)

LDW RI tissue sampling areas (2004-2005)

- T1
- T2
- T3
- T4

East Waterway; Windward (2002)

- Juvenile chinook salmon beach seine location (2002)

Waterway Sediment Operable Unit; ESG (1999)

- Striped perch hand-collected (SCUBA) location (1998)
- English sole trawl line (1998)

King County Water Quality Assessment; King County (1999b)

- English sole and shiner perch trawl line (1996-1998)

EVS95

- English sole trawl line (1995)

Puget Sound Ambient Monitoring Program; West et al. (2001)

- English sole trawl line (1992, 1995)
- Road
- Navigation channel
- River mile

[a] Pacific staghorn sculpin were also collected in a subset of shrimp traps shown on Map 4-10.

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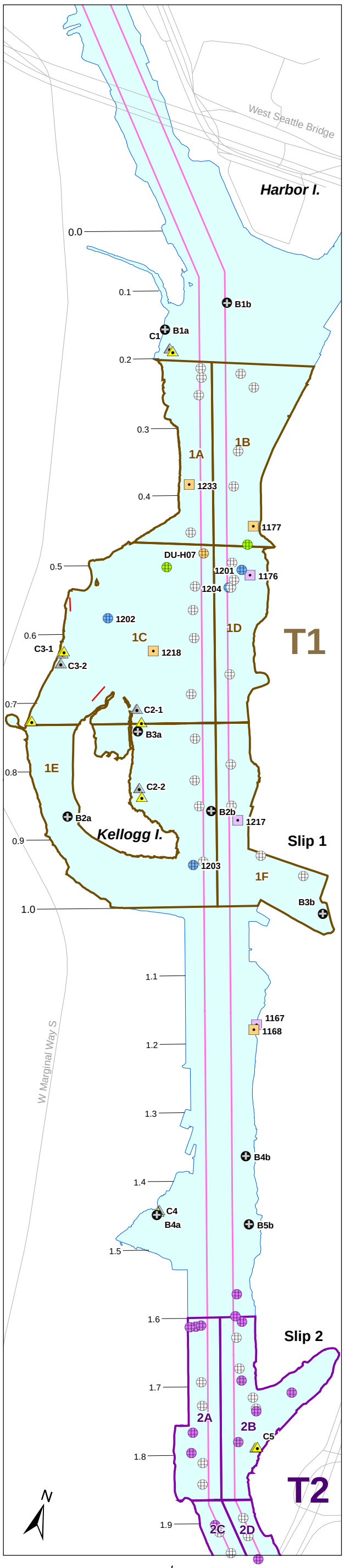
0 0.1 0.2 Miles

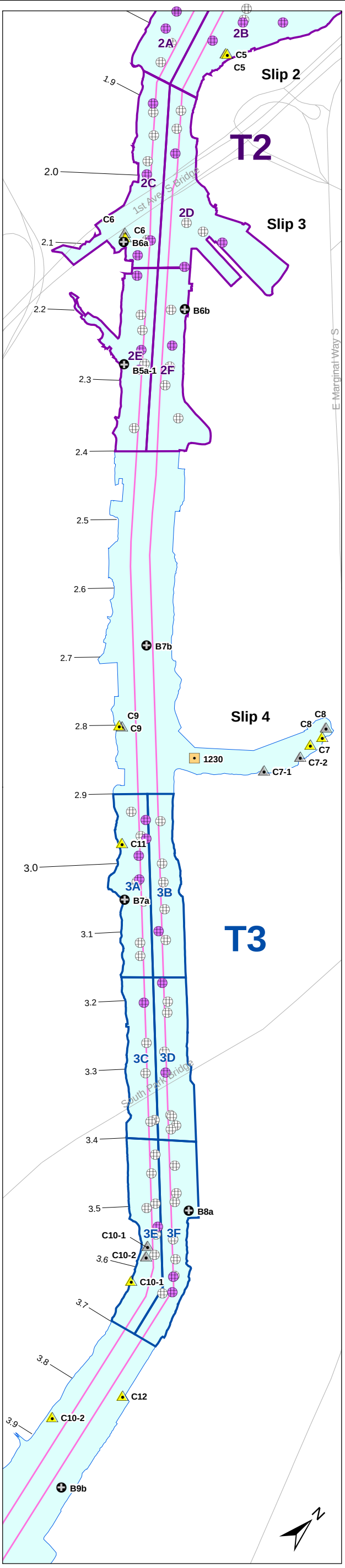
0 0.1 0.2 Kilometers

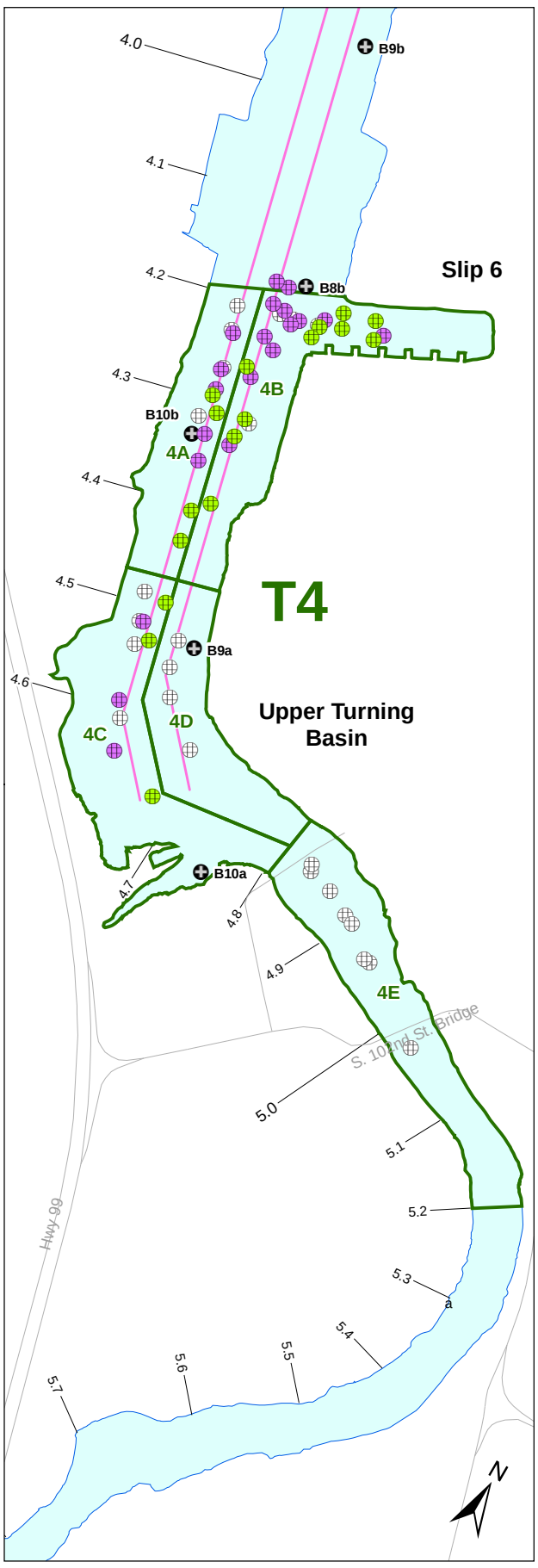
Scale is the same for each inset map

Map 4-9. Fish tissue sampling locations

Prepared by CEH, 07/13/2010, MAP 2665; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Tissue







Tissue sample locations by sampling event

LDW RI

- Dungeness and slender crabs[a] (2007)
- Dungeness and slender crabs[a] (2005)
- Dungeness and slender crabs[a] (2004)
- Benthic invertebrates (2004)
- Clams (2007)
- Clams (2004)

LDW RI tissue sampling areas (2004, 2005, 2007)

- T1
- T2
- T3
- T4

Waterway Sediment Operable Unit; ESG (1998)

- Dungeness and red rock crabs (1998)

King County Water Quality Assessment; King County (1999b)

- Dungeness crabs (1997)
- Amphipods (1997-1998)
- Wild mussels (1996-1997)
- Transplanted mussels (1996-1997)
- Road
- Navigation channel
- River mile

[a] Each location represents an individual crab trap or a pair of crab and shrimp traps. Crabs were also captured in a subset of LDW RI trawls shown on Map 4-9. At some locations, crabs were captured but were not used in the compositing for chemical analysis. In addition, crabs were not captured at all crab trap locations.

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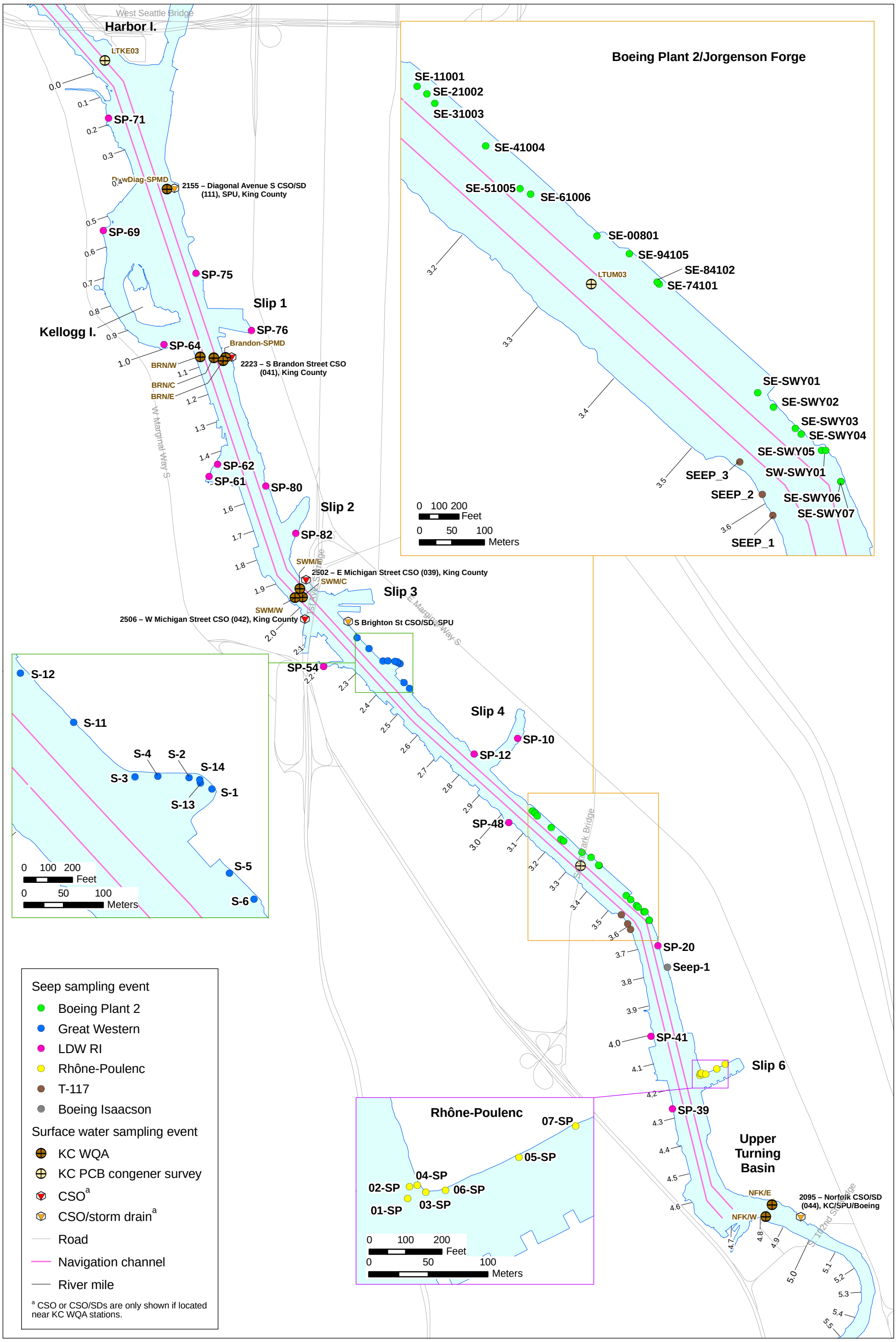
0 0.1 0.2 Miles

0 0.1 0.2 Kilometers

Scale is the same for each inset map

Map 4-10. Benthic invertebrate and shellfish tissue sampling locations

Prepared by CEH, 07/13/2010; MAP 2848; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Tissue



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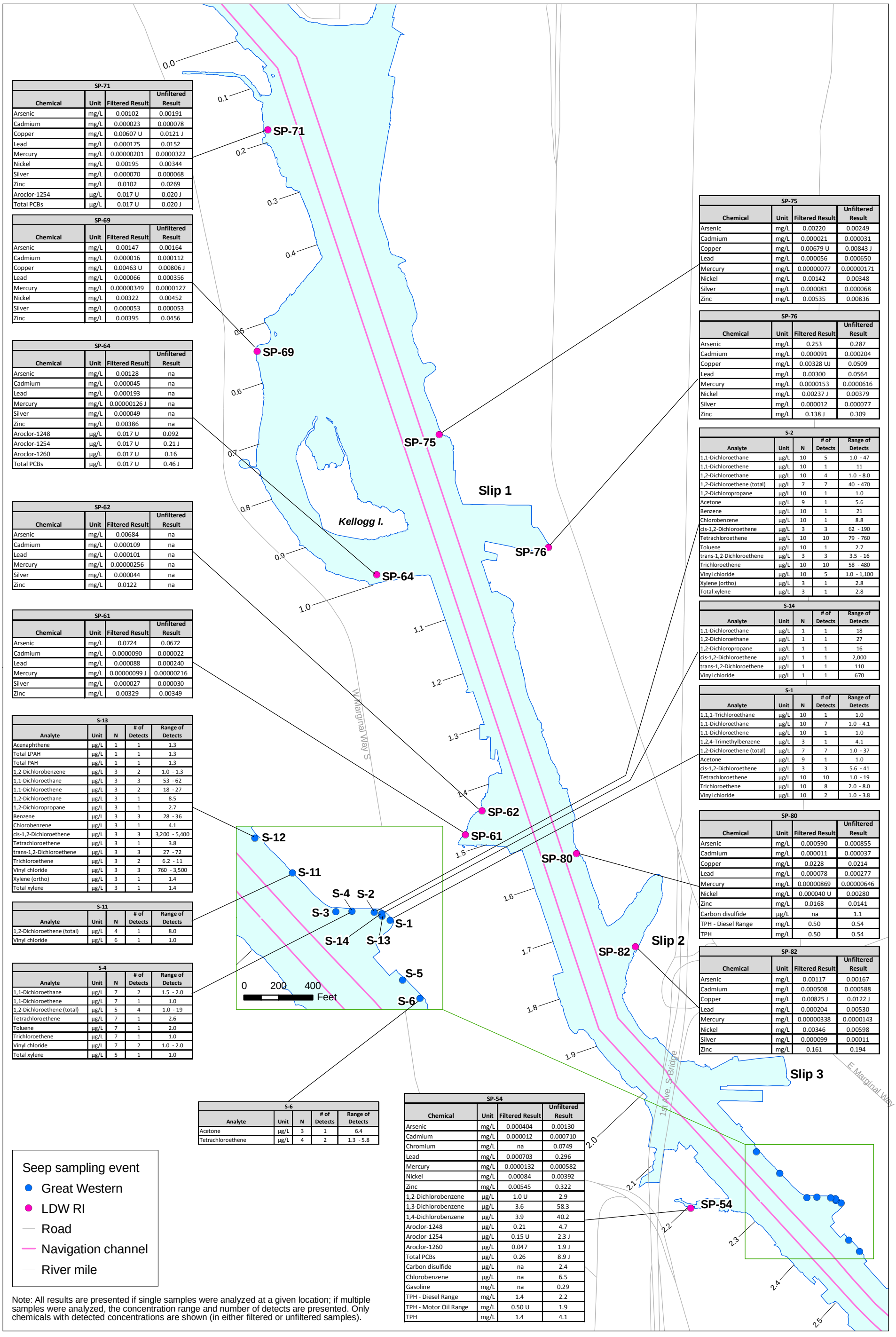
Map 4-11a. Seep water and surface water sampling locations

Prepared by CEH, 07/13/2010, Map 2809, W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Nature and Extent\Seeps and porewater



SP-71			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	0.00102	0.00191
Cadmium	mg/L	0.000023	0.000078
Copper	mg/L	0.00607 U	0.0121 J
Lead	mg/L	0.000175	0.0152
Mercury	mg/L	0.00000201	0.0000322
Nickel	mg/L	0.00195	0.00344
Silver	mg/L	0.000070	0.000068
Zinc	mg/L	0.0102	0.0269
Aroclor-1254	µg/L	0.017 U	0.020 J
Total PCBs	µg/L	0.017 U	0.020 J

SP-69			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	0.00147	0.00164
Cadmium	mg/L	0.000016	0.000112
Copper	mg/L	0.00463 U	0.00806 J
Lead	mg/L	0.000066	0.000356
Mercury	mg/L	0.00000349	0.0000127
Nickel	mg/L	0.00322	0.00452
Silver	mg/L	0.000053	0.000053
Zinc	mg/L	0.00395	0.0456

SP-64			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	0.00128	na
Cadmium	mg/L	0.000045	na
Lead	mg/L	0.000193	na
Mercury	mg/L	0.00000126 J	na
Silver	mg/L	0.000049	na
Zinc	mg/L	0.00386	na
Aroclor-1248	µg/L	0.017 U	0.092
Aroclor-1254	µg/L	0.017 U	0.21 J
Aroclor-1260	µg/L	0.017 U	0.16
Total PCBs	µg/L	0.017 U	0.46 J

SP-62			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	0.00684	na
Cadmium	mg/L	0.000109	na
Lead	mg/L	0.000101	na
Mercury	mg/L	0.00000256	na
Silver	mg/L	0.000044	na
Zinc	mg/L	0.0122	na

SP-61			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	0.0724	0.0672
Cadmium	mg/L	0.0000090	0.000022
Lead	mg/L	0.000088	0.000240
Mercury	mg/L	0.00000099 J	0.00000216
Silver	mg/L	0.000027	0.000030
Zinc	mg/L	0.00329	0.00349

S-13				
Analyte	Unit	N	# of Detects	Range of Detects
Acenaphthene	µg/L	1	1	1.3
Total LPAH	µg/L	1	1	1.3
Total PAH	µg/L	1	1	1.3
1,2-Dichlorobenzene	µg/L	3	2	1.0 - 1.3
1,1-Dichloroethane	µg/L	3	3	53 - 62
1,1-Dichloroethene	µg/L	3	2	18 - 27
1,2-Dichloroethane	µg/L	3	1	8.5
1,2-Dichloropropane	µg/L	3	1	2.7
Benzene	µg/L	3	3	28 - 36
Chlorobenzene	µg/L	3	1	4.1
cis-1,2-Dichloroethene	µg/L	3	3	3,200 - 5,400
Tetrachloroethene	µg/L	3	1	3.8
trans-1,2-Dichloroethene	µg/L	3	3	27 - 72
Trichloroethene	µg/L	3	2	6.2 - 11
Vinyl chloride	µg/L	3	3	760 - 3,500
Xylene (ortho)	µg/L	3	1	1.4
Total xylene	µg/L	3	1	1.4

S-11				
Analyte	Unit	N	# of Detects	Range of Detects
1,2-Dichloroethene (total)	µg/L	4	1	8.0
Vinyl chloride	µg/L	6	1	1.0

S-4				
Analyte	Unit	N	# of Detects	Range of Detects
1,1-Dichloroethane	µg/L	7	2	1.5 - 2.0
1,1-Dichloroethene	µg/L	7	1	1.0
1,2-Dichloroethene (total)	µg/L	5	4	1.0 - 19
Tetrachloroethene	µg/L	7	1	2.6
Toluene	µg/L	7	1	2.0
Trichloroethene	µg/L	7	1	1.0
Vinyl chloride	µg/L	7	2	1.0 - 2.0
Total xylene	µg/L	5	1	1.0

S-6				
Analyte	Unit	N	# of Detects	Range of Detects
Acetone	µg/L	3	1	6.4
Tetrachloroethene	µg/L	4	2	1.3 - 5.8

SP-54			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	0.000404	0.00130
Cadmium	mg/L	0.000012	0.000710
Chromium	mg/L	na	0.0749
Lead	mg/L	0.000703	0.296
Mercury	mg/L	0.0000132	0.000582
Nickel	mg/L	0.00084	0.00392
Zinc	mg/L	0.00545	0.322
1,2-Dichlorobenzene	µg/L	1.0 U	2.9
1,3-Dichlorobenzene	µg/L	3.6	58.3
1,4-Dichlorobenzene	µg/L	3.9	40.2
Aroclor-1248	µg/L	0.21	4.7
Aroclor-1254	µg/L	0.15 U	2.3 J
Aroclor-1260	µg/L	0.047	1.9 J
Total PCBs	µg/L	0.26	8.9 J
Carbon disulfide	µg/L	na	2.4
Chlorobenzene	µg/L	na	6.5
Gasoline	mg/L	na	0.29
TPH - Diesel Range	mg/L	1.4	2.2
TPH - Motor Oil Range	mg/L	0.50 U	1.9
TPH	mg/L	1.4	4.1

SP-75			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	0.00220	0.00249
Cadmium	mg/L	0.000021	0.000031
Copper	mg/L	0.00679 U	0.00843 J
Lead	mg/L	0.000056	0.000650
Mercury	mg/L	0.00000077	0.00000171
Nickel	mg/L	0.00142	0.00348
Silver	mg/L	0.000081	0.000068
Zinc	mg/L	0.00535	0.00836

SP-76			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	0.253	0.287
Cadmium	mg/L	0.000091	0.000204
Copper	mg/L	0.00328 UJ	0.0509
Lead	mg/L	0.00300	0.0564
Mercury	mg/L	0.0000153	0.0000616
Nickel	mg/L	0.00237 J	0.00379
Silver	mg/L	0.000012	0.000077
Zinc	mg/L	0.138 J	0.309

S-2				
Analyte	Unit	N	# of Detects	Range of Detects
1,1-Dichloroethane	µg/L	10	5	1.0 - 47
1,1-Dichloroethene	µg/L	10	1	11
1,2-Dichloroethane	µg/L	10	4	1.0 - 8.0
1,2-Dichloroethene (total)	µg/L	7	7	40 - 470
1,2-Dichloropropane	µg/L	10	1	1.0
Acetone	µg/L	9	1	5.6
Benzene	µg/L	10	1	21
Chlorobenzene	µg/L	10	1	8.8
cis-1,2-Dichloroethene	µg/L	3	3	62 - 190
Tetrachloroethene	µg/L	10	10	79 - 760
Toluene	µg/L	10	1	2.7
trans-1,2-Dichloroethene	µg/L	3	3	3.5 - 16
Trichloroethene	µg/L	10	10	58 - 480
Vinyl chloride	µg/L	10	5	1.0 - 1,100
Xylene (ortho)	µg/L	3	1	2.8
Total xylene	µg/L	3	1	2.8

S-14				
Analyte	Unit	N	# of Detects	Range of Detects
1,1-Dichloroethane	µg/L	1	1	18
1,2-Dichloroethane	µg/L	1	1	27
1,2-Dichloropropane	µg/L	1	1	16
cis-1,2-Dichloroethene	µg/L	1	1	2,000
trans-1,2-Dichloroethene	µg/L	1	1	110
Vinyl chloride	µg/L	1	1	670

S-1				
Analyte	Unit	N	# of Detects	Range of Detects
1,1,1-Trichloroethane	µg/L	10	1	1.0
1,1-Dichloroethane	µg/L	10	7	1.0 - 4.1
1,1-Dichloroethene	µg/L	10	1	1.0
1,2,4-Trimethylbenzene	µg/L	3	1	4.1
1,2-Dichloroethene (total)	µg/L	7	7	1.0 - 37
Acetone	µg/L	9	1	1.0
cis-1,2-Dichloroethene	µg/L	3	3	5.6 - 41
Tetrachloroethene	µg/L	10	10	1.0 - 19
Trichloroethene	µg/L	10	8	2.0 - 8.0
Vinyl chloride	µg/L	10	2	1.0 - 3.8

SP-80			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	0.000590	0.000855
Cadmium	mg/L	0.000011	0.000037
Copper	mg/L	0.0228	0.0214
Lead	mg/L	0.000078	0.000277
Mercury	mg/L	0.00000869	0.00000646
Nickel	mg/L	0.000040 U	0.00280
Zinc	mg/L	0.0168	0.0141
Carbon disulfide	µg/L	na	1.1
TPH - Diesel Range	mg/L	0.50	0.54
TPH	mg/L	0.50	0.54

SP-82			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	0.00117	0.00167
Cadmium	mg/L	0.000508	0.000588
Copper	mg/L	0.00825 J	0.0122 J
Lead	mg/L	0.000204	0.00530
Mercury	mg/L	0.00000338	0.0000143
Nickel	mg/L	0.00346	0.00598
Silver	mg/L	0.000099	0.00011
Zinc	mg/L	0.161	0.194

Seep sampling event
- Great Western
- LDW RI
- Road
- Navigation channel
- River mile

Note: All results are presented if single samples were analyzed at a given location; if multiple samples were analyzed, the concentration range and number of detects are presented. Only chemicals with detected concentrations are shown (in either filtered or unfiltered samples).

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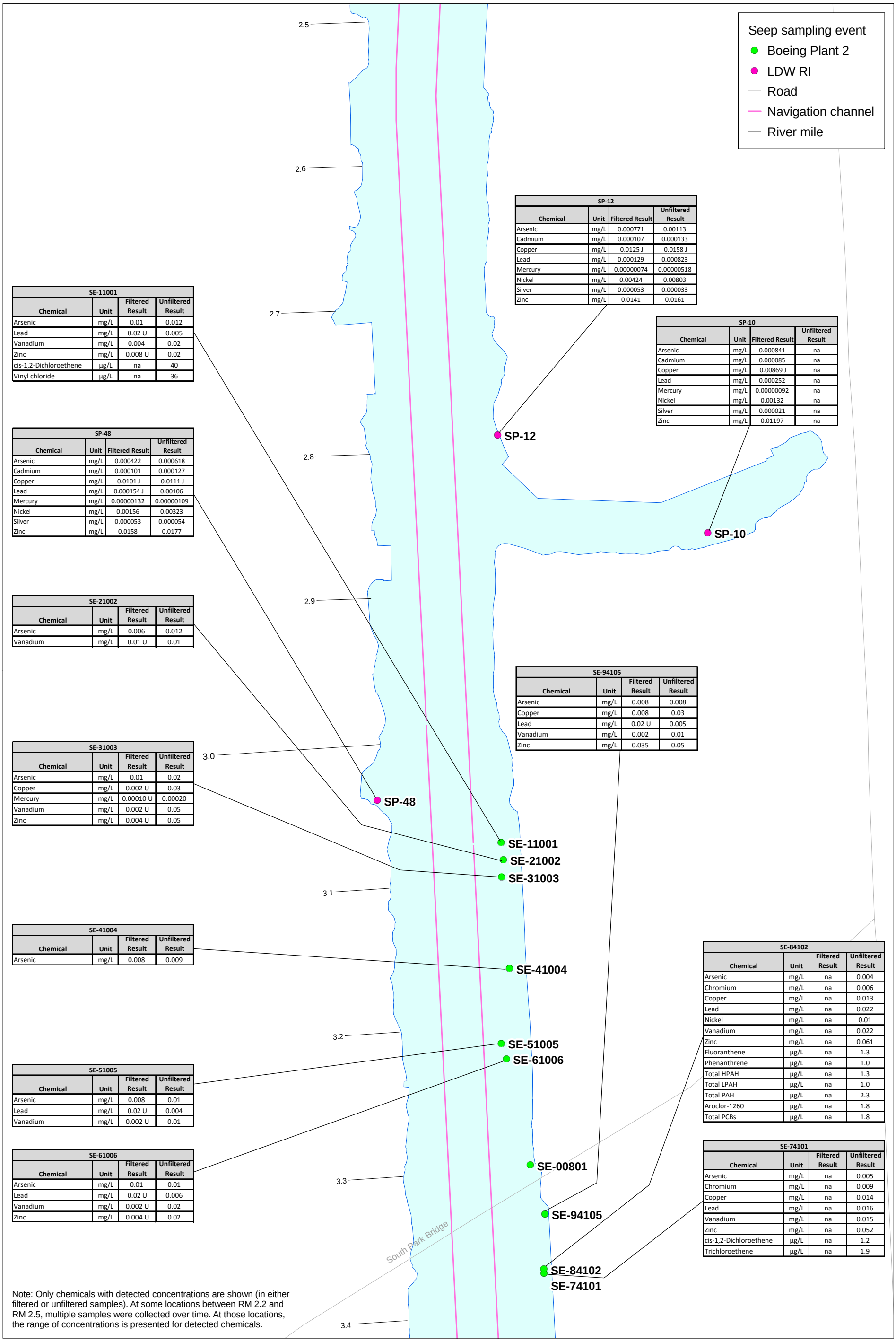
N

0 750 1,500 Feet

0 200 400 Meters

Map 4-11b. Seep water sampling data (only detected chemicals), RM 0.0 to RM 2.5

Prepared by CEH, 07/13/2010; MAP #3794; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase 2 RI\Nature and Extent\Seeps and porewater



SP-12			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	0.000771	0.00113
Cadmium	mg/L	0.000107	0.000133
Copper	mg/L	0.0125 J	0.0158 J
Lead	mg/L	0.000129	0.000823
Mercury	mg/L	0.00000074	0.00000518
Nickel	mg/L	0.00424	0.00803
Silver	mg/L	0.000053	0.000033
Zinc	mg/L	0.0141	0.0161

SP-10			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	0.000841	na
Cadmium	mg/L	0.000085	na
Copper	mg/L	0.00869 J	na
Lead	mg/L	0.000252	na
Mercury	mg/L	0.00000092	na
Nickel	mg/L	0.00132	na
Silver	mg/L	0.000021	na
Zinc	mg/L	0.01197	na

SE-11001			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	0.01	0.012
Lead	mg/L	0.02 U	0.005
Vanadium	mg/L	0.004	0.02
Zinc	mg/L	0.008 U	0.02
cis-1,2-Dichloroethene	µg/L	na	40
Vinyl chloride	µg/L	na	36

SP-48			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	0.000422	0.000618
Cadmium	mg/L	0.000101	0.000127
Copper	mg/L	0.0101 J	0.0111 J
Lead	mg/L	0.000154 J	0.00106
Mercury	mg/L	0.00000132	0.00000109
Nickel	mg/L	0.00156	0.00323
Silver	mg/L	0.000053	0.000054
Zinc	mg/L	0.0158	0.0177

SE-21002			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	0.006	0.012
Vanadium	mg/L	0.01 U	0.01

SE-94105			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	0.008	0.008
Copper	mg/L	0.008	0.03
Lead	mg/L	0.02 U	0.005
Vanadium	mg/L	0.002	0.01
Zinc	mg/L	0.035	0.05

SE-31003			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	0.01	0.02
Copper	mg/L	0.002 U	0.03
Mercury	mg/L	0.00010 U	0.00020
Vanadium	mg/L	0.002 U	0.05
Zinc	mg/L	0.004 U	0.05

SE-41004			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	0.008	0.009

SE-84102			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	na	0.004
Chromium	mg/L	na	0.006
Copper	mg/L	na	0.013
Lead	mg/L	na	0.022
Nickel	mg/L	na	0.01
Vanadium	mg/L	na	0.022
Zinc	mg/L	na	0.061
Fluoranthene	µg/L	na	1.3
Phenanthrene	µg/L	na	1.0
Total HPAH	µg/L	na	1.3
Total LPAH	µg/L	na	1.0
Total PAH	µg/L	na	2.3
Aroclor-1260	µg/L	na	1.8
Total PCBs	µg/L	na	1.8

SE-51005			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	0.008	0.01
Lead	mg/L	0.02 U	0.004
Vanadium	mg/L	0.002 U	0.01

SE-74101			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	na	0.005
Chromium	mg/L	na	0.009
Copper	mg/L	na	0.014
Lead	mg/L	na	0.016
Vanadium	mg/L	na	0.015
Zinc	mg/L	na	0.052
cis-1,2-Dichloroethene	µg/L	na	1.2
Trichloroethene	µg/L	na	1.9

SE-61006			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	0.01	0.01
Lead	mg/L	0.02 U	0.006
Vanadium	mg/L	0.002 U	0.02
Zinc	mg/L	0.004 U	0.02

Note: Only chemicals with detected concentrations are shown (in either filtered or unfiltered samples). At some locations between RM 2.2 and RM 2.5, multiple samples were collected over time. At those locations, the range of concentrations is presented for detected chemicals.

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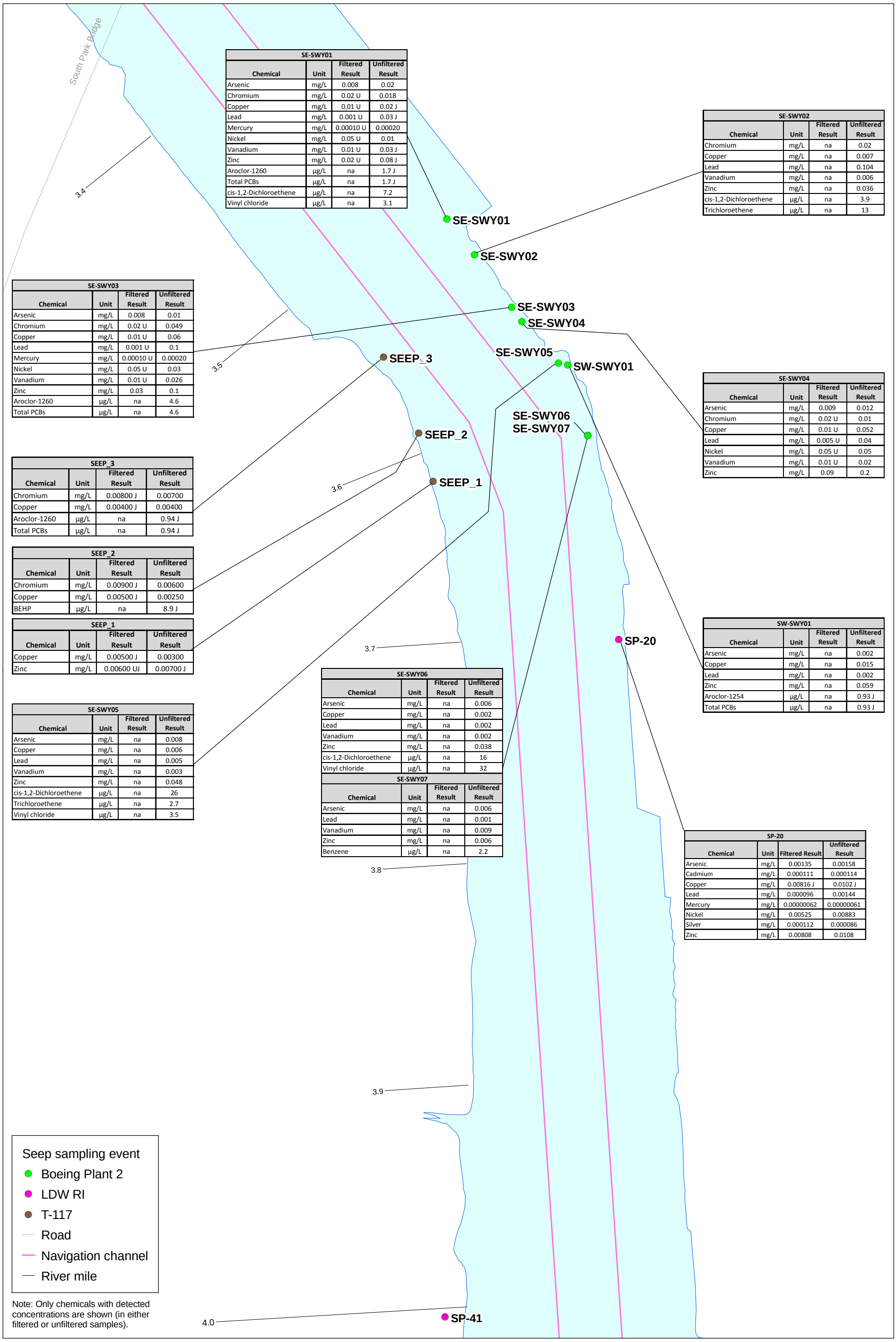
0 300 600 Feet

0 100 200 Meters

Map 4-11c. Seep water sampling data (only detected chemicals), RM 2.5 to RM 3.4

Prepared CEH 07/13/2010; MAP #3794; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Nature and Extent\Seeps and porewater



Note: Only chemicals with detected concentrations are shown (in either filtered or unfiltered samples).

SE-SWY01			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	0.008	0.02
Chromium	mg/L	0.02 U	0.018
Copper	mg/L	0.01 U	0.02 J
Lead	mg/L	0.001 U	0.03 J
Mercury	mg/L	0.00010 U	0.00020
Nickel	mg/L	0.05 U	0.01
Vanadium	mg/L	0.01 U	0.03 J
Zinc	mg/L	0.02 U	0.08 J
Aroclor-1260	µg/L	na	1.7 J
Total PCBs	µg/L	na	1.7 J
cis-1,2-Dichloroethene	µg/L	na	7.2
Vinyl chloride	µg/L	na	3.1

SE-SWY02			
Chemical	Unit	Filtered Result	Unfiltered Result
Chromium	mg/L	na	0.02
Copper	mg/L	na	0.007
Lead	mg/L	na	0.104
Vanadium	mg/L	na	0.006
Zinc	mg/L	na	0.036
cis-1,2-Dichloroethene	µg/L	na	3.9
Trichloroethene	µg/L	na	13

SE-SWY03			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	0.008	0.01
Chromium	mg/L	0.02 U	0.049
Copper	mg/L	0.01 U	0.06
Lead	mg/L	0.001 U	0.1
Mercury	mg/L	0.00010 U	0.00020
Nickel	mg/L	0.05 U	0.03
Vanadium	mg/L	0.01 U	0.026
Zinc	mg/L	0.03	0.1
Aroclor-1260	µg/L	na	4.6
Total PCBs	µg/L	na	4.6

SE-SWY04			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	0.009	0.012
Chromium	mg/L	0.02 U	0.01
Copper	mg/L	0.01 U	0.052
Lead	mg/L	0.005 U	0.04
Nickel	mg/L	0.05 U	0.05
Vanadium	mg/L	0.01 U	0.02
Zinc	mg/L	0.09	0.2

SEEP_3			
Chemical	Unit	Filtered Result	Unfiltered Result
Chromium	mg/L	0.00800 J	0.00700
Copper	mg/L	0.00400 J	0.00400
Aroclor-1260	µg/L	na	0.94 J
Total PCBs	µg/L	na	0.94 J

SEEP_2			
Chemical	Unit	Filtered Result	Unfiltered Result
Chromium	mg/L	0.00900 J	0.00600
Copper	mg/L	0.00500 J	0.00250
BEHP	µg/L	na	8.9 J

SEEP_1			
Chemical	Unit	Filtered Result	Unfiltered Result
Copper	mg/L	0.00500 J	0.00300
Zinc	mg/L	0.00600 UJ	0.00700 J

SW-SWY01			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	na	0.002
Copper	mg/L	na	0.015
Lead	mg/L	na	0.002
Zinc	mg/L	na	0.059
Aroclor-1254	µg/L	na	0.93 J
Total PCBs	µg/L	na	0.93 J

SE-SWY05			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	na	0.008
Copper	mg/L	na	0.006
Lead	mg/L	na	0.005
Vanadium	mg/L	na	0.003
Zinc	mg/L	na	0.048
cis-1,2-Dichloroethene	µg/L	na	26
Trichloroethene	µg/L	na	2.7
Vinyl chloride	µg/L	na	3.5

SE-SWY06			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	na	0.006
Copper	mg/L	na	0.002
Lead	mg/L	na	0.002
Vanadium	mg/L	na	0.002
Zinc	mg/L	na	0.038
cis-1,2-Dichloroethene	µg/L	na	16
Vinyl chloride	µg/L	na	32

SE-SWY07			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	na	0.006
Lead	mg/L	na	0.001
Vanadium	mg/L	na	0.009
Zinc	mg/L	na	0.006
Benzene	µg/L	na	2.2

SP-20			
Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	0.00135	0.00158
Cadmium	mg/L	0.000111	0.000114
Copper	mg/L	0.00816 J	0.0102 J
Lead	mg/L	0.000096	0.00144
Mercury	mg/L	0.00000062	0.00000061
Nickel	mg/L	0.00525	0.00883
Silver	mg/L	0.000112	0.000086
Zinc	mg/L	0.00808	0.0108

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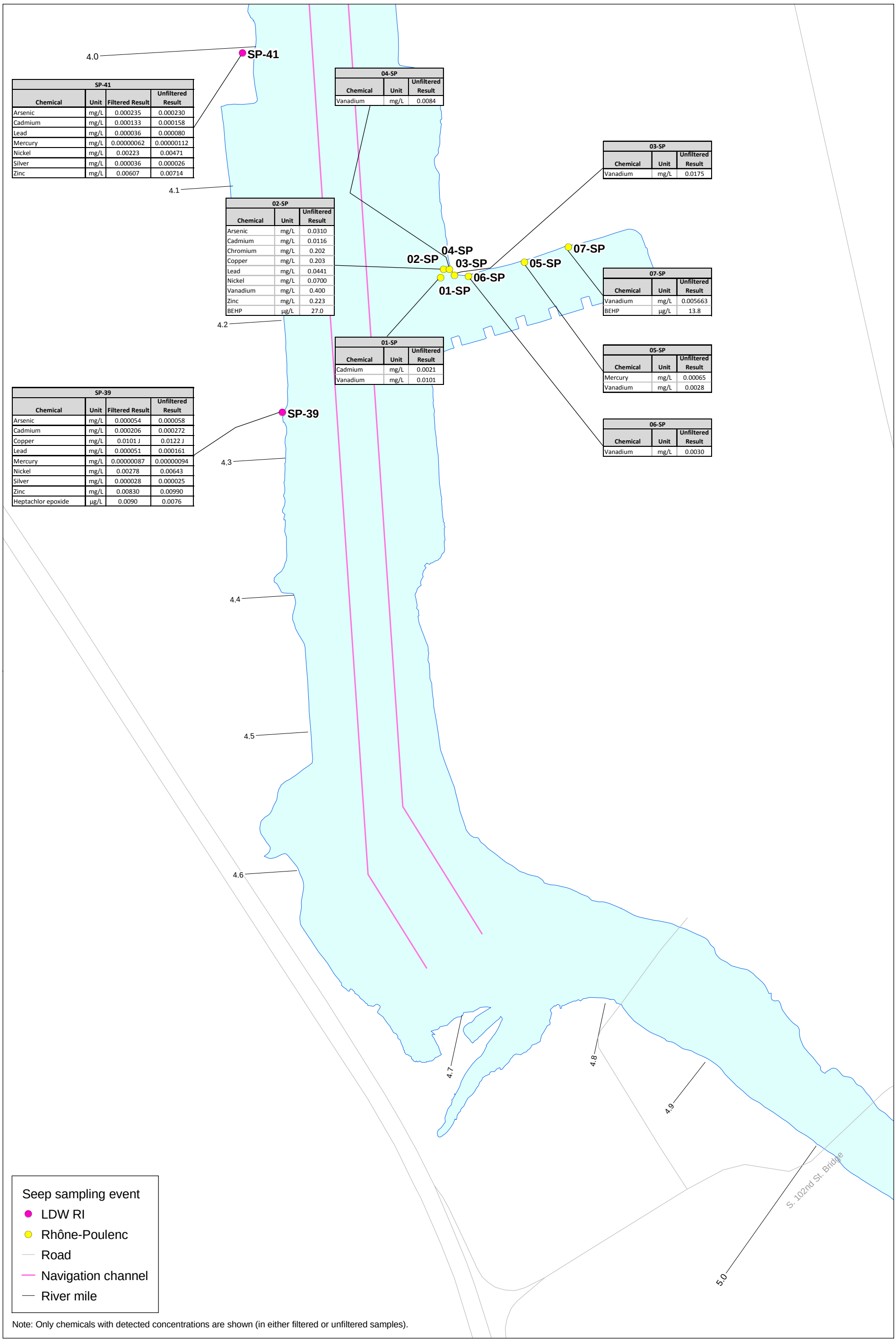
N

0 200 400 Feet

0 50 100 Meters

Map 4-11d. Seep water sampling data (only detected chemicals), RM 3.4 to RM 4.0

Prepared by CEH, 07/13/2010; MAP #3794; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Nature and Extent\Seeps and porewater



SP-41

Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	0.000235	0.000230
Cadmium	mg/L	0.000133	0.000158
Lead	mg/L	0.000036	0.000080
Mercury	mg/L	0.00000062	0.00000112
Nickel	mg/L	0.00223	0.00471
Silver	mg/L	0.000036	0.000026
Zinc	mg/L	0.00607	0.00714

04-SP

Chemical	Unit	Unfiltered Result
Vanadium	mg/L	0.0084

03-SP

Chemical	Unit	Unfiltered Result
Vanadium	mg/L	0.0175

02-SP

Chemical	Unit	Unfiltered Result
Arsenic	mg/L	0.0310
Cadmium	mg/L	0.0116
Chromium	mg/L	0.202
Copper	mg/L	0.203
Lead	mg/L	0.0441
Nickel	mg/L	0.0700
Vanadium	mg/L	0.400
Zinc	mg/L	0.223
BEHP	µg/L	27.0

07-SP

Chemical	Unit	Unfiltered Result
Vanadium	mg/L	0.005663
BEHP	µg/L	13.8

01-SP

Chemical	Unit	Unfiltered Result
Cadmium	mg/L	0.0021
Vanadium	mg/L	0.0101

05-SP

Chemical	Unit	Unfiltered Result
Mercury	mg/L	0.00065
Vanadium	mg/L	0.0028

SP-39

Chemical	Unit	Filtered Result	Unfiltered Result
Arsenic	mg/L	0.000054	0.000058
Cadmium	mg/L	0.000206	0.000272
Copper	mg/L	0.0101 J	0.0122 J
Lead	mg/L	0.000051	0.000161
Mercury	mg/L	0.00000087	0.00000094
Nickel	mg/L	0.00278	0.00643
Silver	mg/L	0.000028	0.000025
Zinc	mg/L	0.00830	0.00990
Heptachlor epoxide	µg/L	0.0090	0.0076

06-SP

Chemical	Unit	Unfiltered Result
Vanadium	mg/L	0.0030

Note: Only chemicals with detected concentrations are shown (in either filtered or unfiltered samples).

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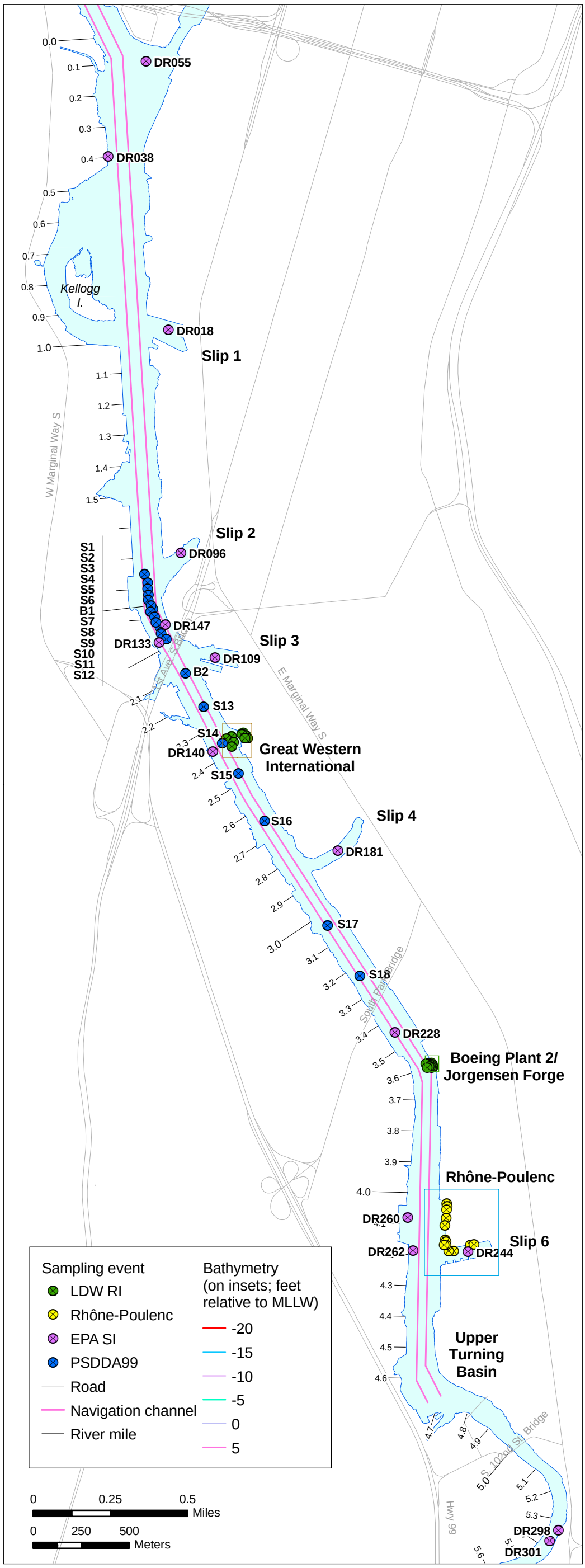
N

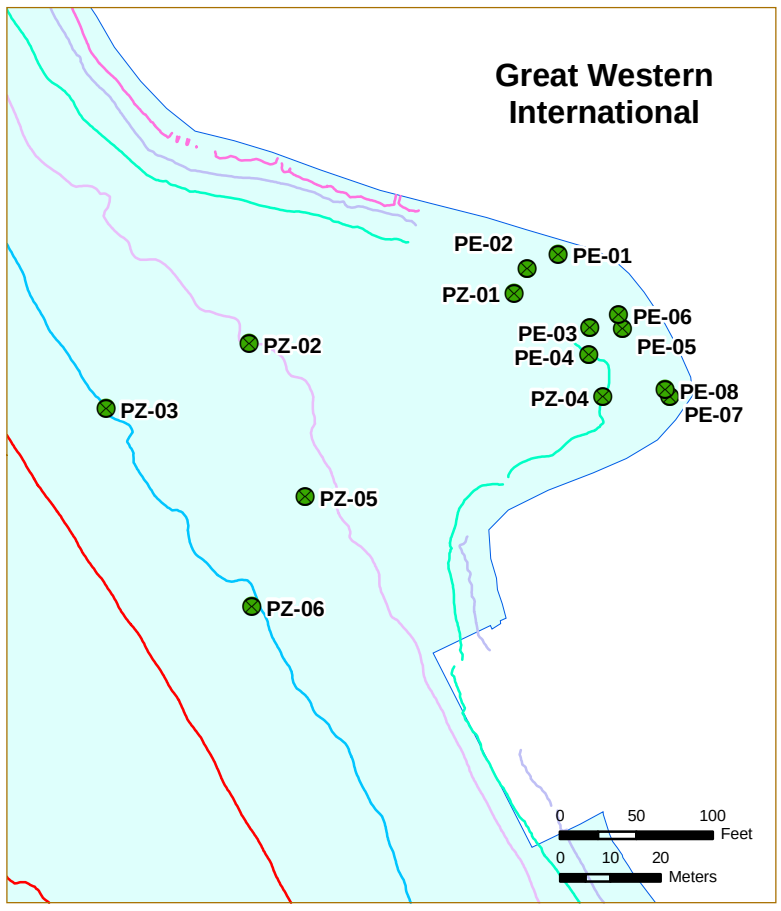
0 300 600 Feet

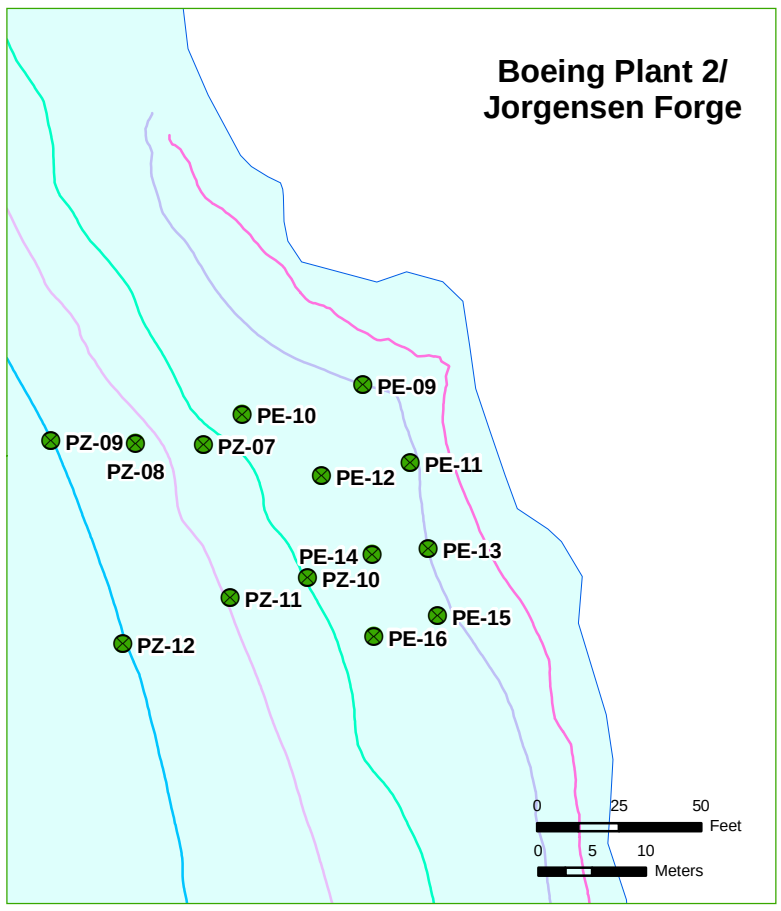
0 100 200 Meters

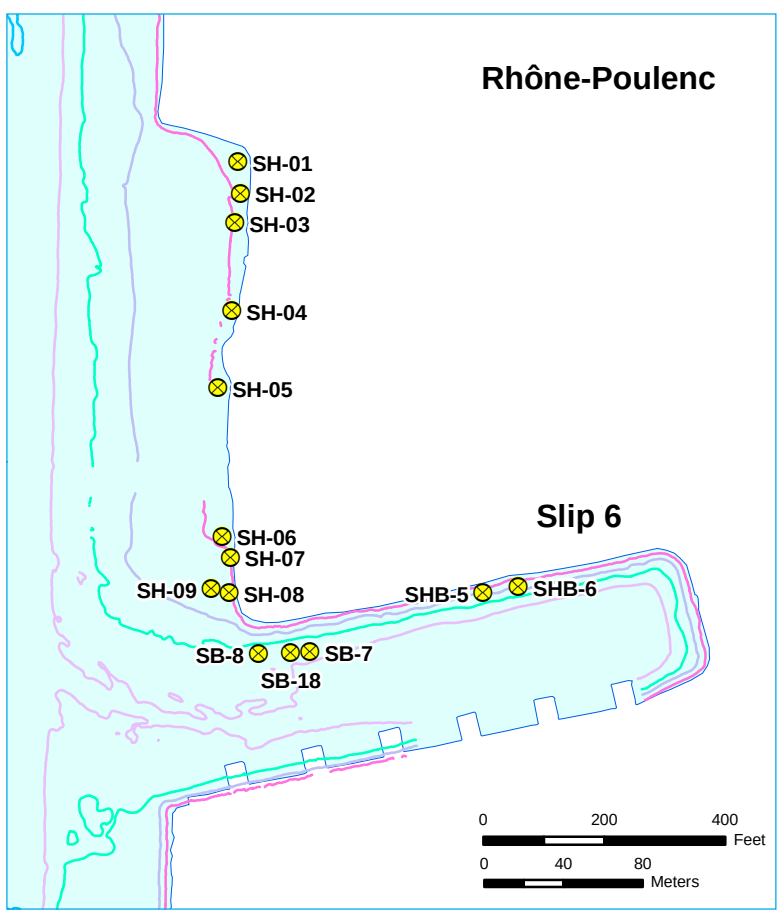
Map 4-11e. Seep water sampling data (only detected chemicals), RM 4.0 to RM 5.0

Prepared by CEH, 07/13/2010; MAP #3794; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Nature and Extent\Seeps and porewater









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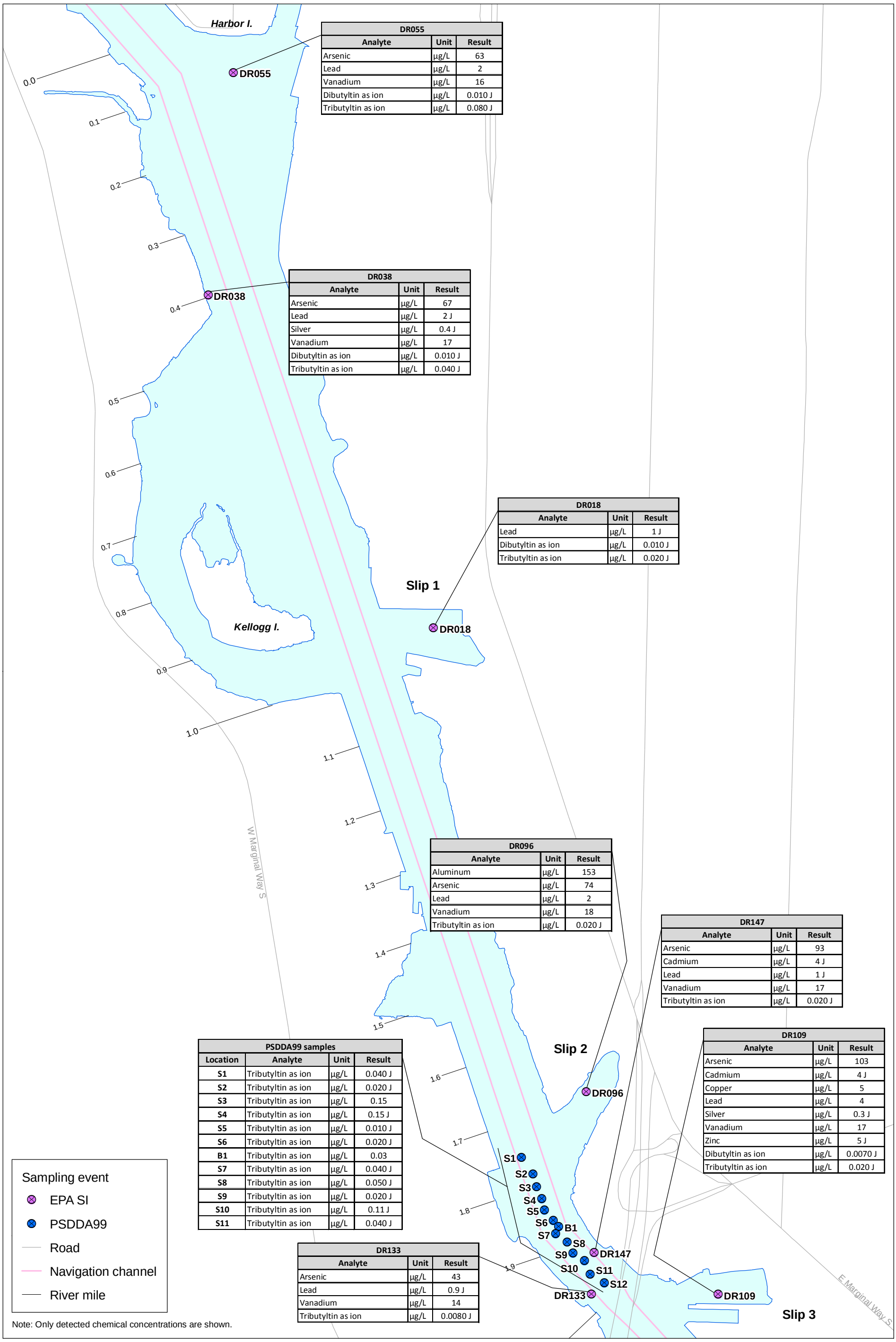
N

Map 4-12a. Porewater sampling locations

Prepared by CEH, 07/13/2010, MAP 2727; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Porewater



DR055		
Analyte	Unit	Result
Arsenic	µg/L	63
Lead	µg/L	2
Vanadium	µg/L	16
Dibutyltin as ion	µg/L	0.010 J
Tributyltin as ion	µg/L	0.080 J

DR038		
Analyte	Unit	Result
Arsenic	µg/L	67
Lead	µg/L	2 J
Silver	µg/L	0.4 J
Vanadium	µg/L	17
Dibutyltin as ion	µg/L	0.010 J
Tributyltin as ion	µg/L	0.040 J

DR018		
Analyte	Unit	Result
Lead	µg/L	1 J
Dibutyltin as ion	µg/L	0.010 J
Tributyltin as ion	µg/L	0.020 J

DR096		
Analyte	Unit	Result
Aluminum	µg/L	153
Arsenic	µg/L	74
Lead	µg/L	2
Vanadium	µg/L	18
Tributyltin as ion	µg/L	0.020 J

DR147		
Analyte	Unit	Result
Arsenic	µg/L	93
Cadmium	µg/L	4 J
Lead	µg/L	1 J
Vanadium	µg/L	17
Tributyltin as ion	µg/L	0.020 J

DR109		
Analyte	Unit	Result
Arsenic	µg/L	103
Cadmium	µg/L	4 J
Copper	µg/L	5
Lead	µg/L	4
Silver	µg/L	0.3 J
Vanadium	µg/L	17
Zinc	µg/L	5 J
Dibutyltin as ion	µg/L	0.0070 J
Tributyltin as ion	µg/L	0.020 J

PSDDA99 samples			
Location	Analyte	Unit	Result
S1	Tributyltin as ion	µg/L	0.040 J
S2	Tributyltin as ion	µg/L	0.020 J
S3	Tributyltin as ion	µg/L	0.15
S4	Tributyltin as ion	µg/L	0.15 J
S5	Tributyltin as ion	µg/L	0.010 J
S6	Tributyltin as ion	µg/L	0.020 J
B1	Tributyltin as ion	µg/L	0.03
S7	Tributyltin as ion	µg/L	0.040 J
S8	Tributyltin as ion	µg/L	0.050 J
S9	Tributyltin as ion	µg/L	0.020 J
S10	Tributyltin as ion	µg/L	0.11 J
S11	Tributyltin as ion	µg/L	0.040 J

DR133		
Analyte	Unit	Result
Arsenic	µg/L	43
Lead	µg/L	0.9 J
Vanadium	µg/L	14
Tributyltin as ion	µg/L	0.0080 J

Note: Only detected chemical concentrations are shown.

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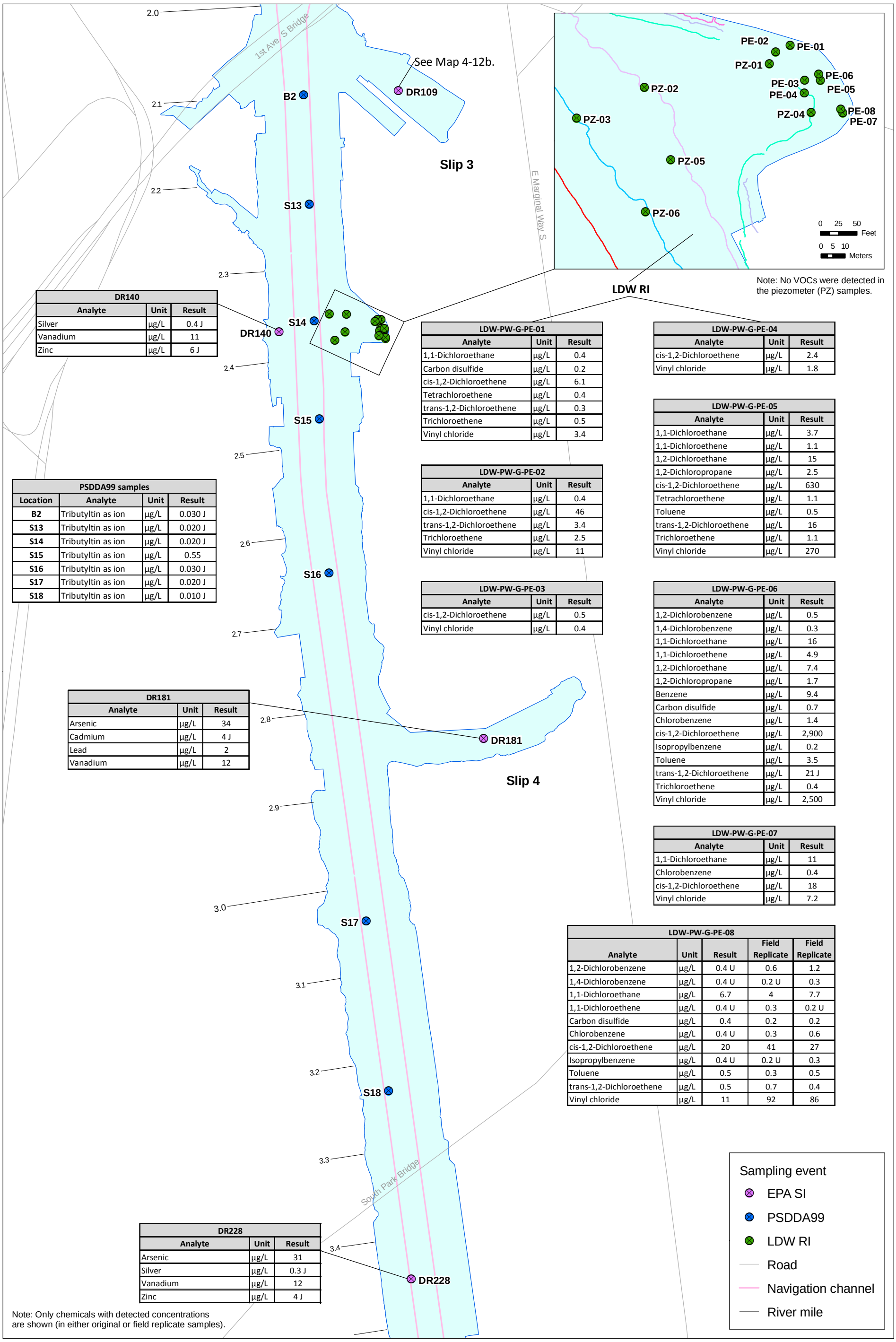
Map 4-12b. Porewater sampling data (only detected chemicals), RM 0.0 to RM 2.0

Prepared by CEH, 07/13/2010, MAP #3800; W:\Projects\10-08-06 Duwamish_RI\data\GIS\Phase 2 RI\Nature and Extent\Seeps and porewater



DR140		
Analyte	Unit	Result
Silver	µg/L	0.4 J
Vanadium	µg/L	11
Zinc	µg/L	6 J

PSDDA99 samples			
Location	Analyte	Unit	Result
B2	Tributyltin as ion	µg/L	0.030 J
S13	Tributyltin as ion	µg/L	0.020 J
S14	Tributyltin as ion	µg/L	0.020 J
S15	Tributyltin as ion	µg/L	0.55
S16	Tributyltin as ion	µg/L	0.030 J
S17	Tributyltin as ion	µg/L	0.020 J
S18	Tributyltin as ion	µg/L	0.010 J

DR181		
Analyte	Unit	Result
Arsenic	µg/L	34
Cadmium	µg/L	4 J
Lead	µg/L	2
Vanadium	µg/L	12

DR228		
Analyte	Unit	Result
Arsenic	µg/L	31
Silver	µg/L	0.3 J
Vanadium	µg/L	12
Zinc	µg/L	4 J

Note: Only chemicals with detected concentrations are shown (in either original or field replicate samples).

LDW-PW-G-PE-01		
Analyte	Unit	Result
1,1-Dichloroethane	µg/L	0.4
Carbon disulfide	µg/L	0.2
cis-1,2-Dichloroethene	µg/L	6.1
Tetrachloroethene	µg/L	0.4
trans-1,2-Dichloroethene	µg/L	0.3
Trichloroethene	µg/L	0.5
Vinyl chloride	µg/L	3.4

LDW-PW-G-PE-02		
Analyte	Unit	Result
1,1-Dichloroethane	µg/L	0.4
cis-1,2-Dichloroethene	µg/L	46
trans-1,2-Dichloroethene	µg/L	3.4
Trichloroethene	µg/L	2.5
Vinyl chloride	µg/L	11

LDW-PW-G-PE-03		
Analyte	Unit	Result
cis-1,2-Dichloroethene	µg/L	0.5
Vinyl chloride	µg/L	0.4

LDW-PW-G-PE-04		
Analyte	Unit	Result
cis-1,2-Dichloroethene	µg/L	2.4
Vinyl chloride	µg/L	1.8

LDW-PW-G-PE-05		
Analyte	Unit	Result
1,1-Dichloroethane	µg/L	3.7
1,1-Dichloroethene	µg/L	1.1
1,2-Dichloroethane	µg/L	15
1,2-Dichloropropane	µg/L	2.5
cis-1,2-Dichloroethene	µg/L	630
Tetrachloroethene	µg/L	1.1
Toluene	µg/L	0.5
trans-1,2-Dichloroethene	µg/L	16
Trichloroethene	µg/L	1.1
Vinyl chloride	µg/L	270

LDW-PW-G-PE-06		
Analyte	Unit	Result
1,2-Dichlorobenzene	µg/L	0.5
1,4-Dichlorobenzene	µg/L	0.3
1,1-Dichloroethane	µg/L	16
1,1-Dichloroethene	µg/L	4.9
1,2-Dichloroethane	µg/L	7.4
1,2-Dichloropropane	µg/L	1.7
Benzene	µg/L	9.4
Carbon disulfide	µg/L	0.7
Chlorobenzene	µg/L	1.4
cis-1,2-Dichloroethene	µg/L	2,900
Isopropylbenzene	µg/L	0.2
Toluene	µg/L	3.5
trans-1,2-Dichloroethene	µg/L	21 J
Trichloroethene	µg/L	0.4
Vinyl chloride	µg/L	2,500

LDW-PW-G-PE-07		
Analyte	Unit	Result
1,1-Dichloroethane	µg/L	11
Chlorobenzene	µg/L	0.4
cis-1,2-Dichloroethene	µg/L	18
Vinyl chloride	µg/L	7.2

LDW-PW-G-PE-08				
Analyte	Unit	Result	Field Replicate	Field Replicate
1,2-Dichlorobenzene	µg/L	0.4 U	0.6	1.2
1,4-Dichlorobenzene	µg/L	0.4 U	0.2 U	0.3
1,1-Dichloroethane	µg/L	6.7	4	7.7
1,1-Dichloroethene	µg/L	0.4 U	0.3	0.2 U
Carbon disulfide	µg/L	0.4	0.2	0.2
Chlorobenzene	µg/L	0.4 U	0.3	0.6
cis-1,2-Dichloroethene	µg/L	20	41	27
Isopropylbenzene	µg/L	0.4 U	0.2 U	0.3
Toluene	µg/L	0.5	0.3	0.5
trans-1,2-Dichloroethene	µg/L	0.5	0.7	0.4
Vinyl chloride	µg/L	11	92	86

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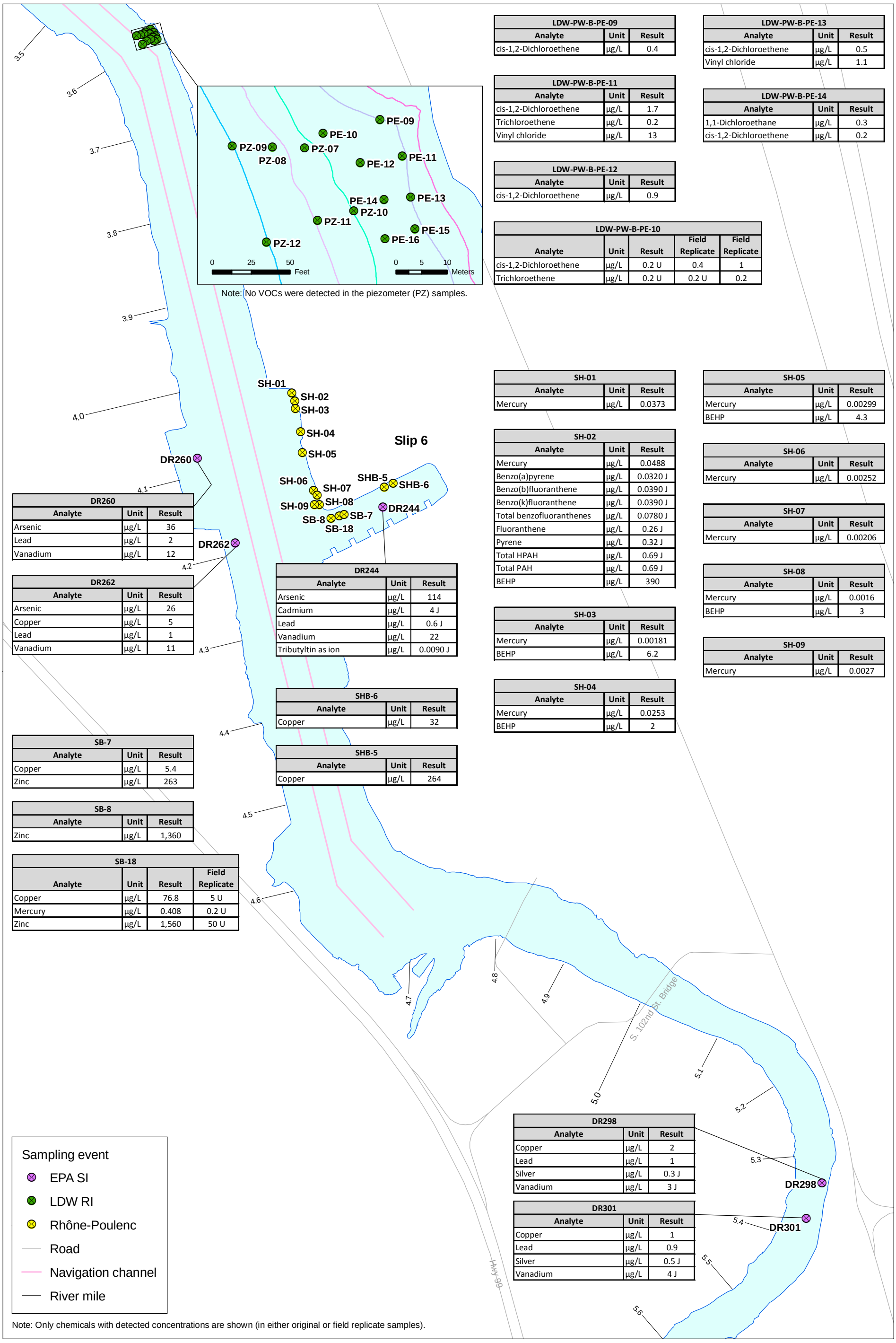
Map 4-12c. Porewater sampling data (only detected chemicals), RM 2.0 to RM 3.5

Prepared by CEH, 07/13/2010; MAP #3800; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Nature and Extent\Seeps and porewater



Note: No VOCs were detected in the piezometer (PZ) samples.

Note: Only chemicals with detected concentrations are shown (in either original or field replicate samples).

LDW-PW-B-PE-09		
Analyte	Unit	Result
cis-1,2-Dichloroethene	µg/L	0.4

LDW-PW-B-PE-11		
Analyte	Unit	Result
cis-1,2-Dichloroethene	µg/L	1.7
Trichloroethene	µg/L	0.2
Vinyl chloride	µg/L	13

LDW-PW-B-PE-12		
Analyte	Unit	Result
cis-1,2-Dichloroethene	µg/L	0.9

LDW-PW-B-PE-10				
Analyte	Unit	Result	Field Replicate	Field Replicate
cis-1,2-Dichloroethene	µg/L	0.2 U	0.4	1
Trichloroethene	µg/L	0.2 U	0.2 U	0.2

LDW-PW-B-PE-13		
Analyte	Unit	Result
cis-1,2-Dichloroethene	µg/L	0.5
Vinyl chloride	µg/L	1.1

LDW-PW-B-PE-14		
Analyte	Unit	Result
1,1-Dichloroethane	µg/L	0.3
cis-1,2-Dichloroethene	µg/L	0.2

SH-01		
Analyte	Unit	Result
Mercury	µg/L	0.0373

SH-02		
Analyte	Unit	Result
Mercury	µg/L	0.0488
Benzo(a)pyrene	µg/L	0.0320 J
Benzo(b)fluoranthene	µg/L	0.0390 J
Benzo(k)fluoranthene	µg/L	0.0390 J
Total benzofluoranthenes	µg/L	0.0780 J
Fluoranthene	µg/L	0.26 J
Pyrene	µg/L	0.32 J
Total HPAH	µg/L	0.69 J
Total PAH	µg/L	0.69 J
BEHP	µg/L	390

SH-03		
Analyte	Unit	Result
Mercury	µg/L	0.00181
BEHP	µg/L	6.2

SH-04		
Analyte	Unit	Result
Mercury	µg/L	0.0253
BEHP	µg/L	2

SH-05		
Analyte	Unit	Result
Mercury	µg/L	0.00299
BEHP	µg/L	4.3

SH-06		
Analyte	Unit	Result
Mercury	µg/L	0.00252

SH-07		
Analyte	Unit	Result
Mercury	µg/L	0.00206

SH-08		
Analyte	Unit	Result
Mercury	µg/L	0.0016
BEHP	µg/L	3

SH-09		
Analyte	Unit	Result
Mercury	µg/L	0.0027

DR260		
Analyte	Unit	Result
Arsenic	µg/L	36
Lead	µg/L	2
Vanadium	µg/L	12

DR262		
Analyte	Unit	Result
Arsenic	µg/L	26
Copper	µg/L	5
Lead	µg/L	1
Vanadium	µg/L	11

DR244		
Analyte	Unit	Result
Arsenic	µg/L	114
Cadmium	µg/L	4 J
Lead	µg/L	0.6 J
Vanadium	µg/L	22
Tributyltin as ion	µg/L	0.0090 J

SHB-6		
Analyte	Unit	Result
Copper	µg/L	32

SHB-5		
Analyte	Unit	Result
Copper	µg/L	264

SB-7		
Analyte	Unit	Result
Copper	µg/L	5.4
Zinc	µg/L	263

SB-8		
Analyte	Unit	Result
Zinc	µg/L	1,360

SB-18			
Analyte	Unit	Result	Field Replicate
Copper	µg/L	76.8	5 U
Mercury	µg/L	0.408	0.2 U
Zinc	µg/L	1,560	50 U

DR298		
Analyte	Unit	Result
Copper	µg/L	2
Lead	µg/L	1
Silver	µg/L	0.3 J
Vanadium	µg/L	3 J

DR301		
Analyte	Unit	Result
Copper	µg/L	1
Lead	µg/L	0.9
Silver	µg/L	0.5 J
Vanadium	µg/L	4 J

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N

0 500 1,000 Feet

0 100 200 Meters

Map 4-12d. Porewater sampling data (only detected chemicals), RM 3.5 to RM 5.5

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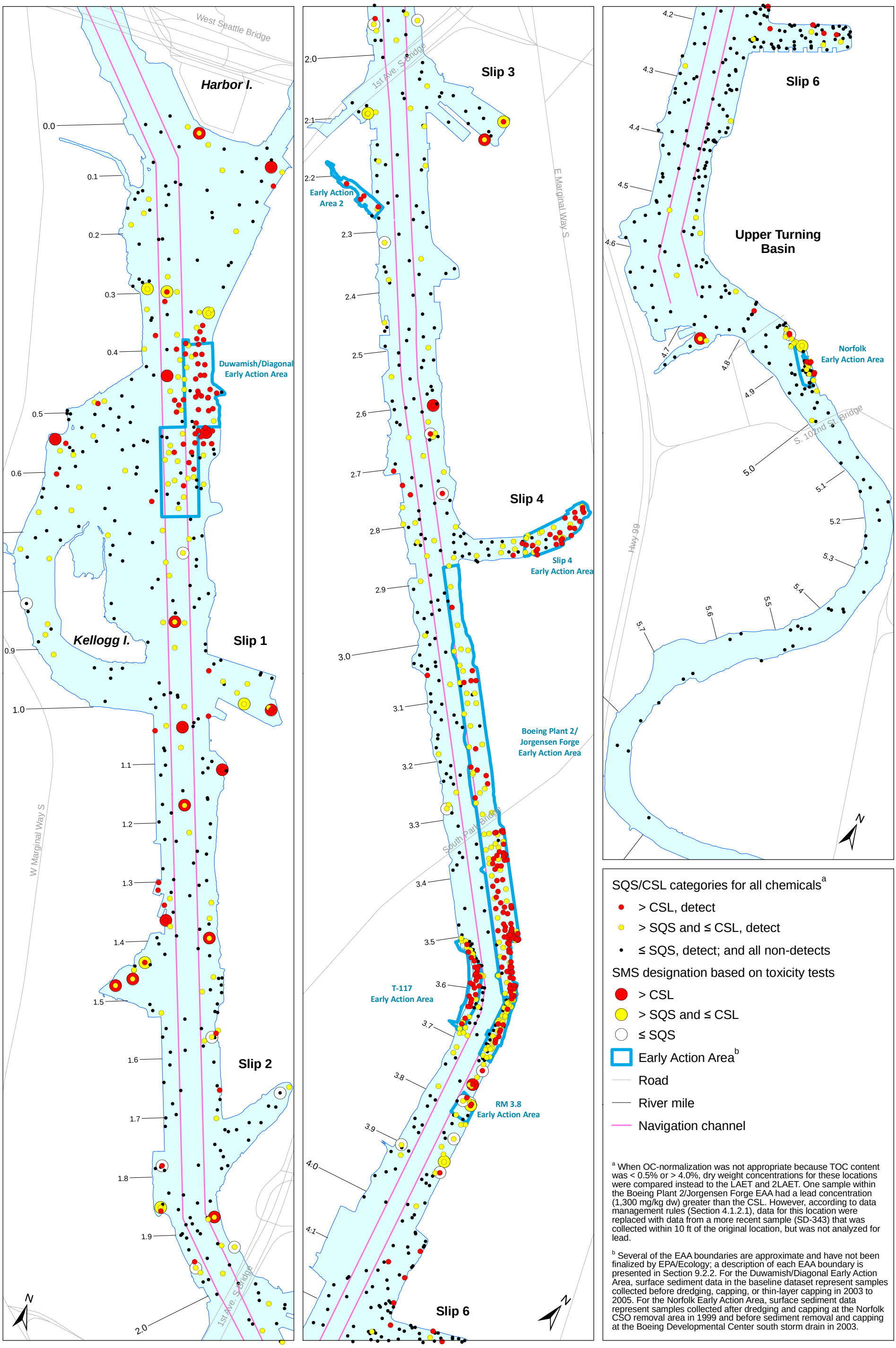

[a] When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations were compared instead to the LAET and 2LAET. One sample within the Boeing Plant 2/Jorgensen Forge EAA had a lead concentration (1,300 mg/kg dw) greater than the CSL. However, according to data management rules (Section 4.1.2.1), data for this location were replaced with data from a more recent sample (SD-343) that was collected within 10 ft of the original location, but was not analyzed for lead.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2. For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer capping in 2003 to 2005. For the Norfolk Early Action Area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

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Map 4-13. Exceedances of SQS and CSL criteria for all chemicals with SMS criteria in the RI baseline surface sediment dataset

Prepared by CEH, 07/13/2010; MAP #3033; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Nature and Extent\Surface Sediment\SMS

Analyte	Exceedance Factor	
	SQS	CSL
PCBs	15	2.8

Chemicals in red exceeded CSL. The EF has no regulatory relevance and is presented here to provide an indication of the general magnitude of the concentration. Sampling locations represented by circles or squares were analyzed for all SMS chemicals. Surface sediment samples were collected at depths ≤15 cm below mudline. "ne" = not exceeded.

Only locations with detected exceedances outside the Duwamish/Diagonal dredged and capped or thin-layer placement areas are shown with exceedance factors. Colored symbols within these areas represent samples collected prior to dredging, capping, or thin-layer placement.

SQS/CSL categories for all SMS chemicals at surface sediment locations[a]

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect

SQS/CSL categories for PCBs at locations where only PCBs were analyzed[a]

- > CSL, detect
- > SQS and ≤ CSL, detect
- ≤ SQS, detect and non-detect

SMS designation based on toxicity tests

- > CSL
- > SQS and ≤ CSL
- ≤ SQS

Outfall classification[b]

- CSO/storm drain
- EOF
- Permitted private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale

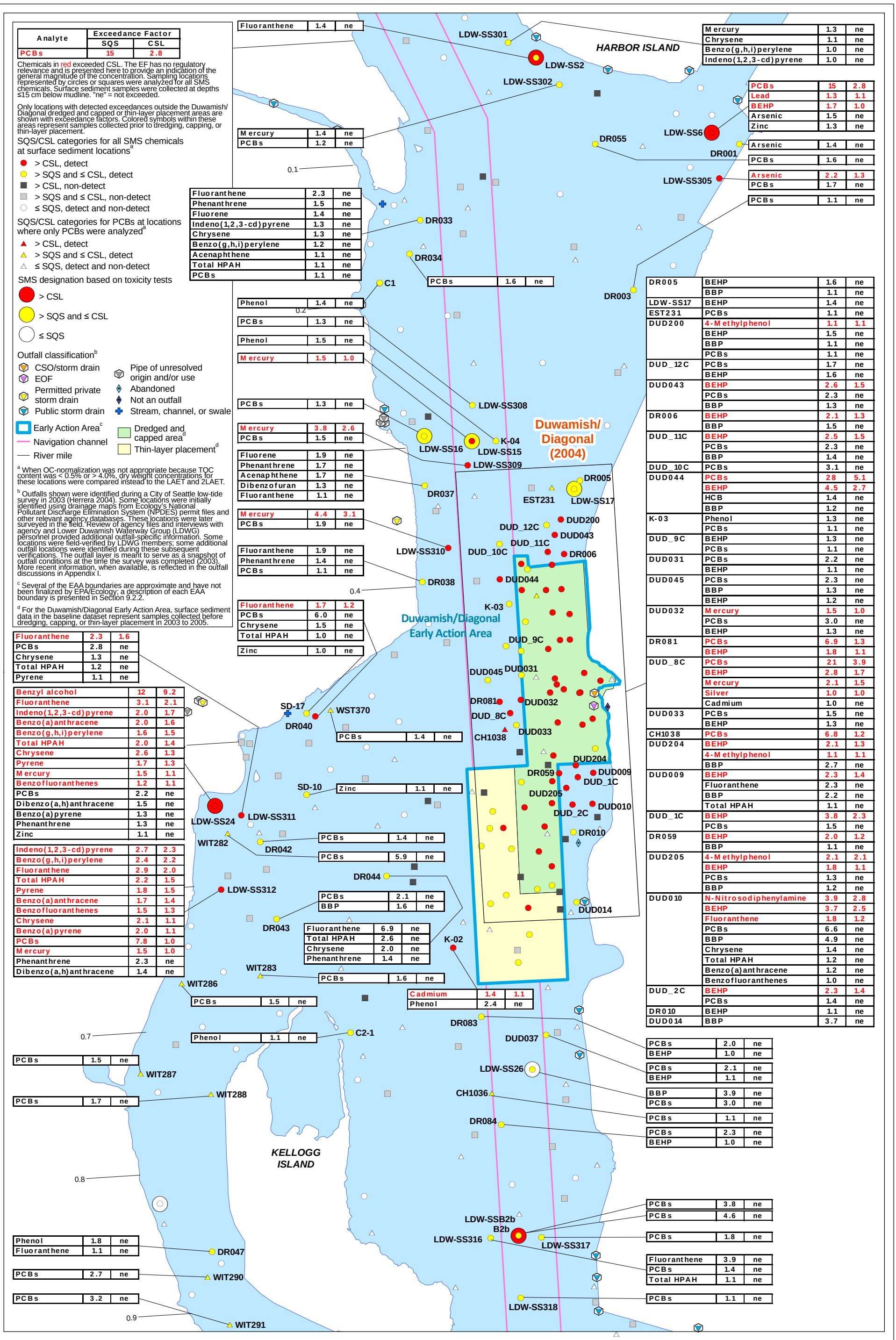
- Early Action Area[c]
- Navigation channel
- River mile
- Dredged and capped area[d]
- Thin-layer placement[d]

[a] When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations were compared instead to the LAET and 2LAET.

[b] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

[c] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[d] For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005.



Fluoranthene	1.4	ne
Mercury	1.3	ne
Chrysene	1.1	ne
Benzo(g,h,i)perylene	1.0	ne
Indeno(1,2,3-cd)pyrene	1.0	ne
PCBs	15	2.8
Lead	1.3	1.1
BEHP	1.7	1.0
Arsenic	1.5	ne
Zinc	1.3	ne
Mercury	1.4	ne
PCBs	1.2	ne
Arsenic	1.4	ne
PCBs	1.6	ne
Arsenic	2.2	1.3
PCBs	1.7	ne
PCBs	1.1	ne
Fluoranthene	2.3	ne
Phenanthrene	1.5	ne
Fluorene	1.4	ne
Indeno(1,2,3-cd)pyrene	1.3	ne
Chrysene	1.3	ne
Benzo(g,h,i)perylene	1.2	ne
Acenaphthene	1.1	ne
Total HPAH	1.1	ne
PCBs	1.1	ne
PCBs	1.6	ne
Phenol	1.4	ne
PCBs	1.3	ne
Phenol	1.5	ne
Mercury	1.5	1.0
PCBs	1.3	ne
Mercury	3.8	2.6
PCBs	1.5	ne
Fluorene	1.9	ne
Phenanthrene	1.7	ne
Acenaphthene	1.7	ne
Dibenzofuran	1.3	ne
Fluoranthene	1.1	ne
Mercury	4.4	3.1
PCBs	1.9	ne
Fluoranthene	1.9	ne
Phenanthrene	1.4	ne
PCBs	1.1	ne
Fluoranthene	1.7	1.2
PCBs	6.0	ne
Chrysene	1.5	ne
Total HPAH	1.0	ne
Zinc	1.0	ne
Fluoranthene	2.3	1.6
PCBs	2.8	ne
Chrysene	1.3	ne
Total HPAH	1.2	ne
Pyrene	1.1	ne
Benzyl alcohol	12	9.2
Fluoranthene	3.1	2.1
Indeno(1,2,3-cd)pyrene	2.0	1.7
Benzo(a)anthracene	2.0	1.6
Benzo(g,h,i)perylene	1.6	1.5
Total HPAH	2.0	1.4
Chrysene	2.6	1.3
Pyrene	1.7	1.3
Mercury	1.5	1.1
Benzofluoranthenes	1.2	1.1
PCBs	2.2	ne
Dibenzo(a,h)anthracene	1.5	ne
Benzo(a)pyrene	1.3	ne
Phenanthrene	1.3	ne
Zinc	1.1	ne
Indeno(1,2,3-cd)pyrene	2.7	2.3
Benzo(g,h,i)perylene	2.4	2.2
Fluoranthene	2.9	2.0
Total HPAH	2.2	1.5
Pyrene	1.8	1.5
Benzo(a)anthracene	1.7	1.4
Benzofluoranthenes	1.5	1.3
Chrysene	2.1	1.1
Benzo(a)pyrene	2.0	1.1
PCBs	7.8	1.0
Mercury	1.5	1.0
Phenanthrene	2.3	ne
Dibenzo(a,h)anthracene	1.4	ne
PCBs	1.4	ne
PCBs	1.4	ne
PCBs	5.9	ne
PCBs	2.1	ne
BBP	1.6	ne
Fluoranthene	6.9	ne
Total HPAH	2.6	ne
Chrysene	2.0	ne
Phenanthrene	1.4	ne
PCBs	1.6	ne
PCBs	1.5	ne
Cadmium	1.4	1.1
Phenol	2.4	ne
Phenol	1.1	ne
PCBs	1.5	ne
PCBs	1.7	ne
Phenol	1.8	ne
Fluoranthene	1.1	ne
PCBs	2.7	ne
PCBs	3.2	ne
PCBs	2.0	ne
BEHP	1.0	ne
PCBs	2.1	ne
BEHP	1.1	ne
BBP	3.9	ne
PCBs	3.0	ne
PCBs	1.1	ne
PCBs	2.3	ne
BEHP	1.0	ne
PCBs	3.8	ne
PCBs	4.6	ne
PCBs	1.8	ne
Fluoranthene	3.9	ne
PCBs	1.4	ne
Total HPAH	1.1	ne
PCBs	1.1	ne

DR005	BEHP	1.6	ne
	BBP	1.1	ne
LDW-SS17	BEHP	1.4	ne
EST231	PCBs	1.1	ne
DUD200	4-Methylphenol	1.1	1.1
	BEHP	1.5	ne
	BBP	1.1	ne
	PCBs	1.1	ne
DUD_12C	PCBs	1.7	ne
	BEHP	1.6	ne
DUD043	BEHP	2.6	1.5
	PCBs	2.3	ne
	BBP	1.3	ne
DR006	BEHP	2.1	1.3
	BBP	1.5	ne
DUD_11C	BEHP	2.5	1.5
	PCBs	2.3	ne
	BBP	1.4	ne
DUD_10C	PCBs	3.1	ne
DUD044	PCBs	28	5.1
	BEHP	4.5	2.7
	HCB	1.4	ne
	BBP	1.2	ne
K-03	Phenol	1.3	ne
	PCBs	1.1	ne
DUD_9C	BEHP	1.3	ne
	PCBs	1.1	ne
DUD031	PCBs	2.2	ne
	BEHP	1.1	ne
DUD045	PCBs	2.3	ne
	BBP	1.3	ne
	BEHP	1.2	ne
DUD032	Mercury	1.5	1.0
	PCBs	3.0	ne
	BEHP	1.3	ne
DR081	PCBs	6.9	1.3
	BEHP	1.8	1.1
DUD_8C	PCBs	21	3.9
	BEHP	2.8	1.7
	Mercury	2.1	1.5
	Silver	1.0	1.0
	Cadmium	1.0	ne
DUD033	PCBs	1.5	ne
	BEHP	1.3	ne
CH1038	PCBs	6.8	1.2
DUD204	BEHP	2.1	1.3
	4-Methylphenol	1.1	1.1
	BBP	2.7	ne
DUD009	BEHP	2.3	1.4
	Fluoranthene	2.3	ne
	BBP	2.2	ne
	Total HPAH	1.1	ne
DUD_1C	BEHP	3.8	2.3
	PCBs	1.5	ne
DR059	BEHP	2.0	1.2
	BBP	1.1	ne
DUD205	4-Methylphenol	2.1	2.1
	BEHP	1.8	1.1
	PCBs	1.3	ne
	BBP	1.2	ne
DUD010	N-Nitrosodiphenylamine	3.9	2.8
	BEHP	3.7	2.5
	Fluoranthene	1.8	1.2
	PCBs	6.6	ne
	BBP	4.9	ne
	Chrysene	1.4	ne
	Total HPAH	1.2	ne
	Benzo(a)anthracene	1.2	ne
	Benzofluoranthenes	1.0	ne
DUD_2C	BEHP	2.3	1.4
	PCBs	1.4	ne
DR010	BEHP	1.1	ne
DUD014	BBP	3.7	ne

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N

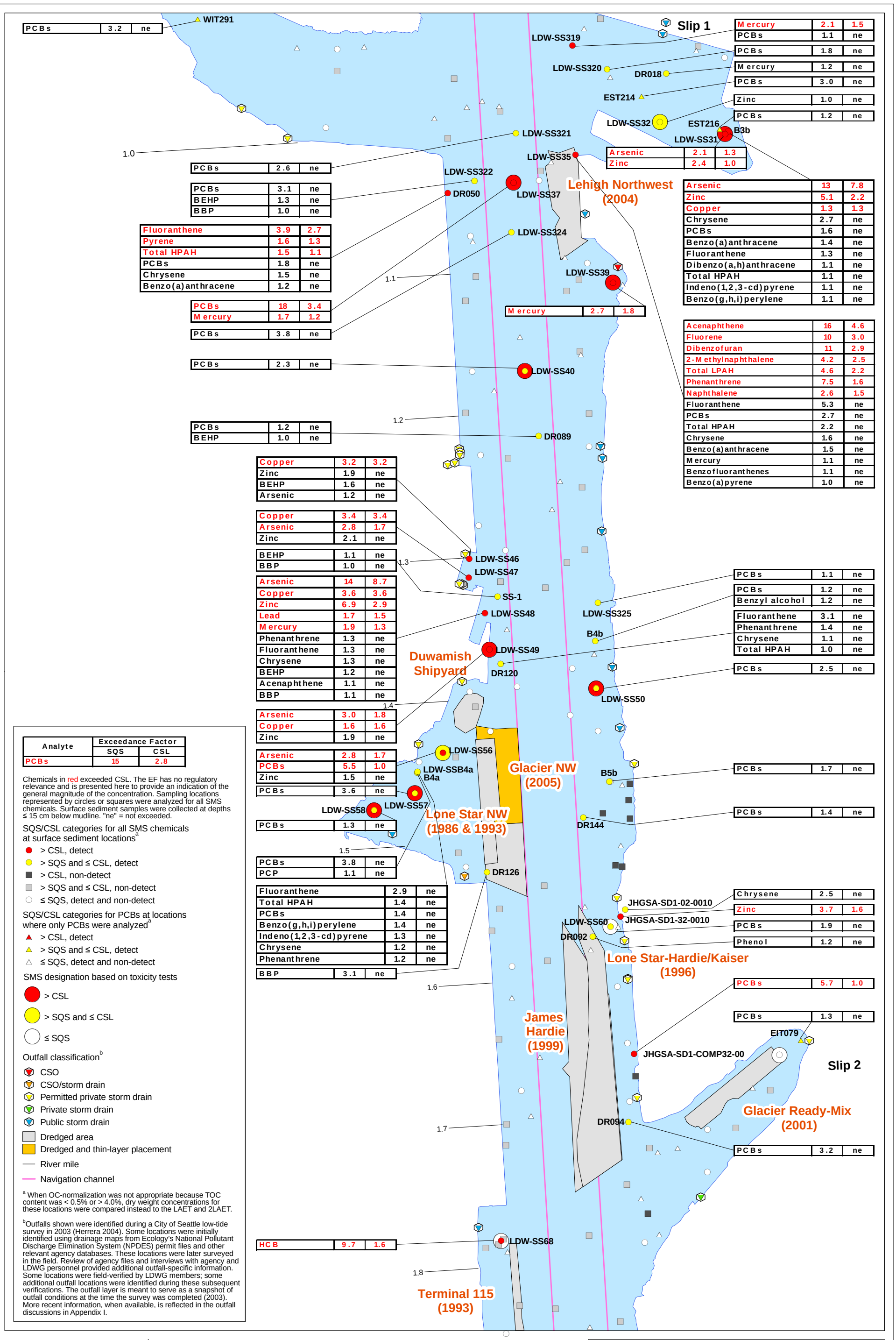
0 250 500 Feet

0 75 150 Meters

Map 4-14a. Chemical and toxicity test results compared to SMS criteria for baseline surface sediment sampling locations, RM 0.0 to RM 0.9

Prepared by CEH, 07/14/2010; Map 2896; W:\Projects\00-08-06 Duwamish_RI\data\GIS\Phase2 RI\Nature and Extent\Surface Sediment\SMS

Dredging information provided by AECOM.



Analyte	Exceedance Factor	
	SQS	CSL
PCBs	15	2.8

Chemicals in red exceeded CSL. The EF has no regulatory relevance and is presented here to provide an indication of the general magnitude of the concentration. Sampling locations represented by circles or squares were analyzed for all SMS chemicals. Surface sediment samples were collected at depths ≤ 15 cm below mudline. "ne" = not exceeded.

SQS/CSL categories for all SMS chemicals at surface sediment locations[a]

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect

SQS/CSL categories for PCBs at locations where only PCBs were analyzed[a]

- > CSL, detect
- > SQS and ≤ CSL, detect
- ≤ SQS, detect and non-detect

SMS designation based on toxicity tests

- > CSL
- > SQS and ≤ CSL
- ≤ SQS

Outfall classification[b]

- CSO
- CSO/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Dredged area
- Dredged and thin-layer placement
- River mile
- Navigation channel

[a] When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations were compared instead to the LAET and 2LAET.

[b] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

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N

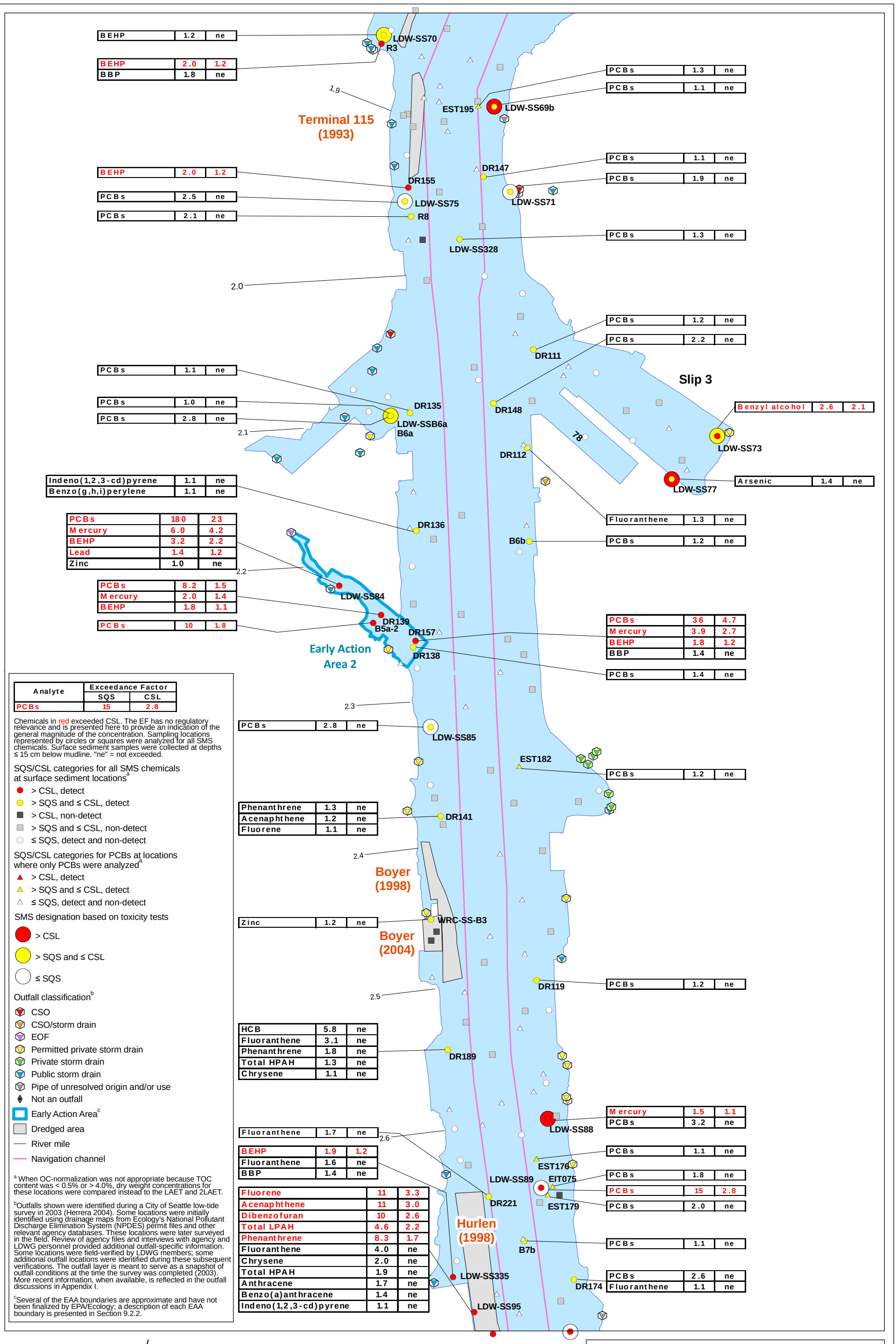
0 250 500 Feet

0 75 150 Meters

Map 4-14b. Chemical and toxicity test results compared to SMS criteria for baseline surface sediment sampling locations, RM 0.9 to RM 1.8

Prepared by CEH, 07/14/2010; Map 2896; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Nature and Extent\Surface Sediment\SMS

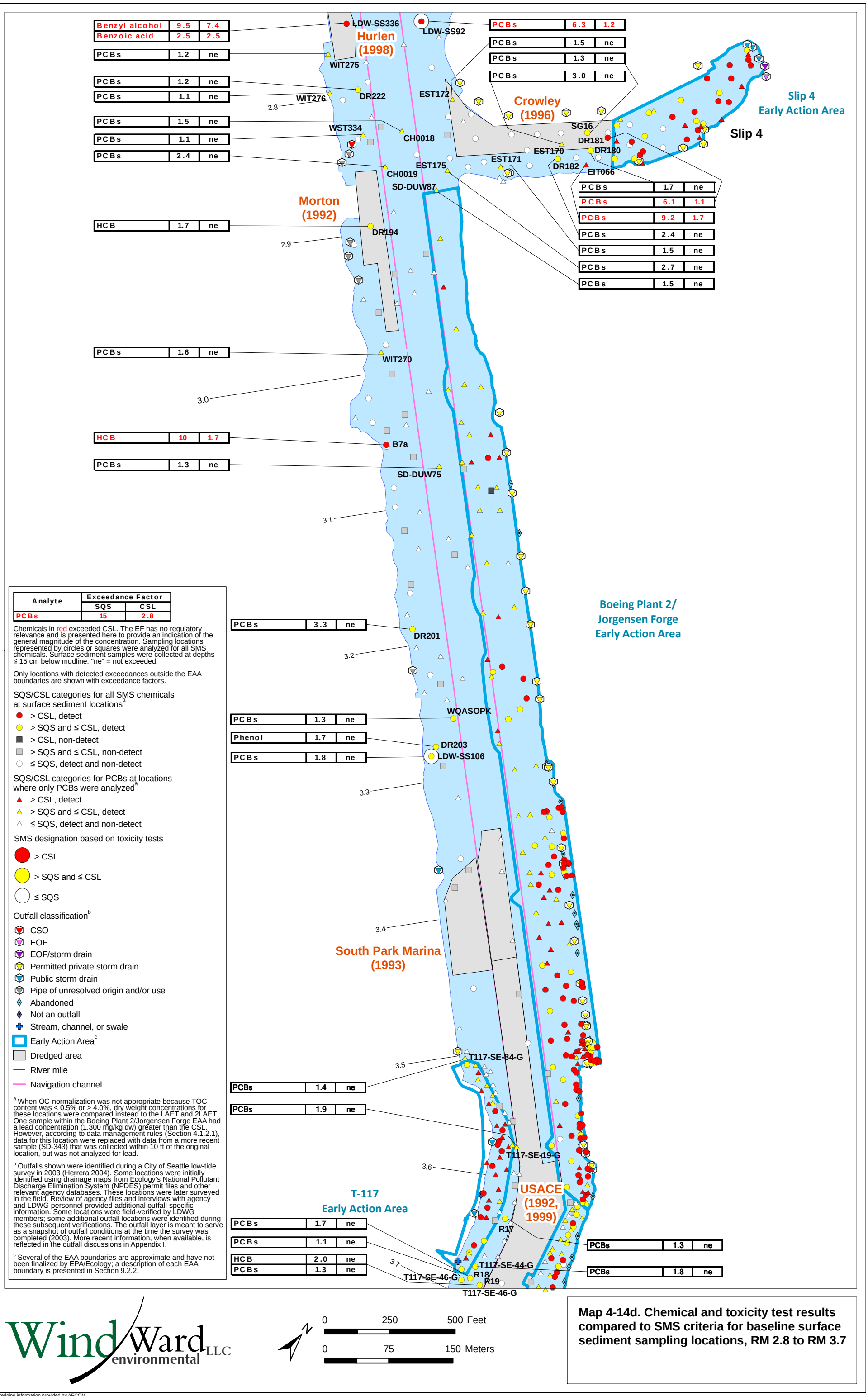
Dredging information provided by AECOM.



Map 4-14c. Chemical and toxicity test results compared to SMS criteria for baseline surface sediment sampling locations, RM 1.8 to RM 2.7

Prepared by CEH, 07/14/2010; Map 2896; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Nature and Extent\Surface Sediment\SMS

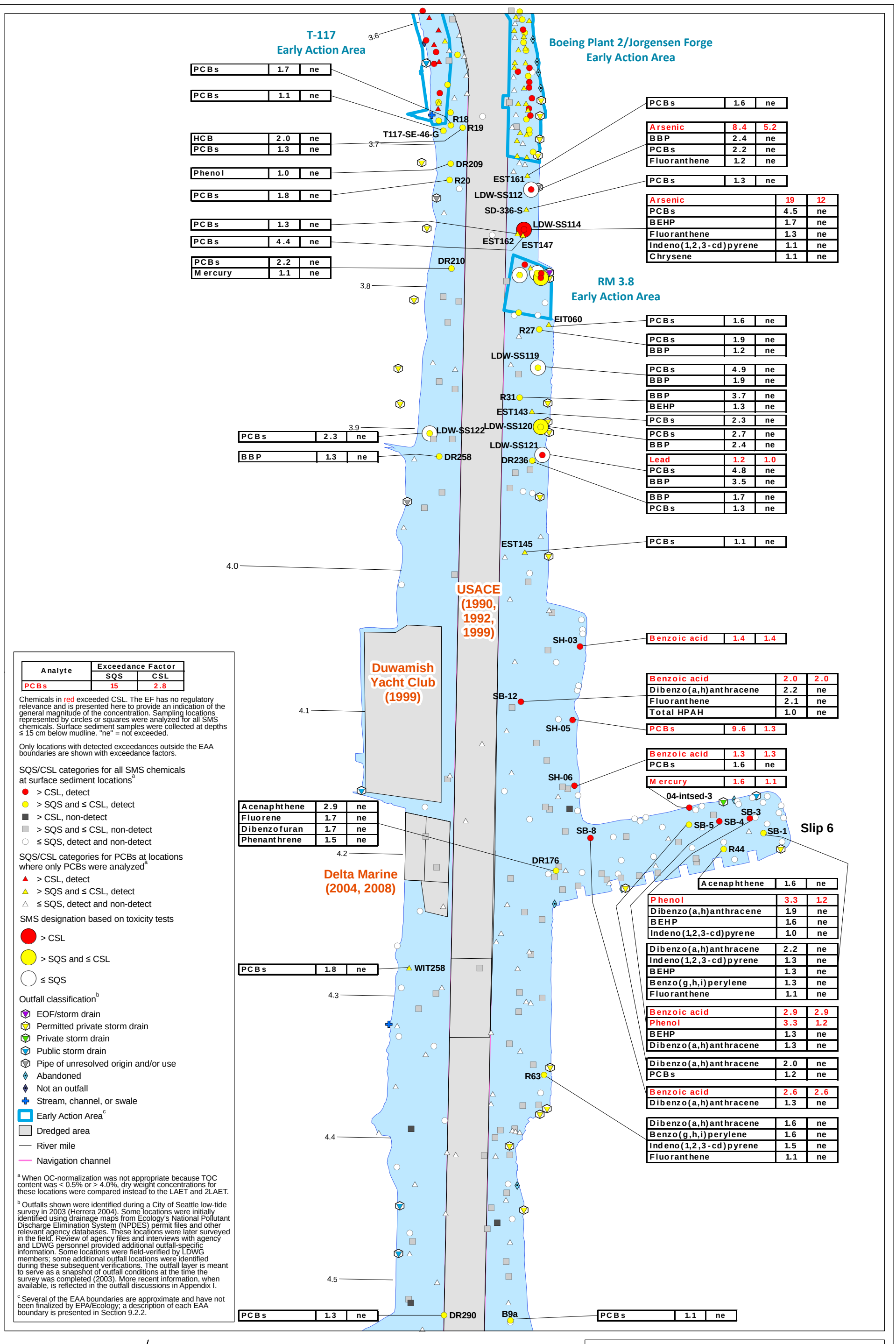
Dredging information provided by AECOM.



Map 4-14d. Chemical and toxicity test results compared to SMS criteria for baseline surface sediment sampling locations, RM 2.8 to RM 3.7

Prepared by CEH, 07/14/2010; Map 2896; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Nature and Extent\Surface Sediment\SMS

Dredging information provided by AECOM.



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N

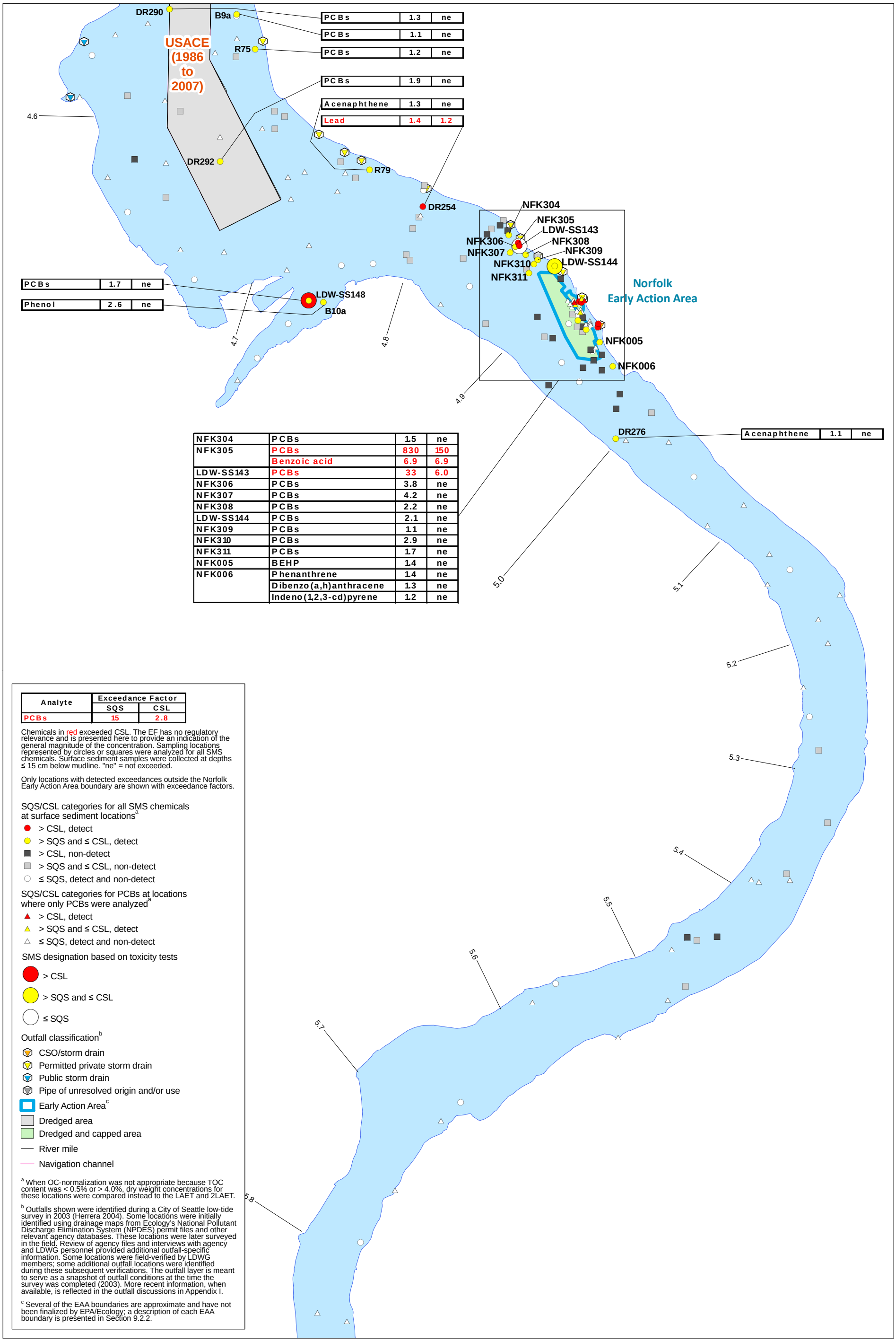
0 250 500 Feet

0 75 150 Meters

Map 4-14e. Chemical and toxicity test results compared to SMS criteria for baseline surface sediment sampling locations, RM 3.7 to RM 4.5

Prepared by CEH, 07/14/2010; Map 2886; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Nature and Extent\Surface Sediment\SMS

Dredging information provided by AECOM.



PCBs	1.3	ne
PCBs	1.1	ne
PCBs	1.2	ne
PCBs	1.9	ne
Acenaphthene	1.3	ne
Lead	1.4	1.2
PCBs	1.7	ne
Phenol	2.6	ne
Acenaphthene	1.1	ne

NFK304	PCBs	1.5	ne
NFK305	PCBs	830	150
	Benzoic acid	6.9	6.9
LDW-SS143	PCBs	33	6.0
NFK306	PCBs	3.8	ne
NFK307	PCBs	4.2	ne
NFK308	PCBs	2.2	ne
LDW-SS144	PCBs	2.1	ne
NFK309	PCBs	1.1	ne
NFK310	PCBs	2.9	ne
NFK311	PCBs	1.7	ne
NFK005	BEHP	1.4	ne
NFK006	Phenanthrene	1.4	ne
	Dibenzo(a,h)anthracene	1.3	ne
	Indeno(1,2,3-cd)pyrene	1.2	ne

Analyte	Exceedance Factor	
	SQS	CSL
PCBs	15	2.8

Chemicals in red exceeded CSL. The EF has no regulatory relevance and is presented here to provide an indication of the general magnitude of the concentration. Sampling locations represented by circles or squares were analyzed for all SMS chemicals. Surface sediment samples were collected at depths ≤ 15 cm below mudline. "ne" = not exceeded.

Only locations with detected exceedances outside the Norfolk Early Action Area boundary are shown with exceedance factors.

SQS/CSL categories for all SMS chemicals at surface sediment locations[a]

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect

SQS/CSL categories for PCBs at locations where only PCBs were analyzed[a]

- > CSL, detect
- > SQS and ≤ CSL, detect
- ≤ SQS, detect and non-detect

SMS designation based on toxicity tests

- > CSL
- > SQS and ≤ CSL
- ≤ SQS

Outfall classification[b]

- CSO/storm drain
- Permitted private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Early Action Area[c]
- Dredged area
- Dredged and capped area
- River mile
- Navigation channel

[a] When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations were compared instead to the LAET and 2LAET.

[b] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

[c] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

Wind Ward environmental LLC

N

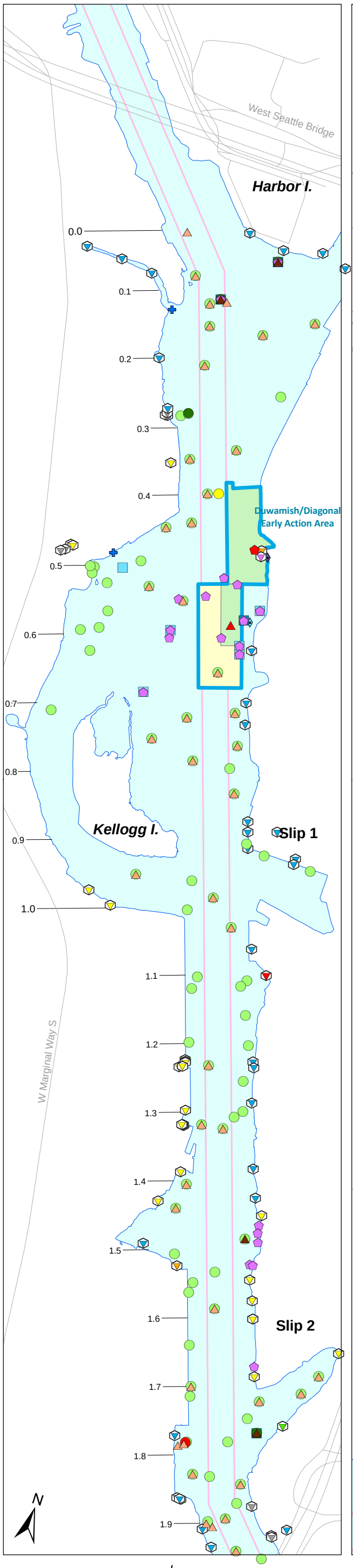
0 250 500 Feet

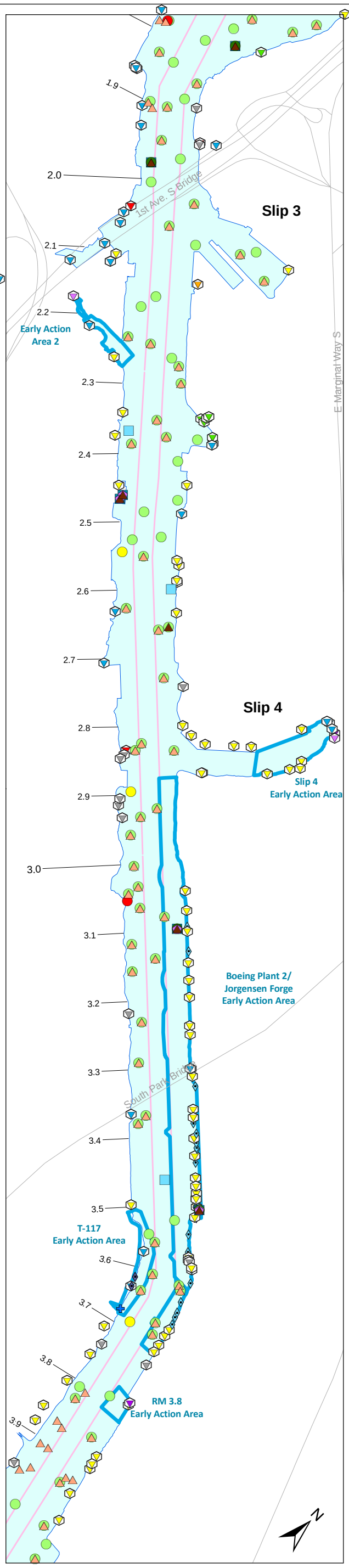
0 75 150 Meters

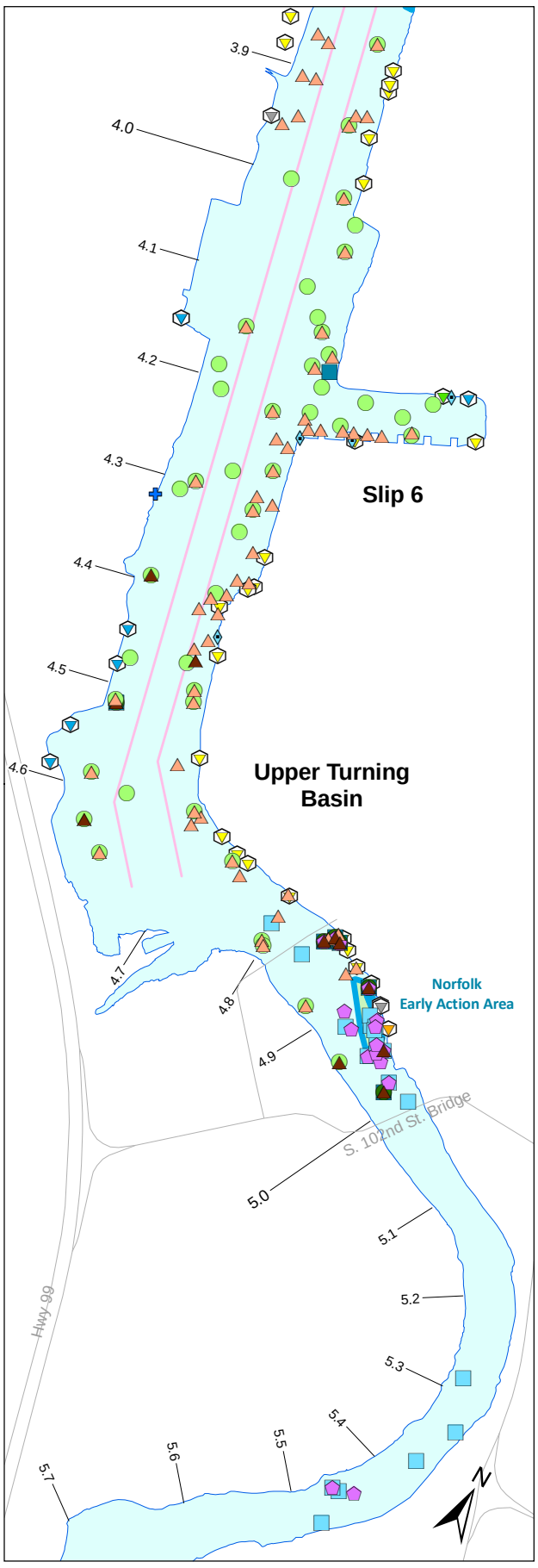
Map 4-14f. Chemical and toxicity test results compared to SMS criteria for baseline surface sediment sampling locations, RM 4.5 to RM 5.8

Prepared by CEH, 07/14/2010; Map 2886; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Nature and Extent\Surface Sediment\SMS

Dredging information provided by AECOM.







1,2,4-Trichlorobenzene
- > CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect

2,4-Dimethylphenol
- > SQS and CSL, detect[a]
- > SQS and CSL, non-detect[a]

Hexachlorobenzene
- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect

Other chemicals
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect

Early Action Area[b]

Dredged and capped area[c]

Thin-layer placement[c]

Outfall classification[d]
- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale

Road

River mile

Navigation channel

[a] SQS and CSL have the same value for 2,4-dimethylphenol.
[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.
[c] For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, and thin-layer placement in 2003 to 2005. For the Norfolk Early Action Area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO/SD removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.
[d] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time of the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.
Note: Multiple symbols are shown at a single location if more than one of these chemicals was not detected but the RLs were above the SQS or CSL chemical criteria.

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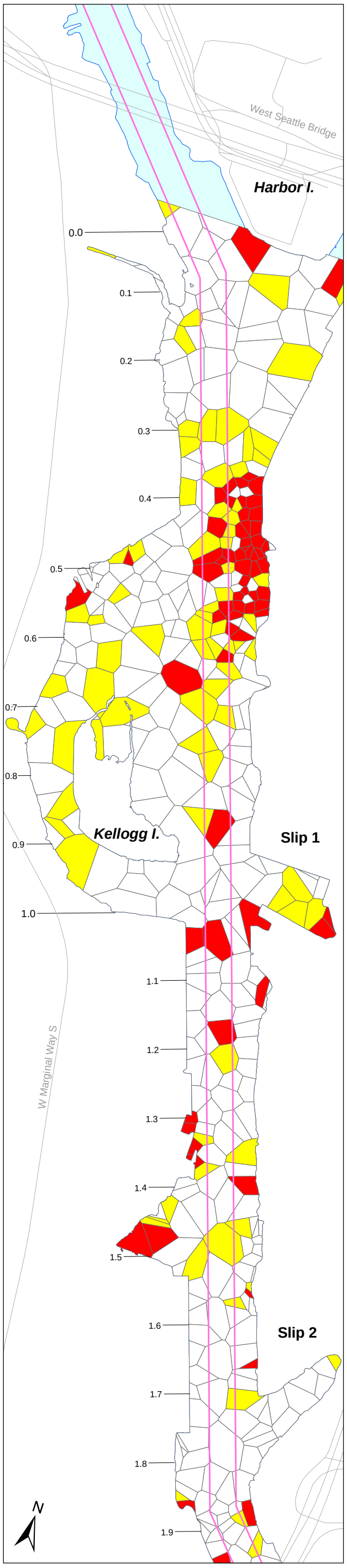
0 0.1 0.2 Miles

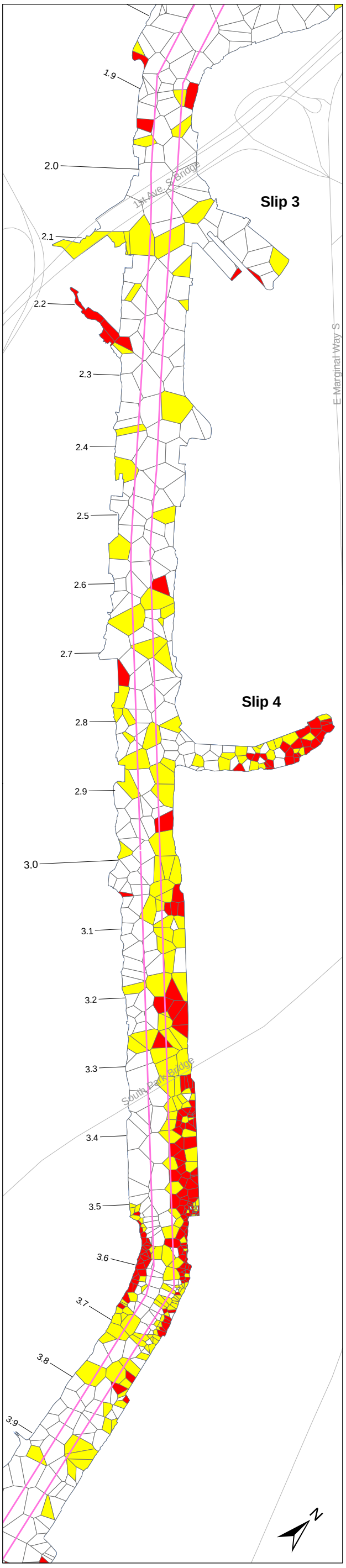
0 0.1 0.2 Kilometers

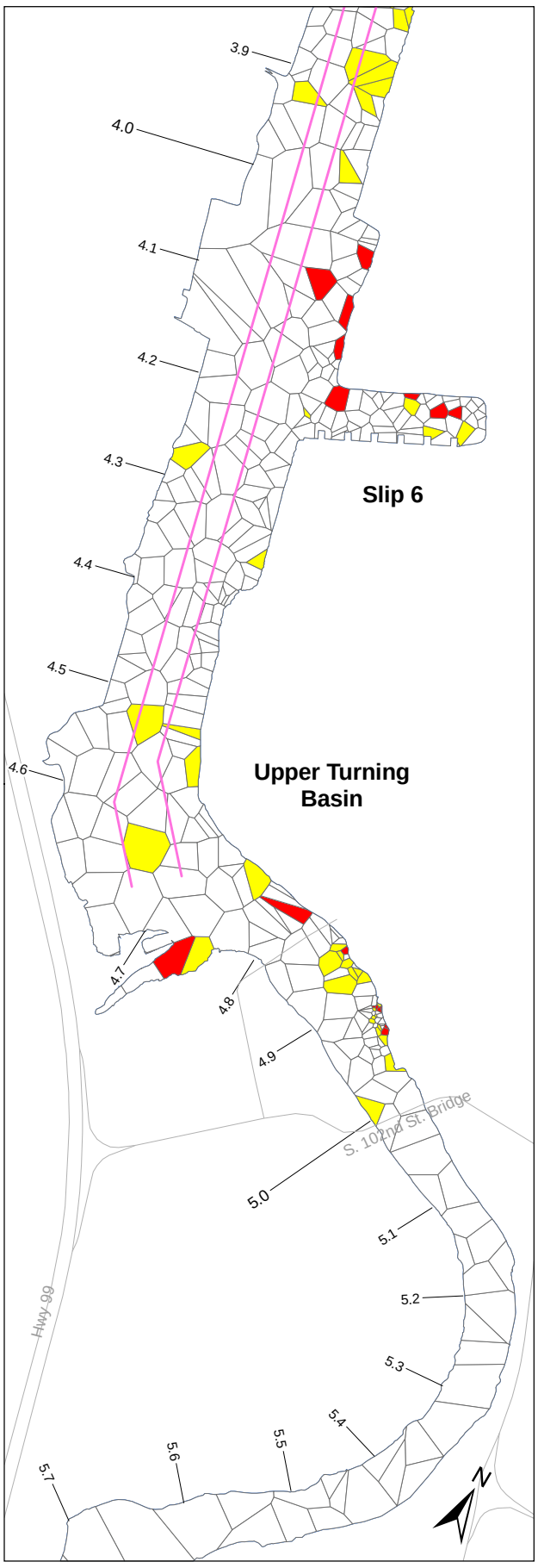
Scale is the same for each inset map

Map 4-15. Surface sediment sampling locations with non-detect RLs greater than SQS or CSL chemical criteria (and no detected exceedances) and locations with detected 1,2,4-trichlorobenzene, 2,4-dimethylphenol, and hexachlorobenzene

Prepared by CEH, 07/14/2010; MAP #2417; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Nature and Extent\Surface Sediment\SMS







- > CSL toxicity or > CSL chemistry if no toxicity data[a]
- > SQS and ≤ CSL toxicity or > SQS and ≤ CSL chemistry if no toxicity data[a]
- ≤ SQS toxicity or ≤ SQS chemistry if no toxicity data[a]
- Outside LDW study area
- Road
- River mile
- Navigation channel

[a] Exceedances of the SQS and CSL chemical criteria are based on detected concentrations. For chemicals whose SQS and CSL are on an organic carbon normalized basis, if the TOC was < 0.5% or > 4.0%, the dry weight concentration of that chemical was compared to the LAET and 2LAET, and exceedances of the LAET and 2LAET were equated with exceedances of the SQS and CSL, respectively.

Wind Ward environmental LLC

0 0.1 0.2 Miles

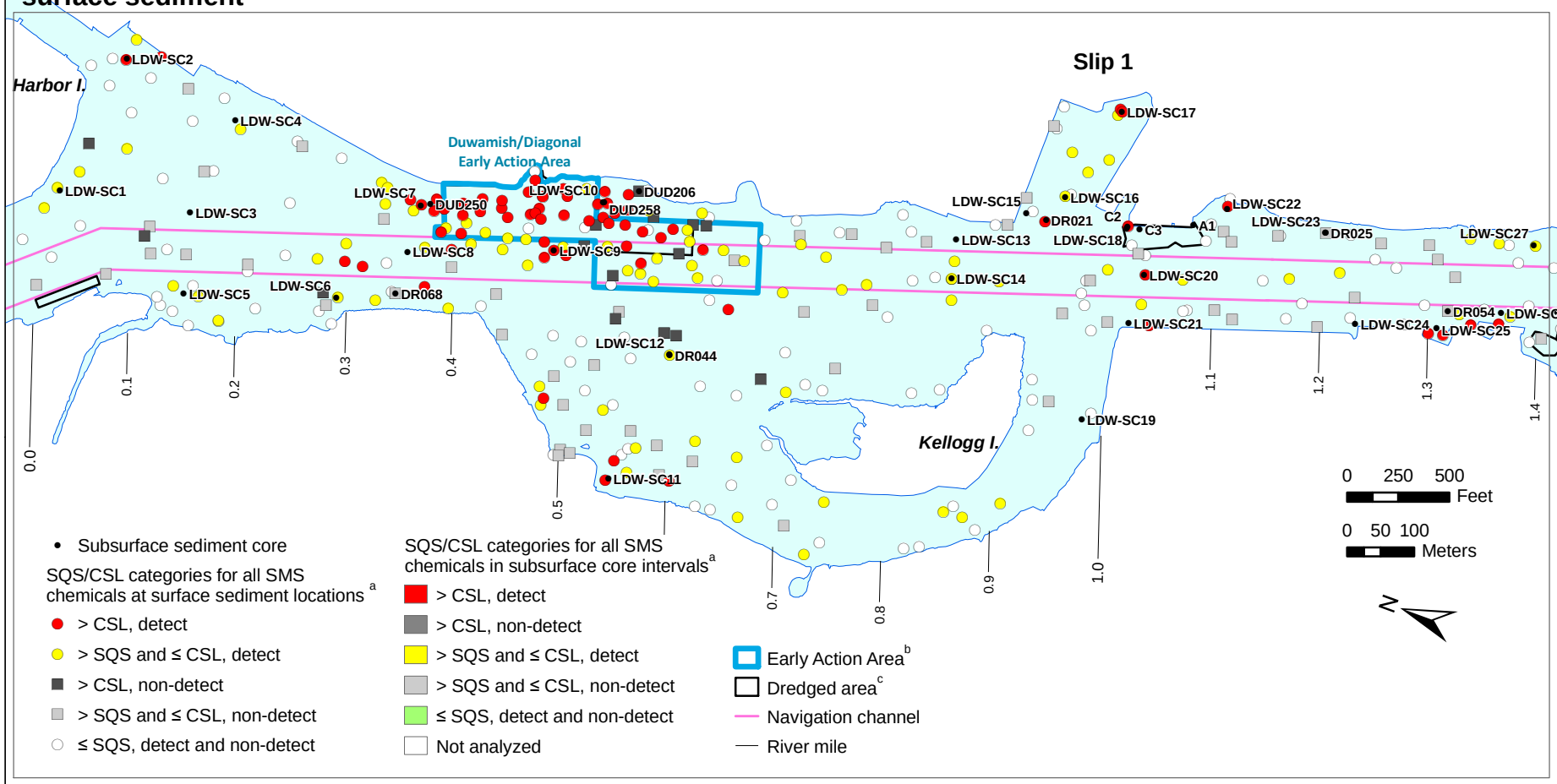
0 0.1 0.2 Kilometers

Scale is the same for each inset map

Map 4-16. Exceedances of SQS and CSL (chemical criteria and toxicity combined) using Thiessen polygons for the baseline surface sediment dataset

Prepared by CEH, 07/14/2010; MAP #2383; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Nature and Extent\Surface Sediment\SMS

Subsurface sediment core locations and exceedances of SQS and CSL (chemical criteria and toxicity combined) in surface sediment



[a] When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations were compared instead to the LAET and 2LAET.

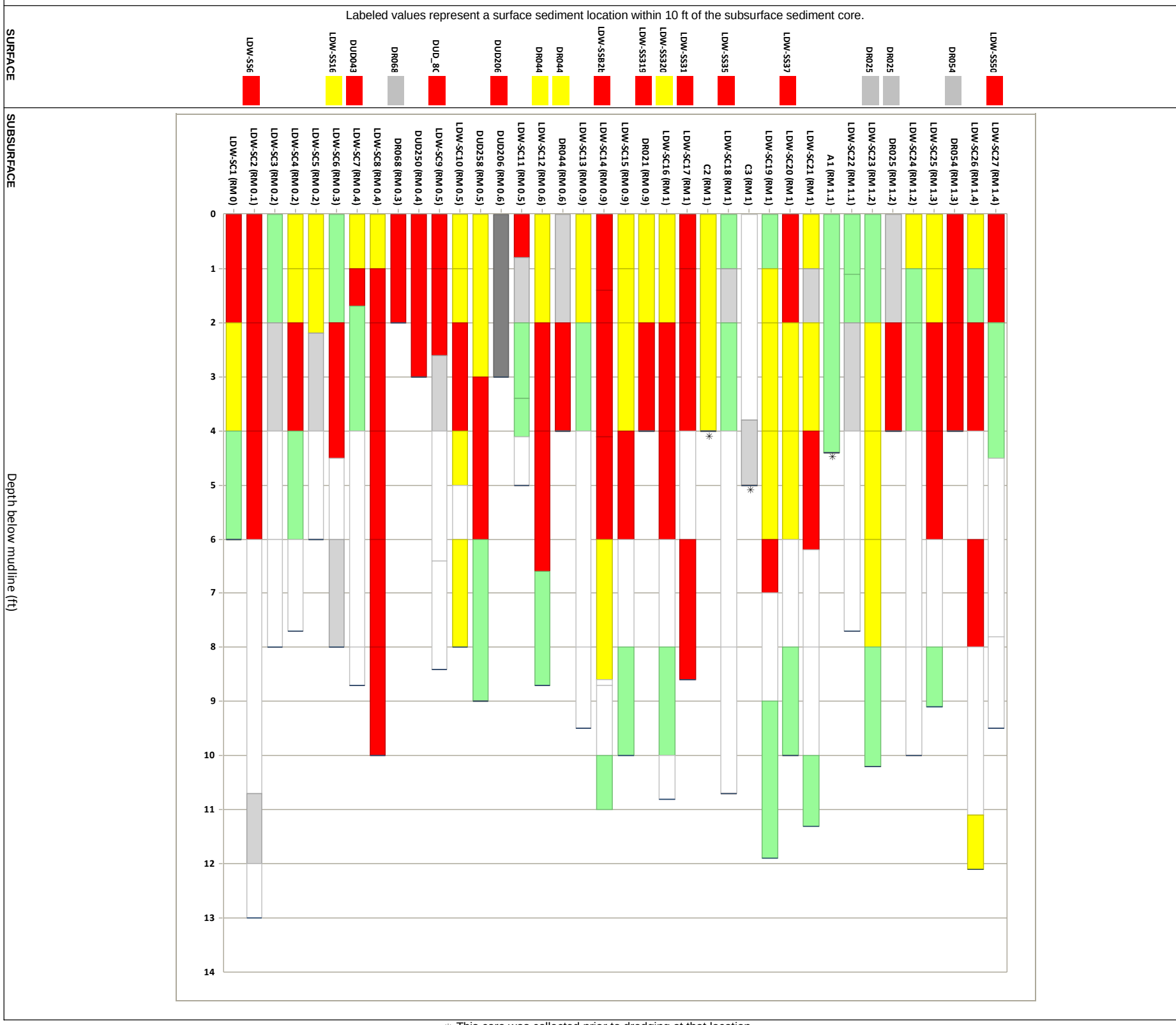
[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] Subsurface sediment data in the Duwamish/Diagonal Early Action Area were collected prior to dredging and capping or thin-layer placement. In other dredged areas subsurface data were collected prior to dredging.

Note: This map does not include samples in the Duwamish/Diagonal dredged and capped area.

Exceedances of SQS and CSL in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment location within 10 ft of the subsurface sediment core.



✳ This core was collected prior to dredging at that location.

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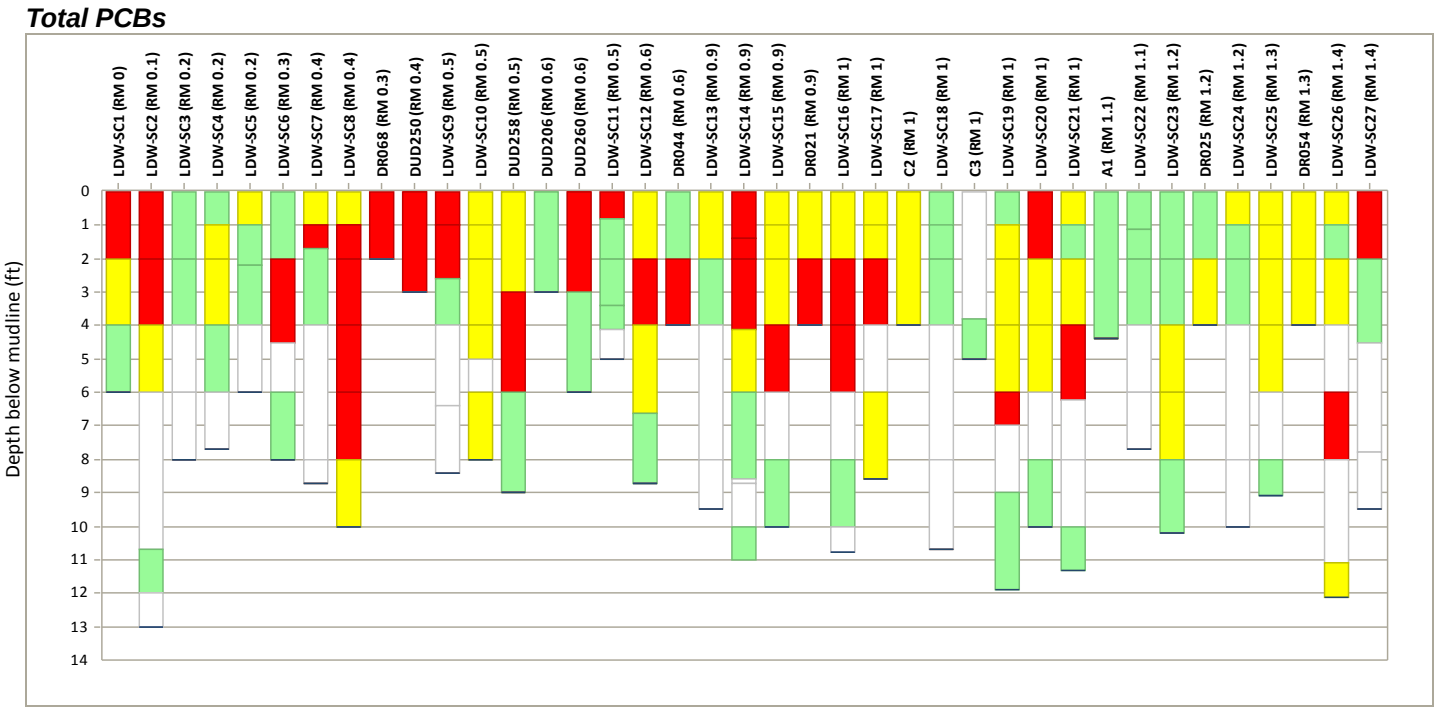
Map 4-17a. Comparisons of concentrations of all SMS chemicals to SMS criteria (SQS or CSL) in subsurface sediment cores, RM 0.0 to RM 1.4

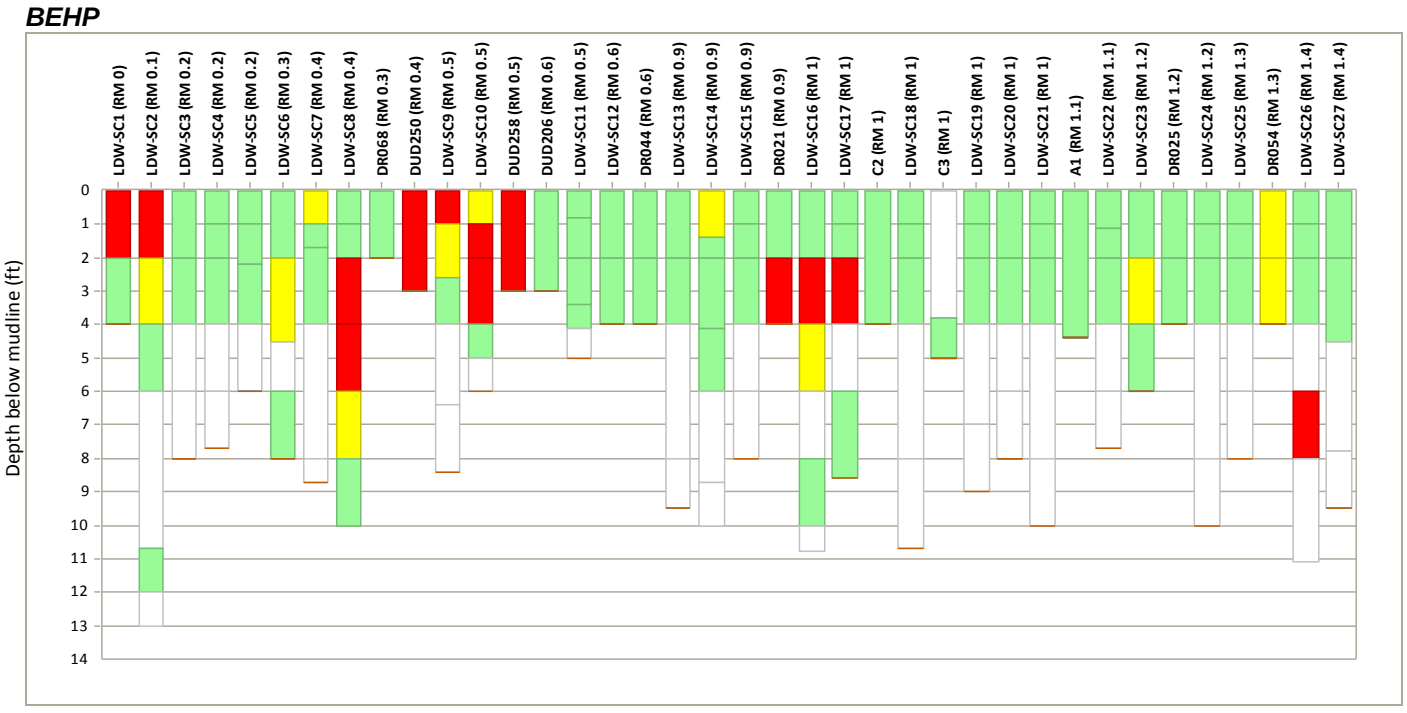
Prepared by CEH, 07/14/2010; MAP 2984; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.

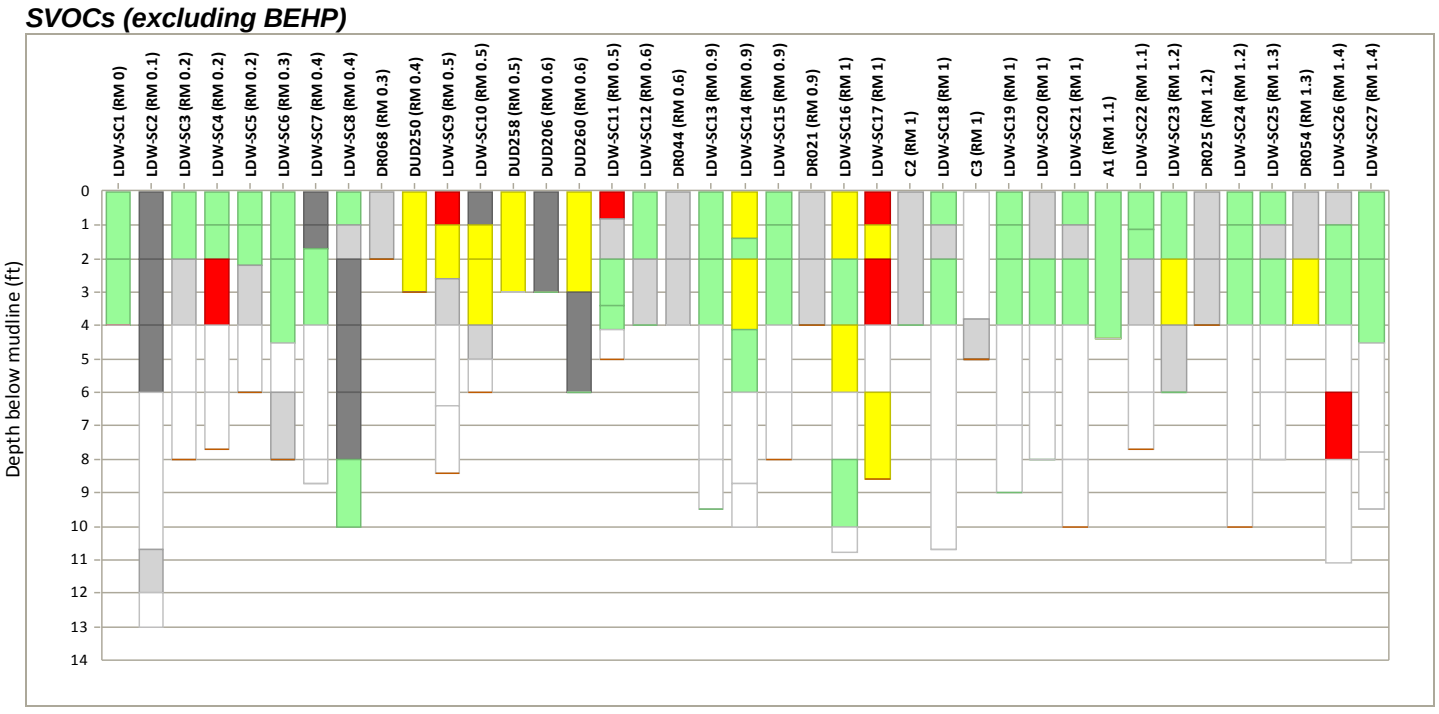
Total PCBs



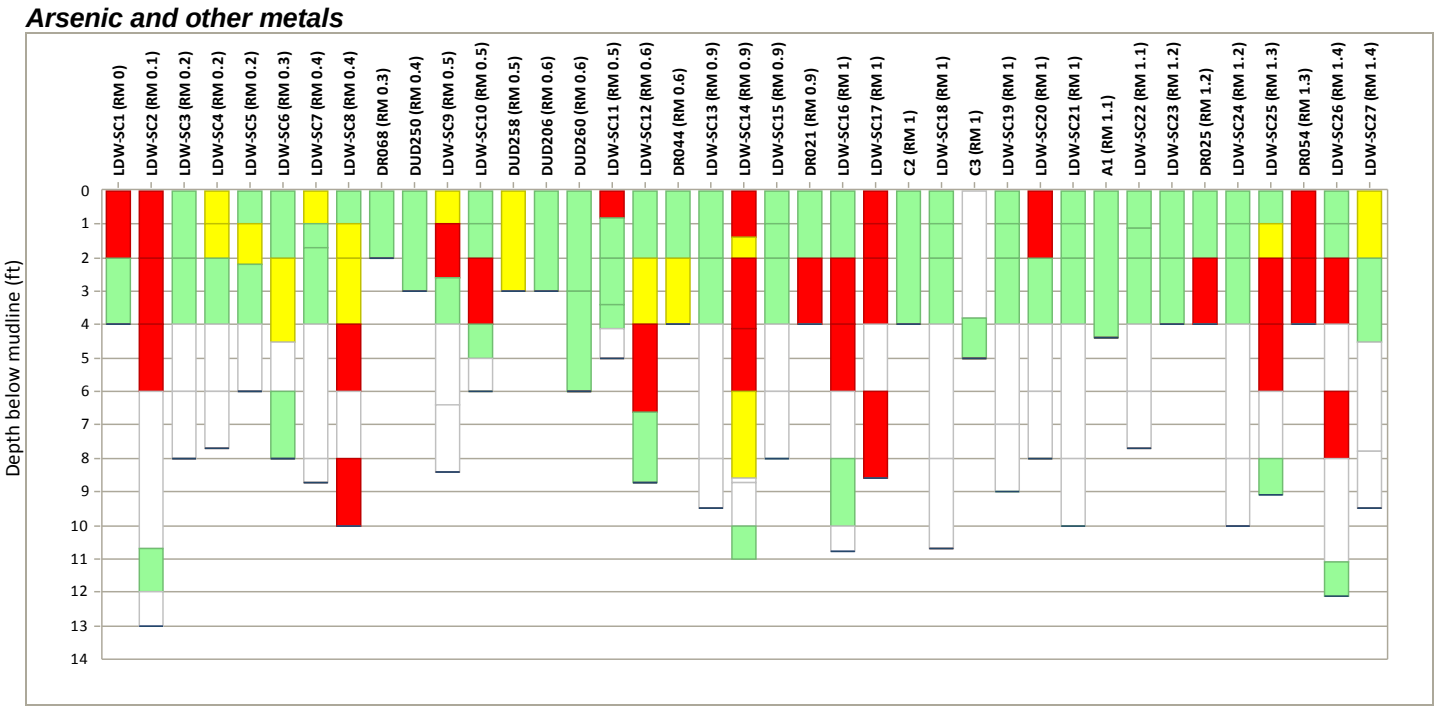
BEHP



SVOCs (excluding BEHP)



Arsenic and other metals



Wind Ward LLC environmental

SQS/CSL categories for SMS chemicals in subsurface core intervals[a]

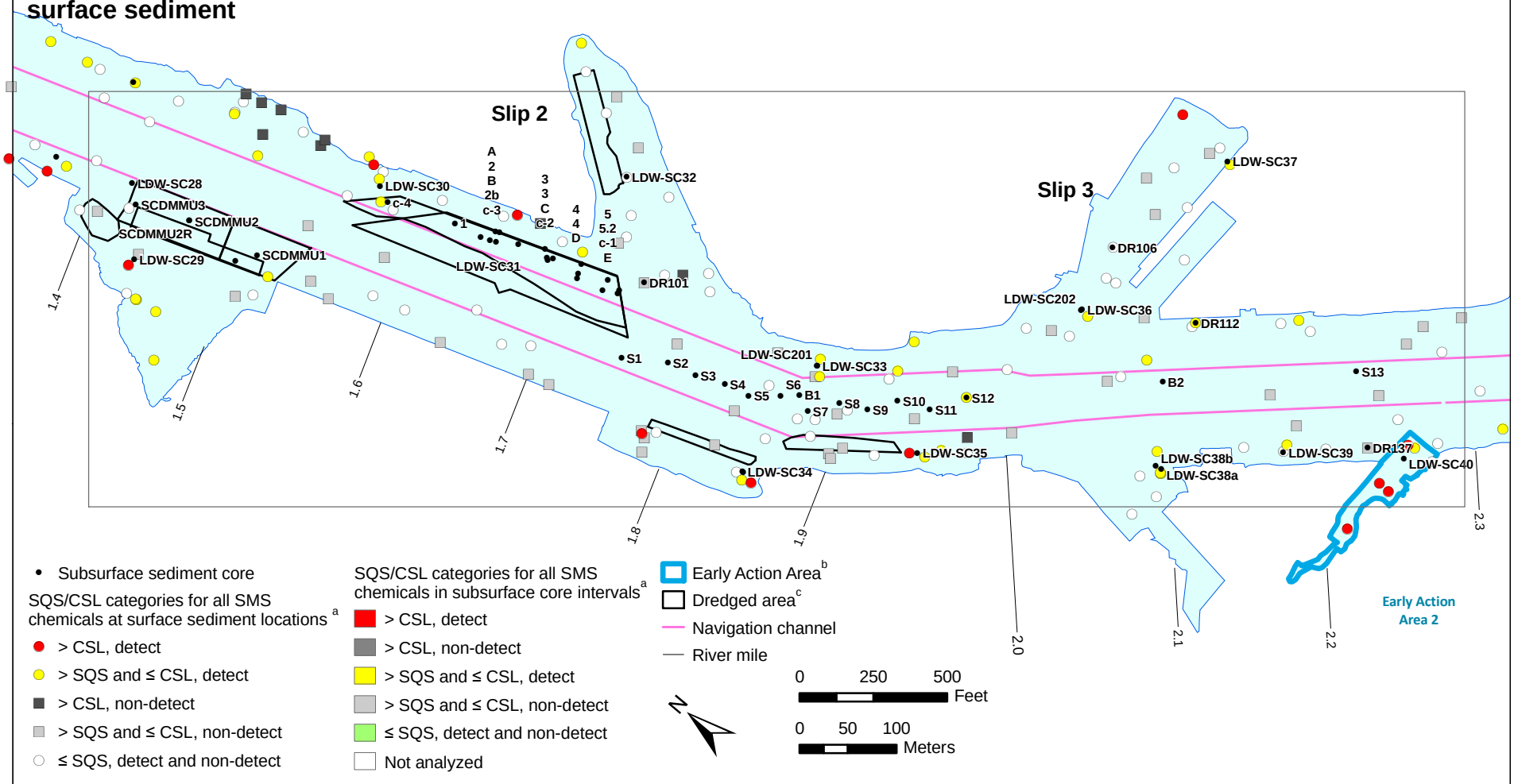
- > CSL, detected
- > SQS and ≤ CSL, detected
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not analyzed

[a] When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations were compared instead to the LAET and 2LAET.

Map 4-17b. Comparisons of concentrations of total PCBs, BEHP, SVOCs, and metals to SMS criteria (SQS or CSL) in subsurface sediment cores, RM 0.0 to RM 1.4

Prepared by CEH, 07/14/2010; MAP 2984; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Subsurface sediment core locations and exceedances of SQS and CSL (chemical criteria and toxicity combined) in surface sediment



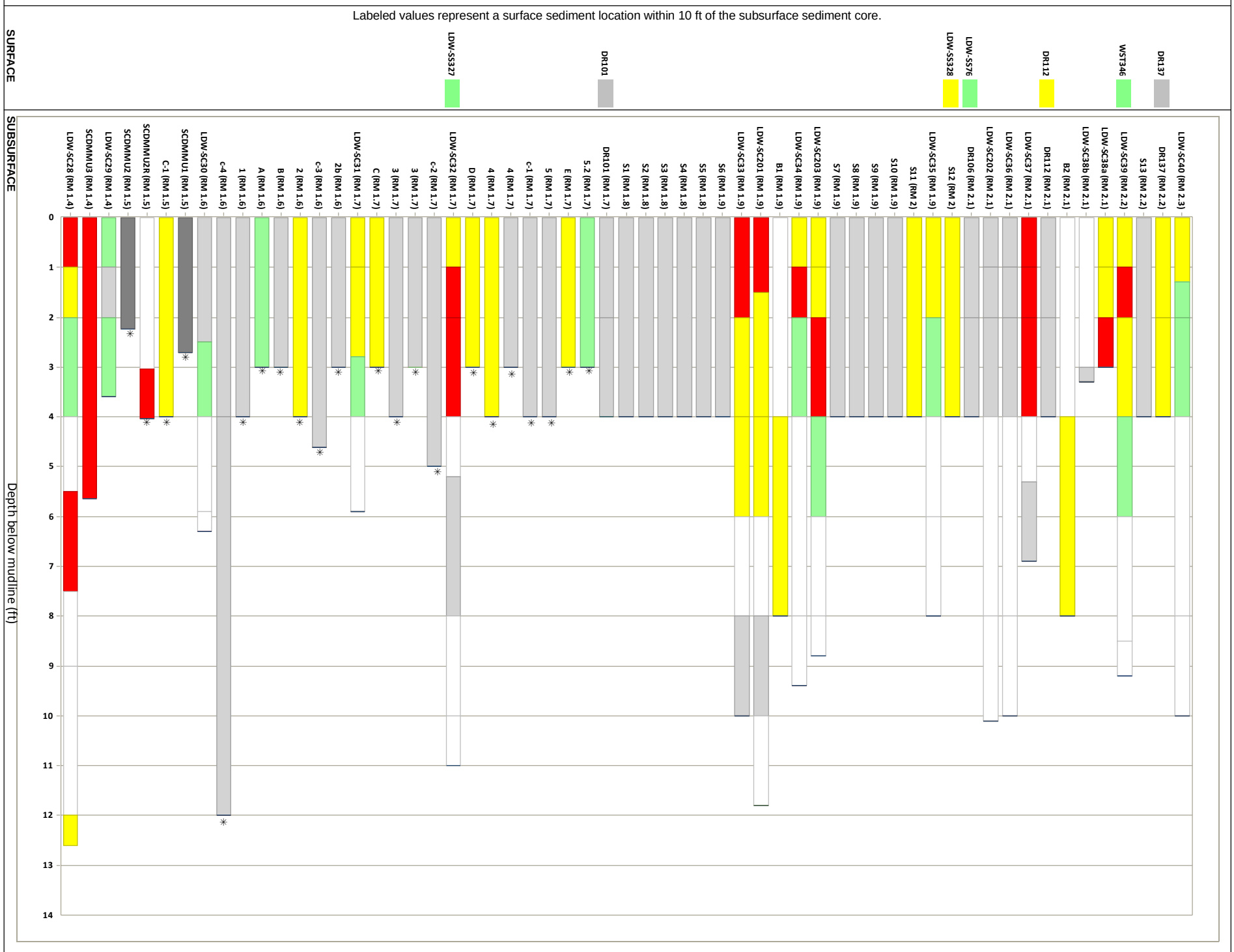
[a] When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations were compared instead to the LAET and 2LAET.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] Subsurface sediment data in dredged areas were collected prior to dredging.

Exceedances of SQS and CSL in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment location within 10 ft of the subsurface sediment core.



✳ This core was collected prior to dredging at that location.

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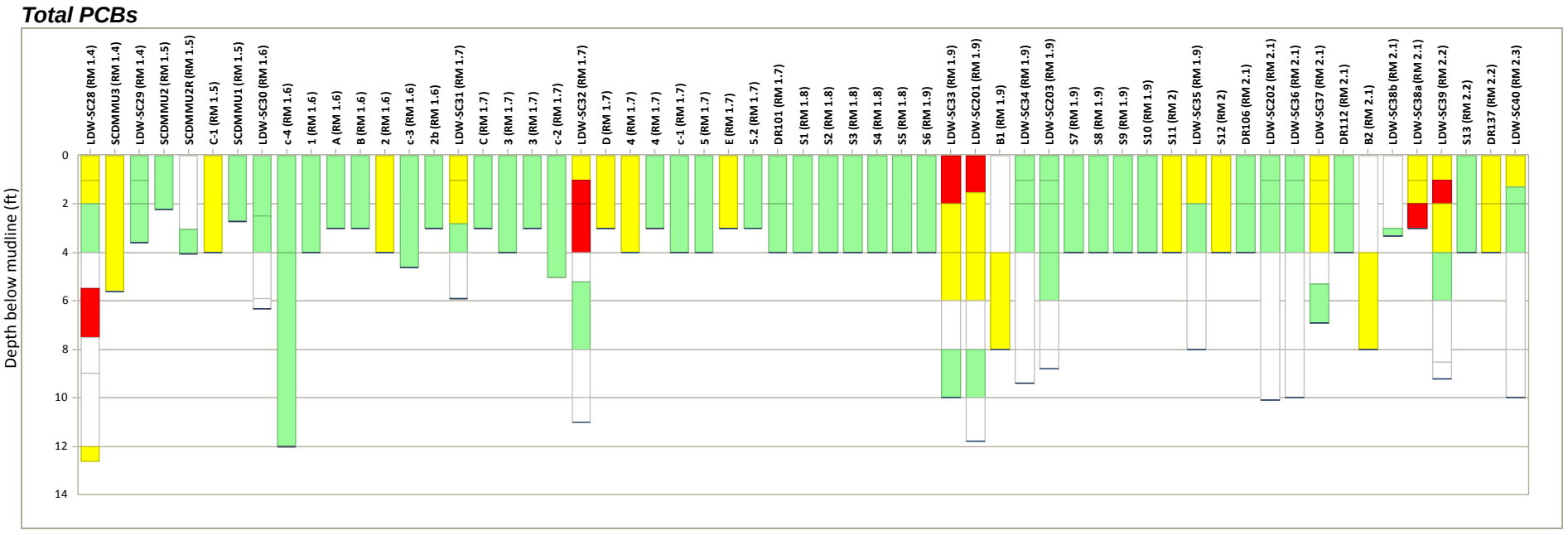
Map 4-17c. Comparisons of concentrations of all SMS chemicals to SMS criteria (SQS or CSL) in subsurface sediment cores, RM 1.4 to RM 2.3

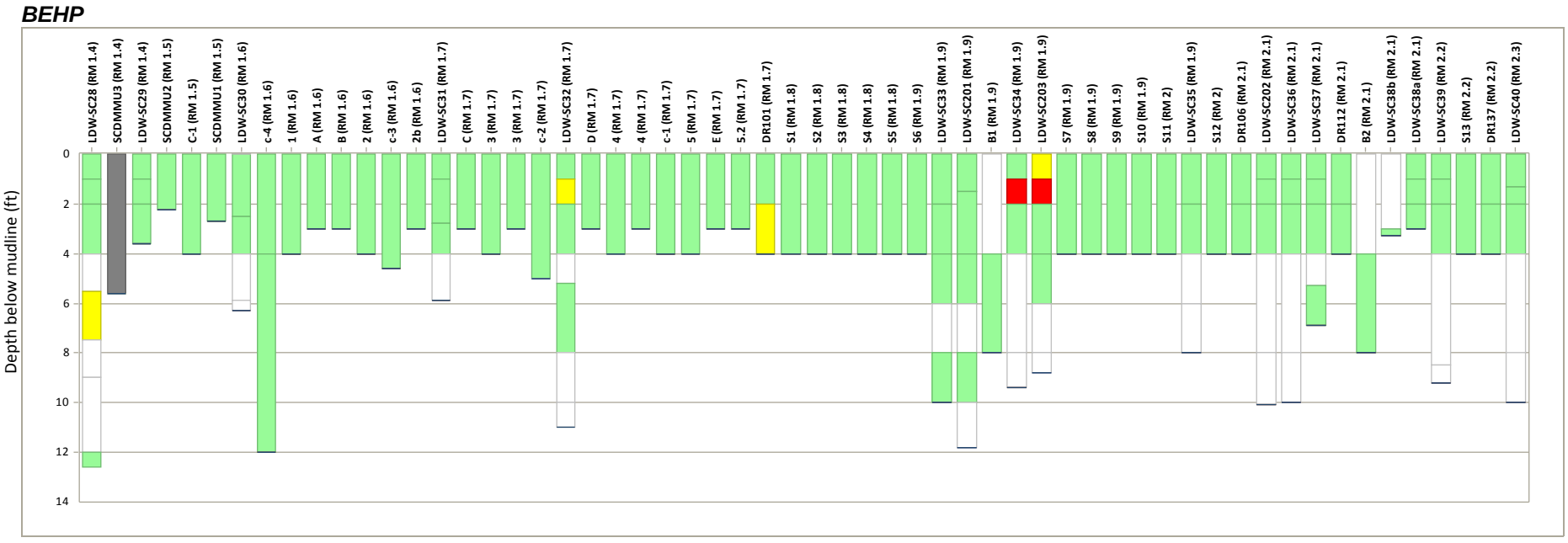
Prepared by CEH, 07/14/2010; MAP 2984; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.

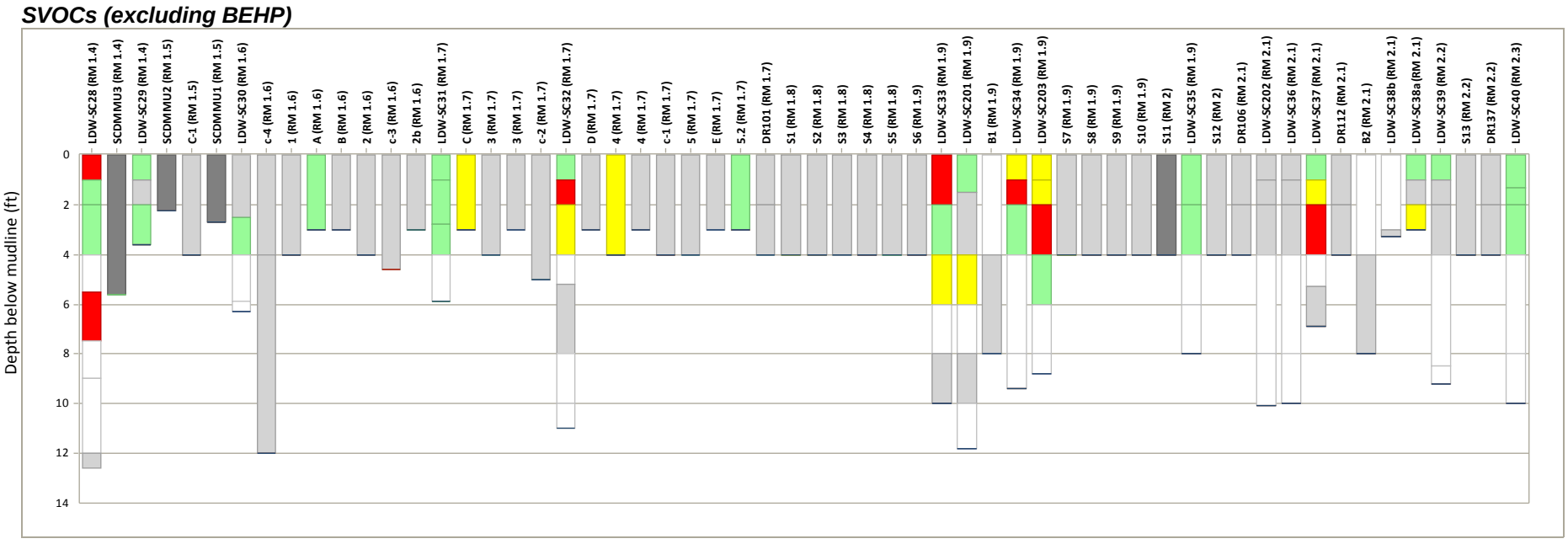
Total PCBs



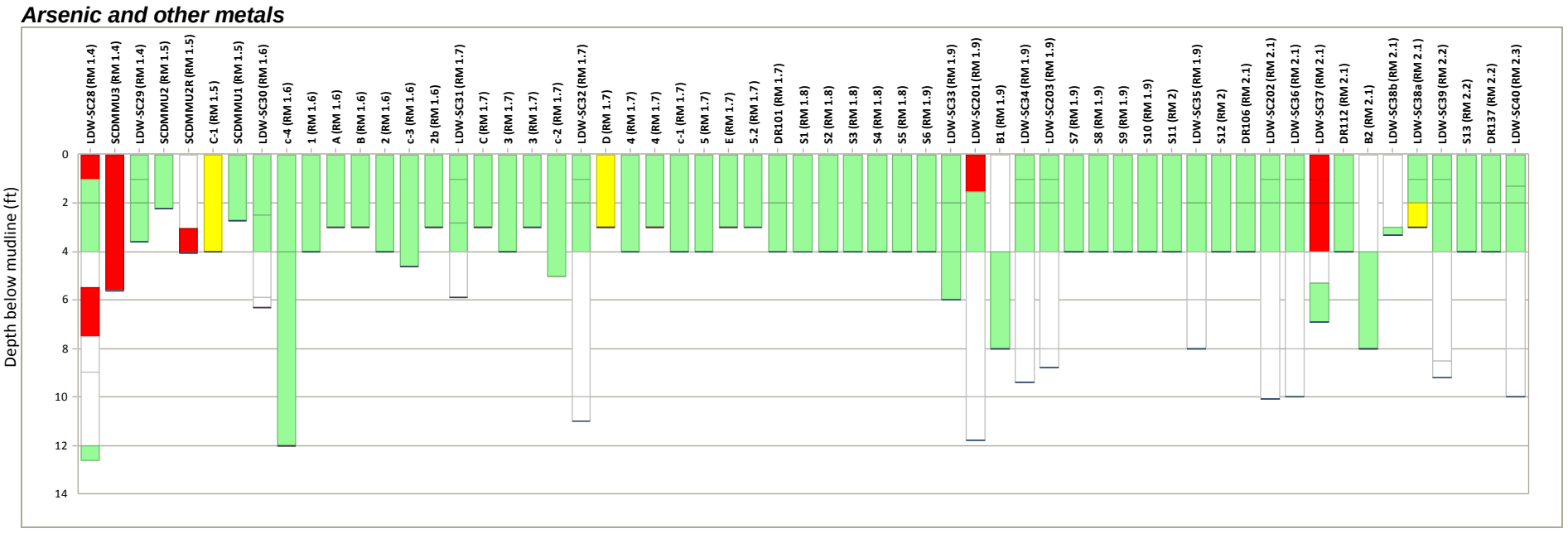
BEHP



SVOCs (excluding BEHP)



Arsenic and other metals



Prepared by CEH, 07/14/2010, MAP 2984; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

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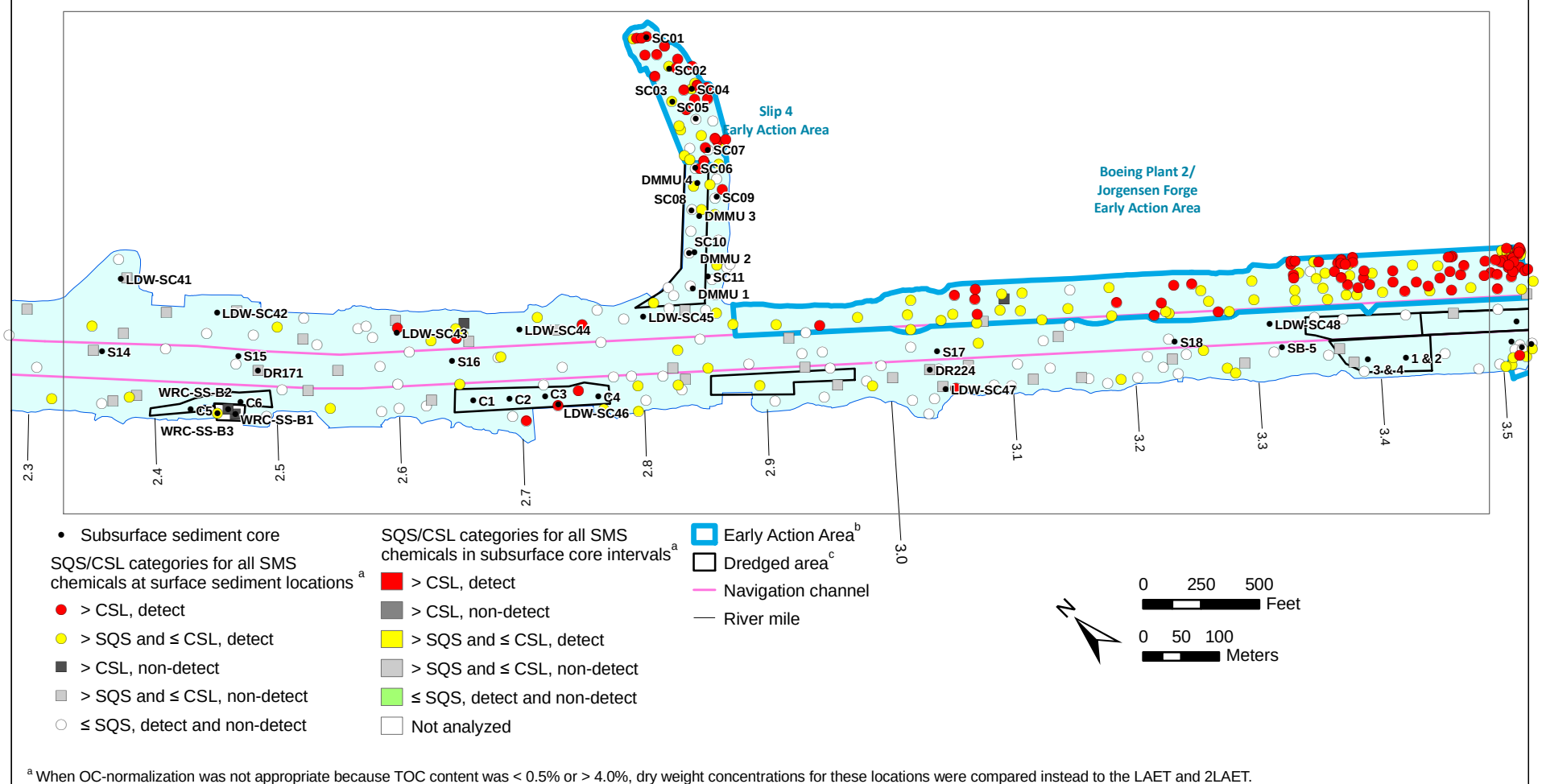
SQS/CSL categories for SMS chemicals in subsurface core intervals[a]

- > CSL, detected
- > SQS and ≤ CSL, detected
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not analyzed

[a] When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations were compared instead to the LAET and 2LAET.

Map 4-17d. Comparisons of concentrations of total PCBs, BEHP, SVOCs, and metals to SMS criteria (SQS or CSL) in subsurface sediment cores, RM 1.4 to RM 2.3

Subsurface sediment core locations and exceedances of SQS and CSL (chemical criteria and toxicity combined) in surface sediment



- Subsurface sediment core

SQS/CSL categories for all SMS chemicals at surface sediment locations[a]

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect

SQS/CSL categories for all SMS chemicals in subsurface core intervals[a]

- > CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not analyzed

- Early Action Area[b]
- Dredged area[c]
- Navigation channel
- River mile

[a] When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations were compared instead to the LAET and 2LAET.

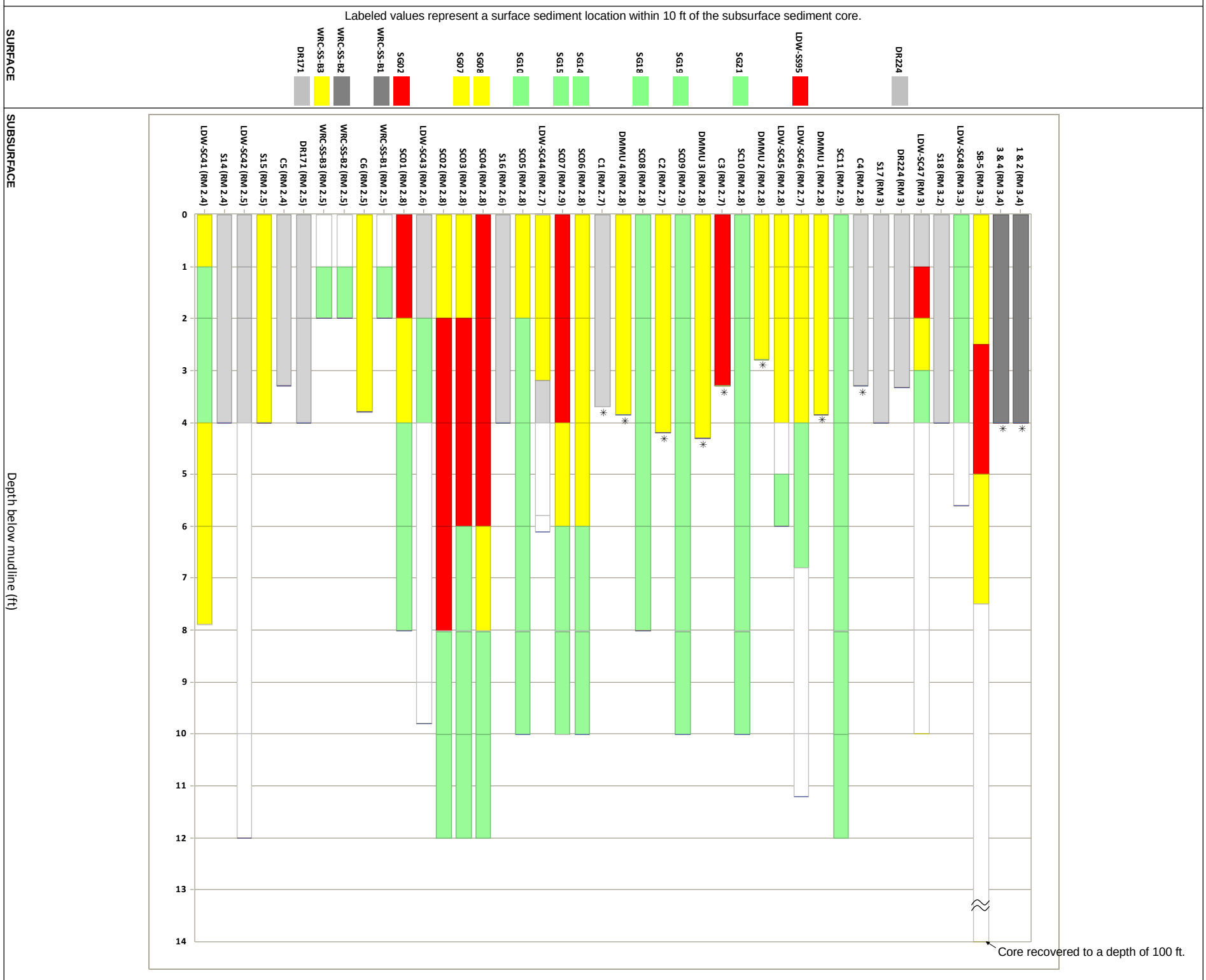
[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] Subsurface sediment data in dredged areas were collected prior to dredging.

Note: This map does not include samples in the Boeing Plant 2/Jorgensen Forge Early Action Area.

Exceedances of SQS and CSL in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment location within 10 ft of the subsurface sediment core.



✳ This core was collected prior to dredging at that location.

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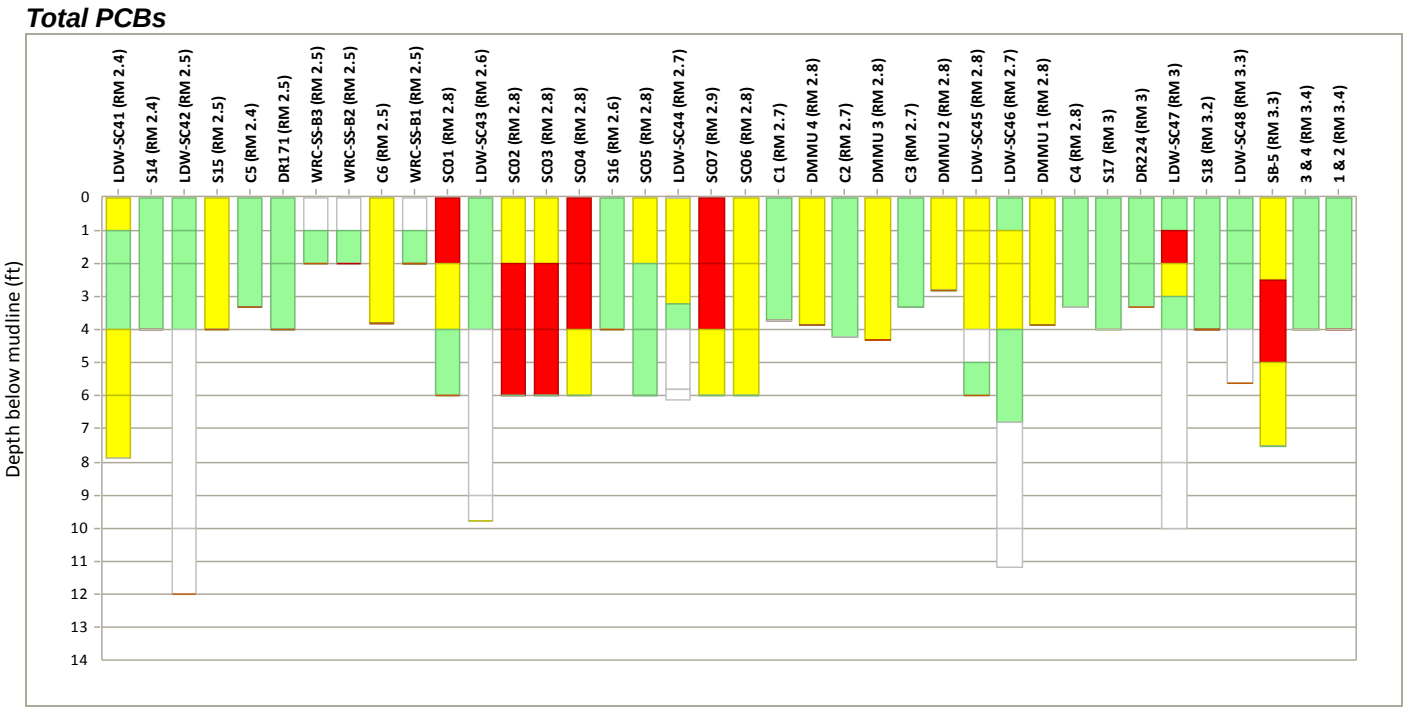
Map 4-17e. Comparisons of concentrations of all SMS chemicals to SMS criteria (SQS or CSL) in subsurface sediment cores, RM 2.3 to RM 3.5

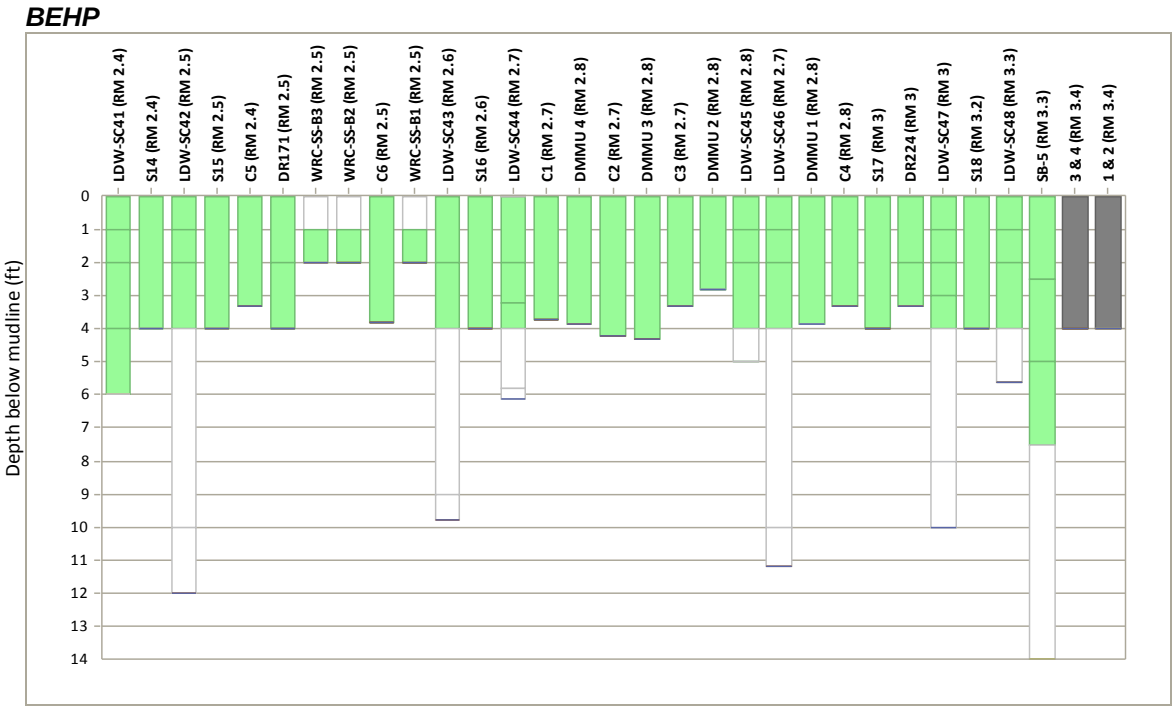
Prepared by CEH, 07/14/2010; MAP 2984; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.

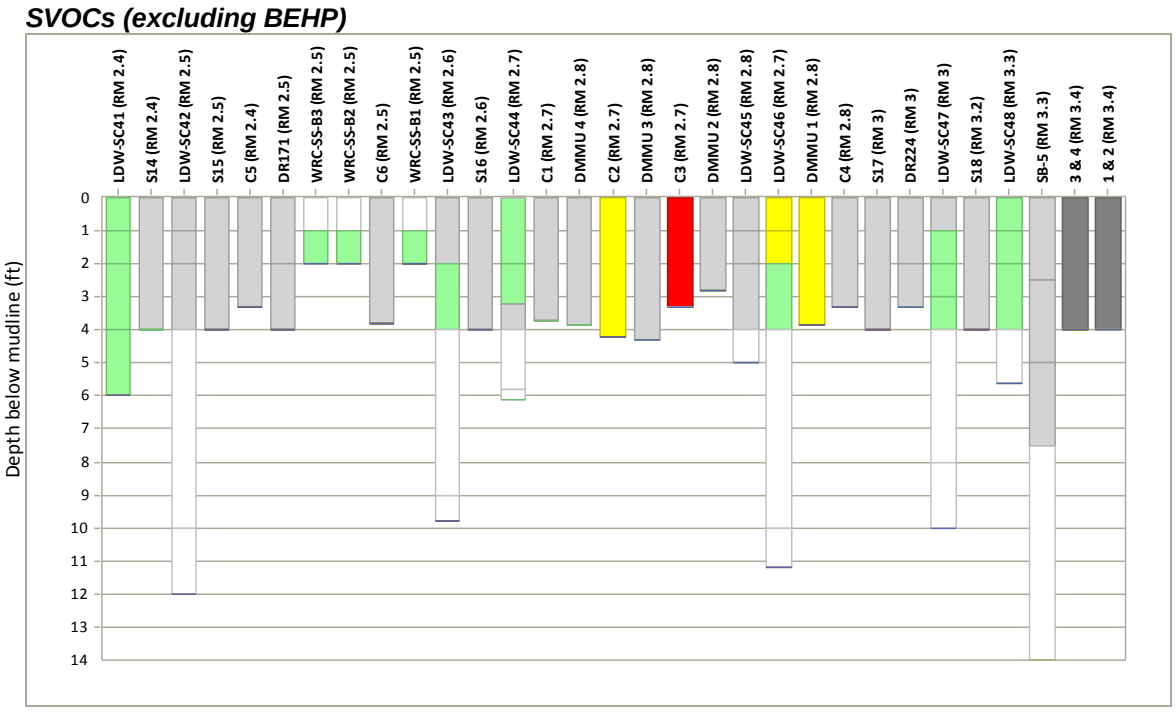
Total PCBs



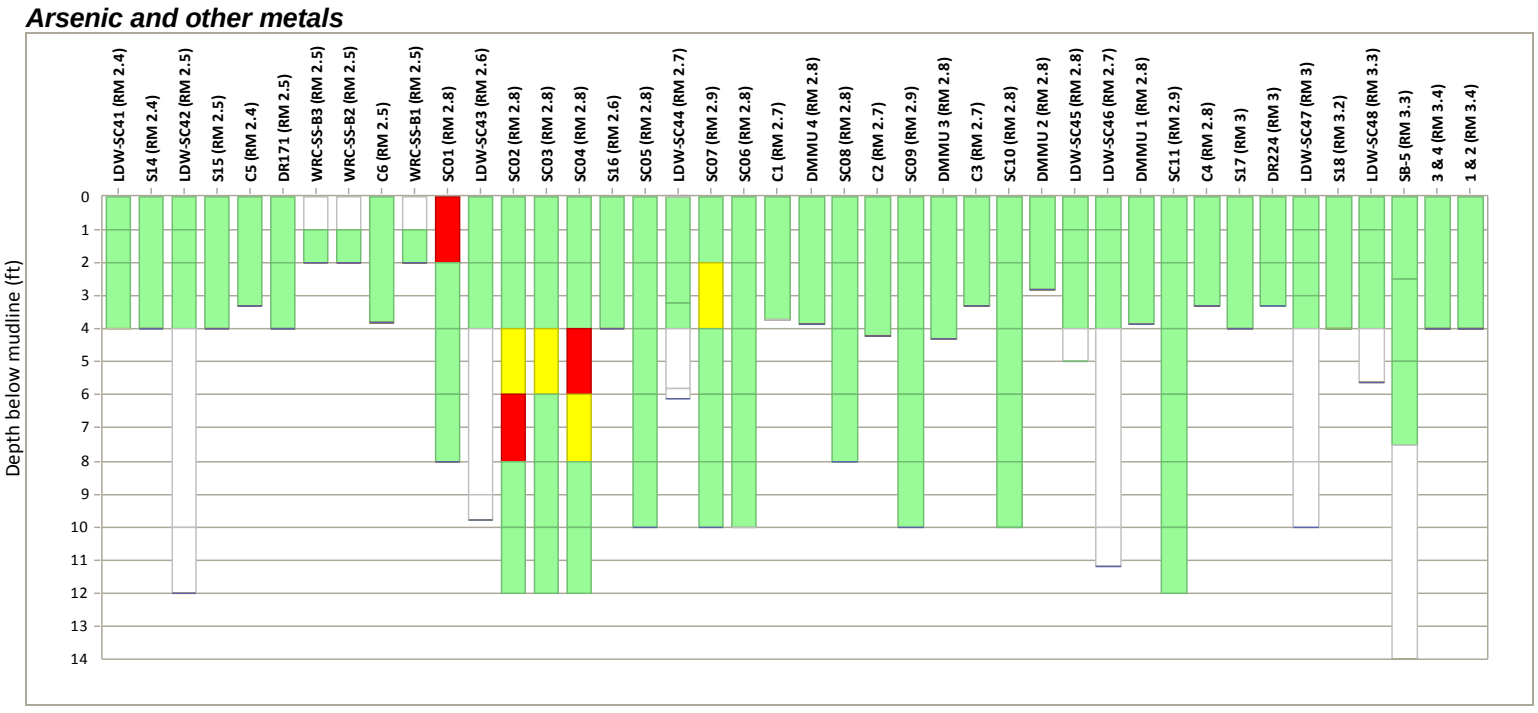
BEHP



SVOCs (excluding BEHP)



Arsenic and other metals



Wind Ward environmental LLC

SQS/CSL categories for SMS chemicals in subsurface core intervals[a]

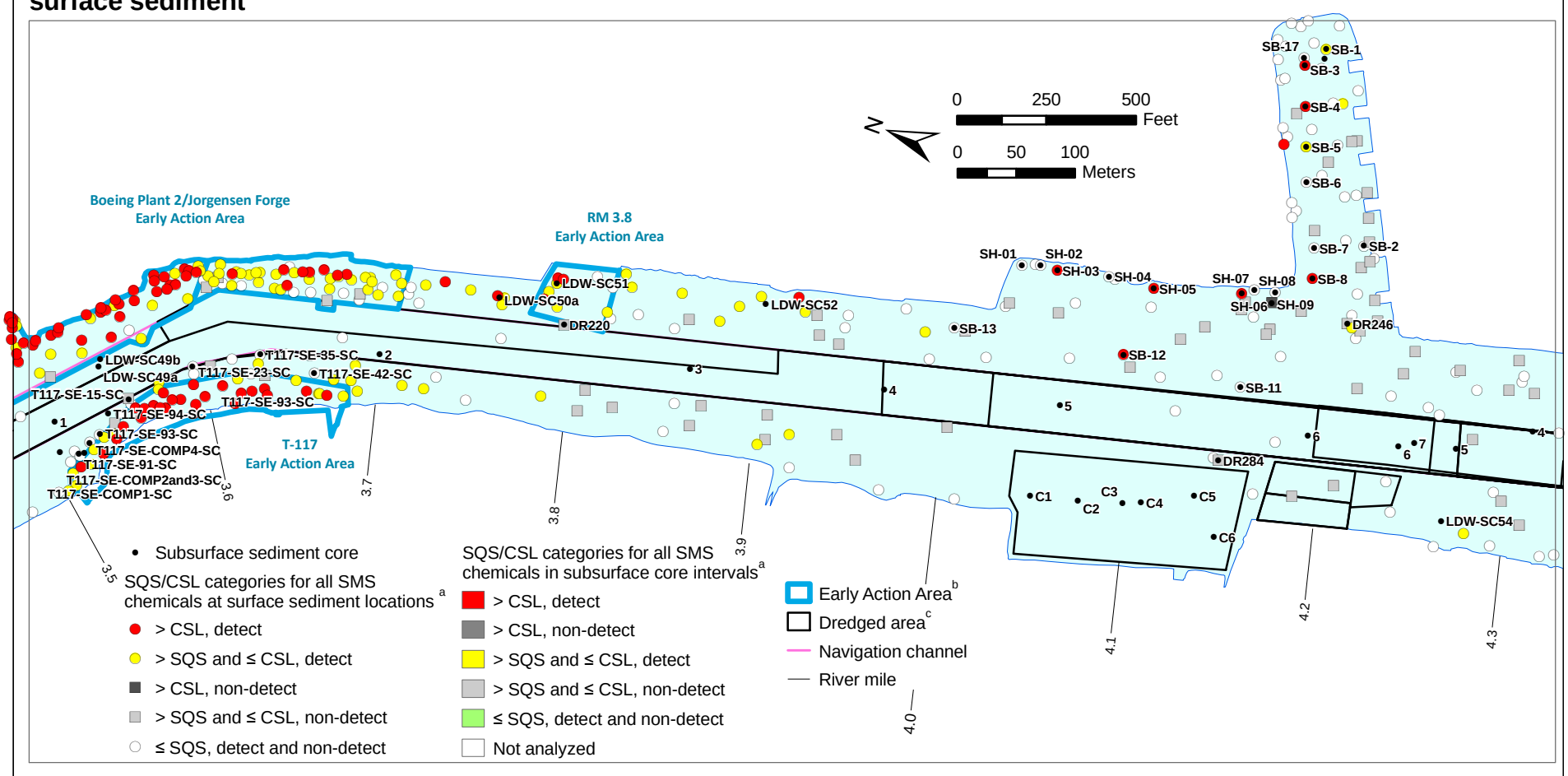
- > CSL, detected
- > SQS and ≤ CSL, detected
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not analyzed

[a] When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations were compared instead to the LAET and 2LAET.

Map 4-17f. Comparisons of concentrations of total PCBs, BEHP, SVOCs, and metals to SMS criteria (SQS or CSL) in subsurface sediment cores, RM 2.3 to RM 3.5

Prepared by CEH, 07/14/2010; MAP 2984; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Subsurface sediment core locations and exceedances of SQS and CSL (chemical criteria and toxicity combined) in surface sediment



[a] When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations were compared instead to the LAET and 2LAET.

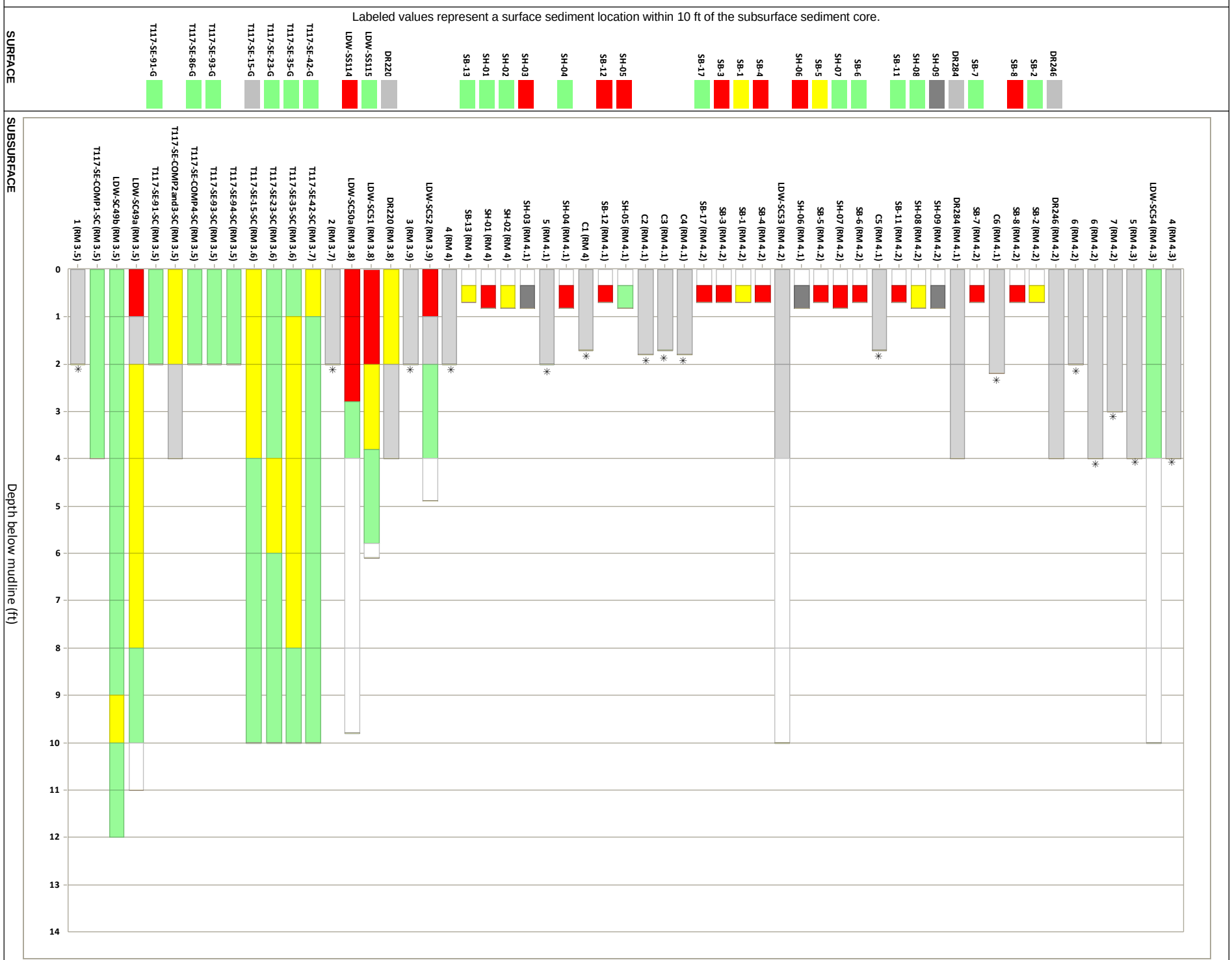
[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] Subsurface sediment data in dredged areas were collected prior to dredging.

Note: This map does not include samples in the Boeing Plant 2/Jorgensen Forge or T-117 Early Action Areas.

Exceedances of SQS and CSL in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment location within 10 ft of the subsurface sediment core.



✳ This core was collected prior to dredging at that location.

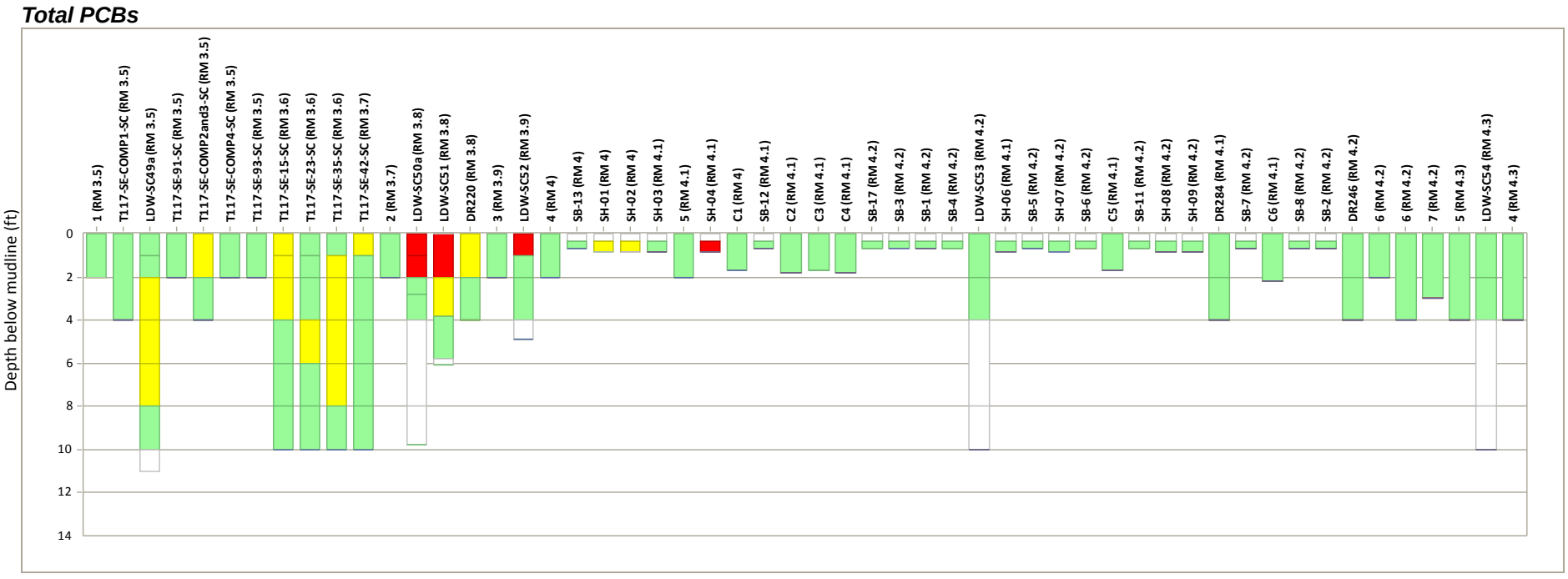
Wind Ward environmental LLC

Map 4-17g. Comparisons of concentrations of all SMS chemicals to SMS criteria (SQS or CSL) in subsurface sediment cores, RM 3.5 to RM 4.3

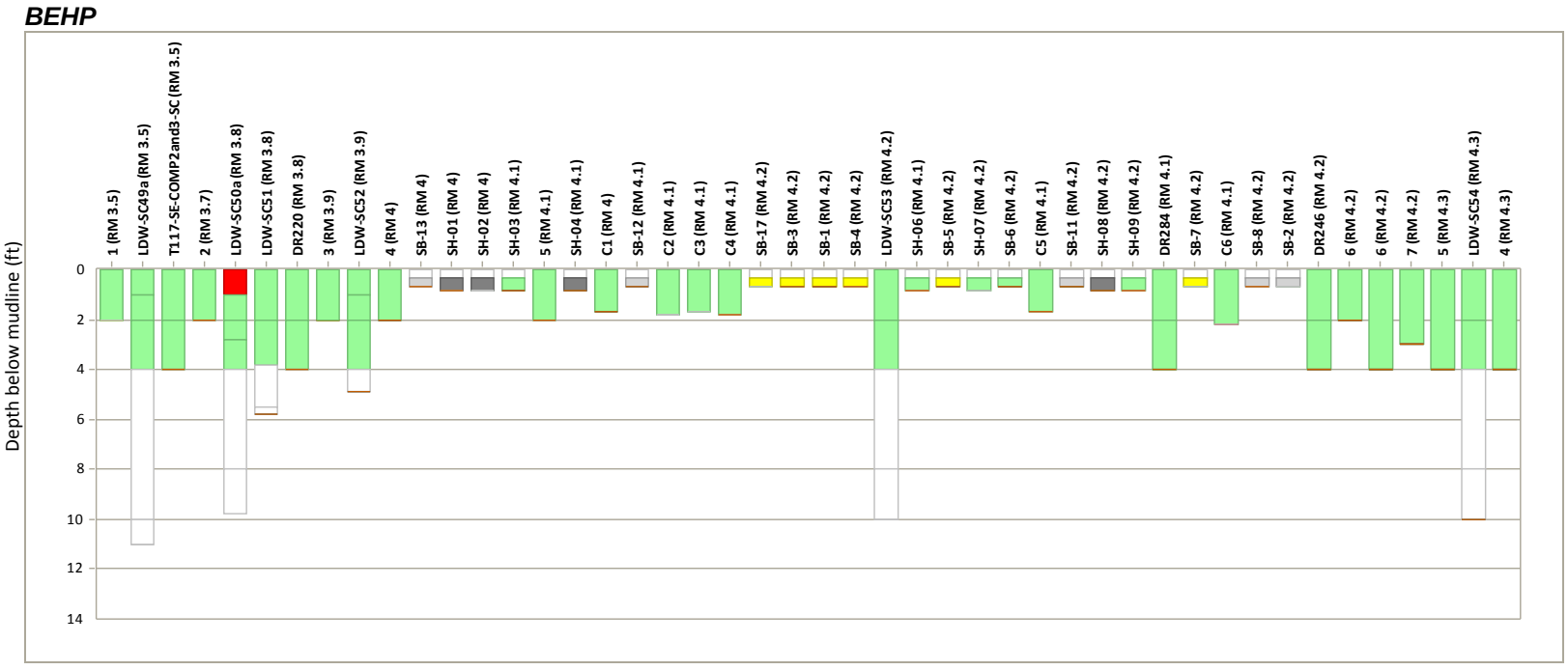
Prepared by CEH, 07/14/2010; MAP 2984; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.

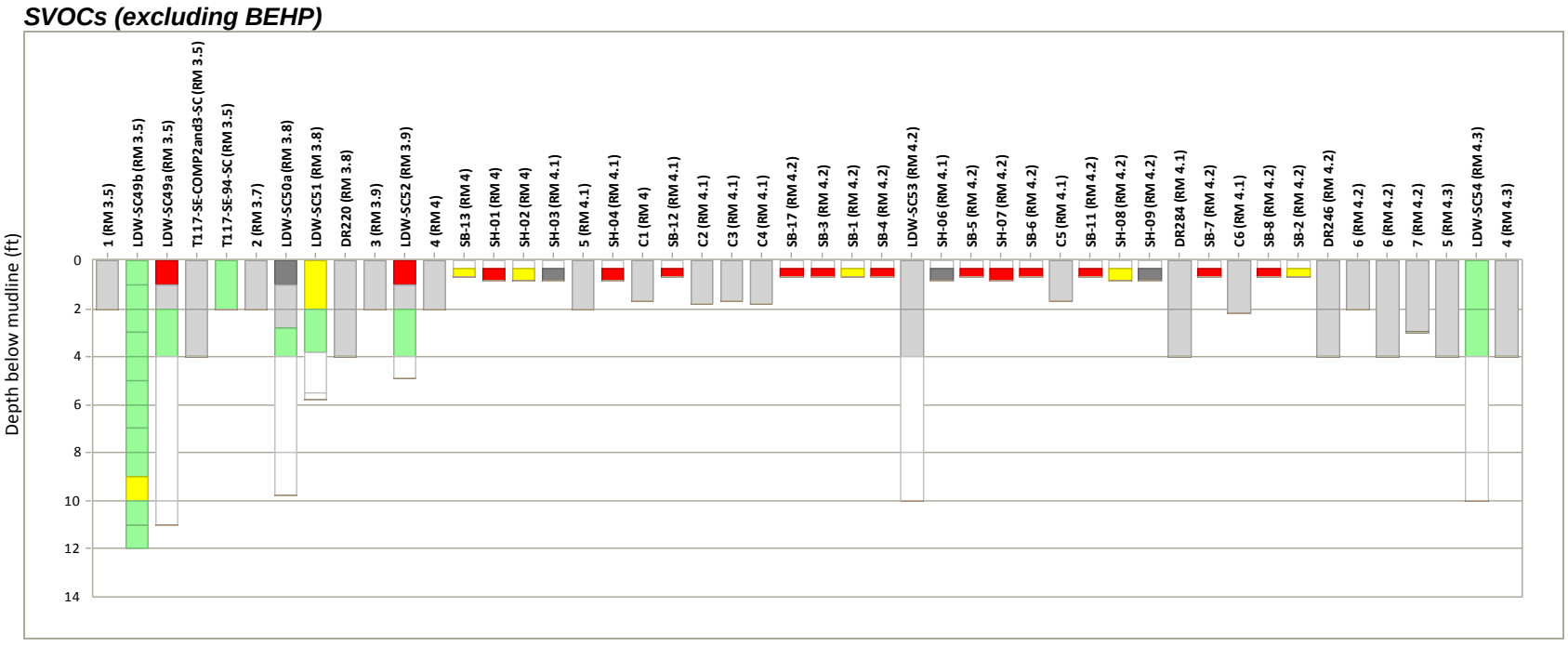
Total PCBs



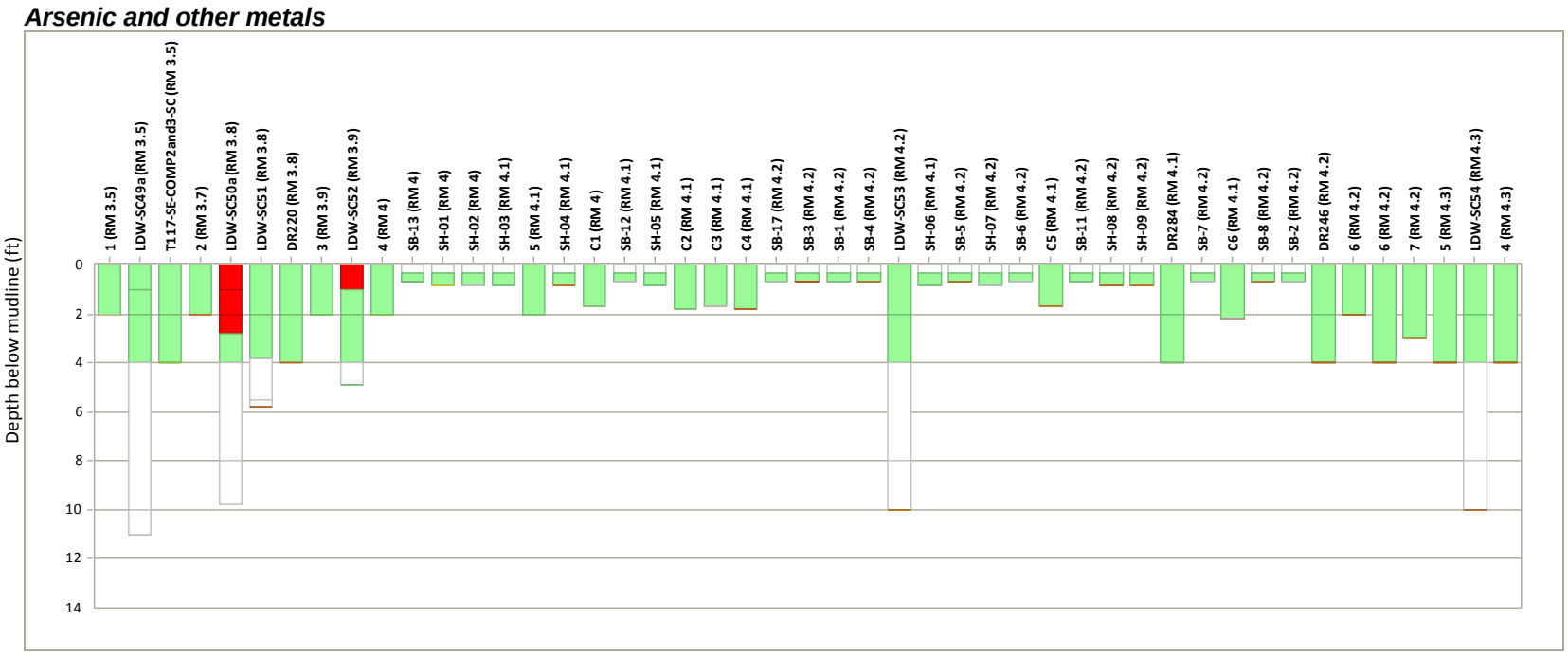
BEHP



SVOCs (excluding BEHP)



Arsenic and other metals



Wind Ward environmental LLC

SQS/CSL categories for SMS chemicals in subsurface core intervals[a]

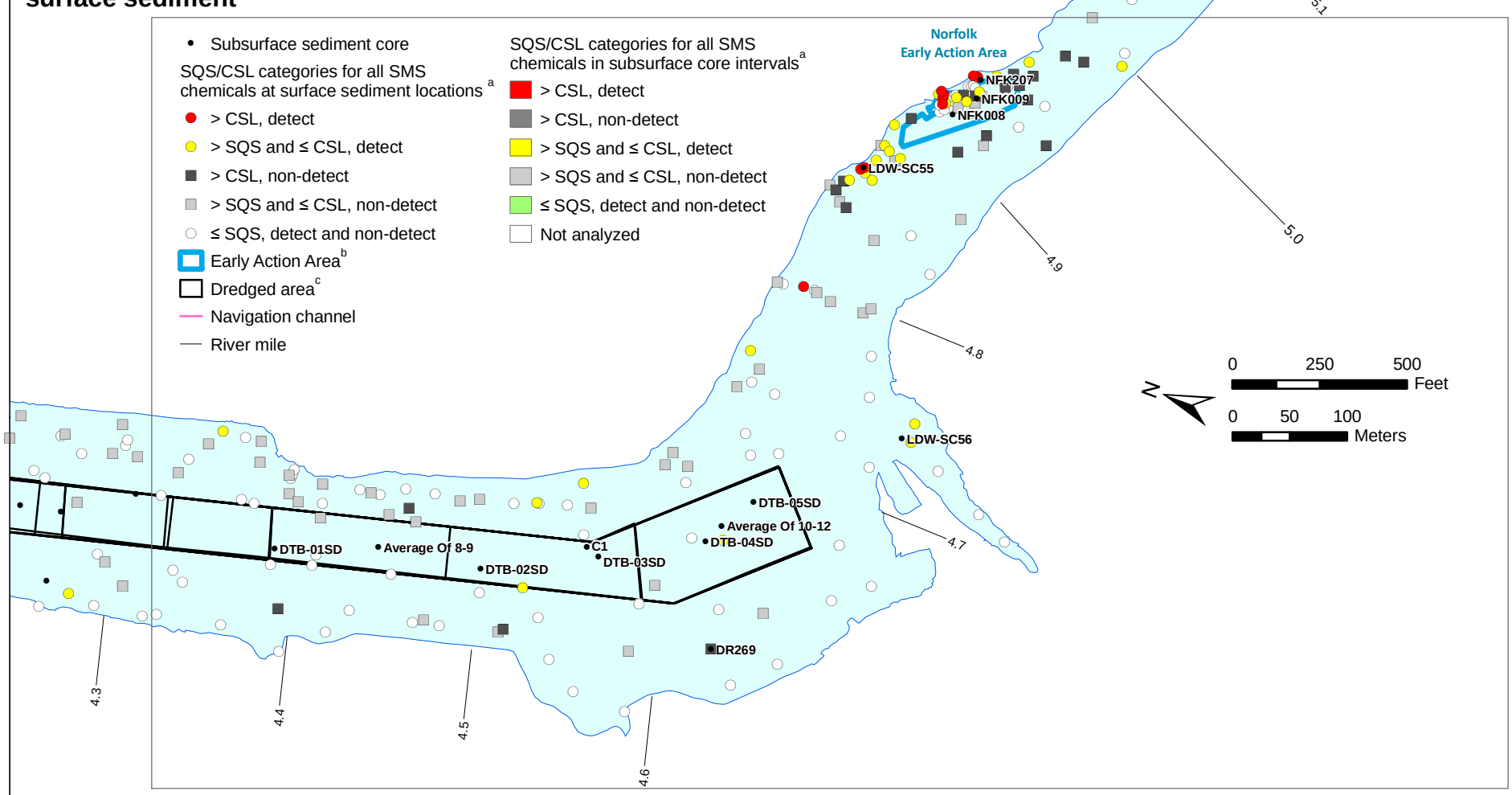
- > CSL, detected
- > SQS and ≤ CSL, detected
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not analyzed

[a] When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations were compared instead to the LAET and 2LAET.

Map 4-17h. Comparisons of concentrations of total PCBs, BEHP, SVOCs, and metals to SMS criteria (SQS or CSL) in subsurface sediment cores, RM 3.5 to RM 4.3

Prepared by CEH, 07/14/2010; MAP 2984; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Subsurface sediment core locations and exceedances of SQS and CSL (chemical criteria and toxicity combined) in surface sediment



[a] When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations were compared instead to the LAET and 2LAET.

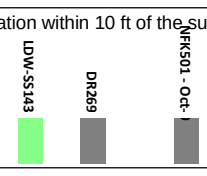
[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] Subsurface data in the Norfolk Early Action Area were collected prior to dredging and capping. In other dredged areas, subsurface data were collected prior to dredging.

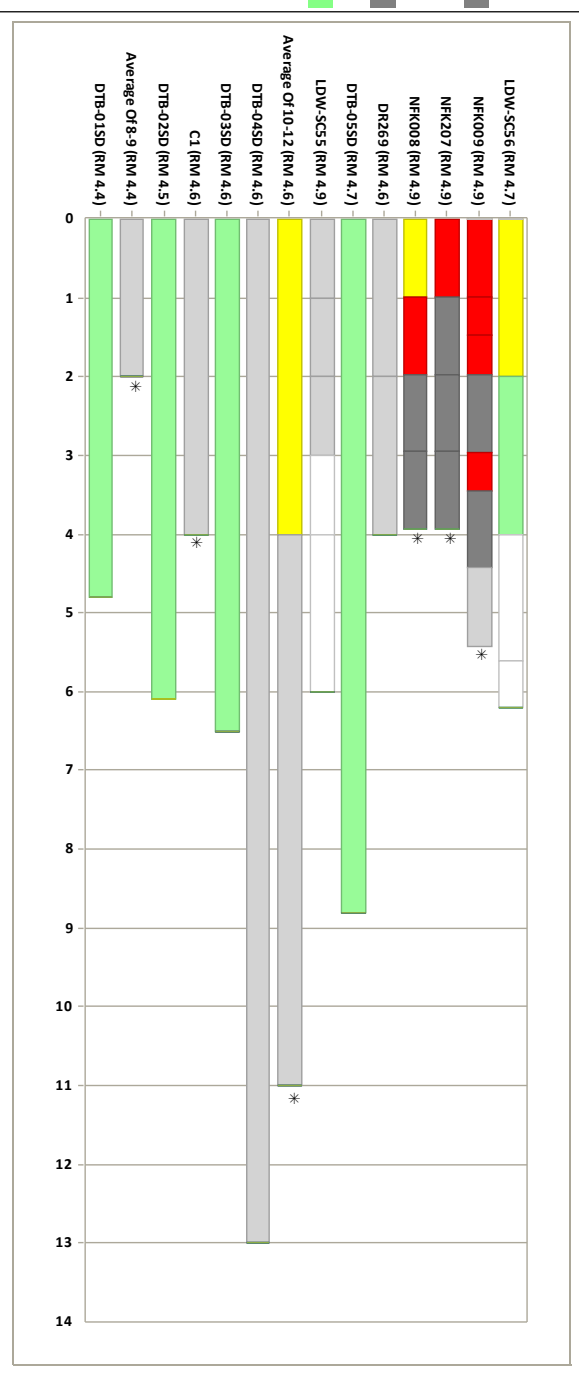
Exceedances of SQS and CSL in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment location within 10 ft of the subsurface sediment core.

SURFACE



SUBSURFACE



✳ This core was collected prior to dredging at that location.

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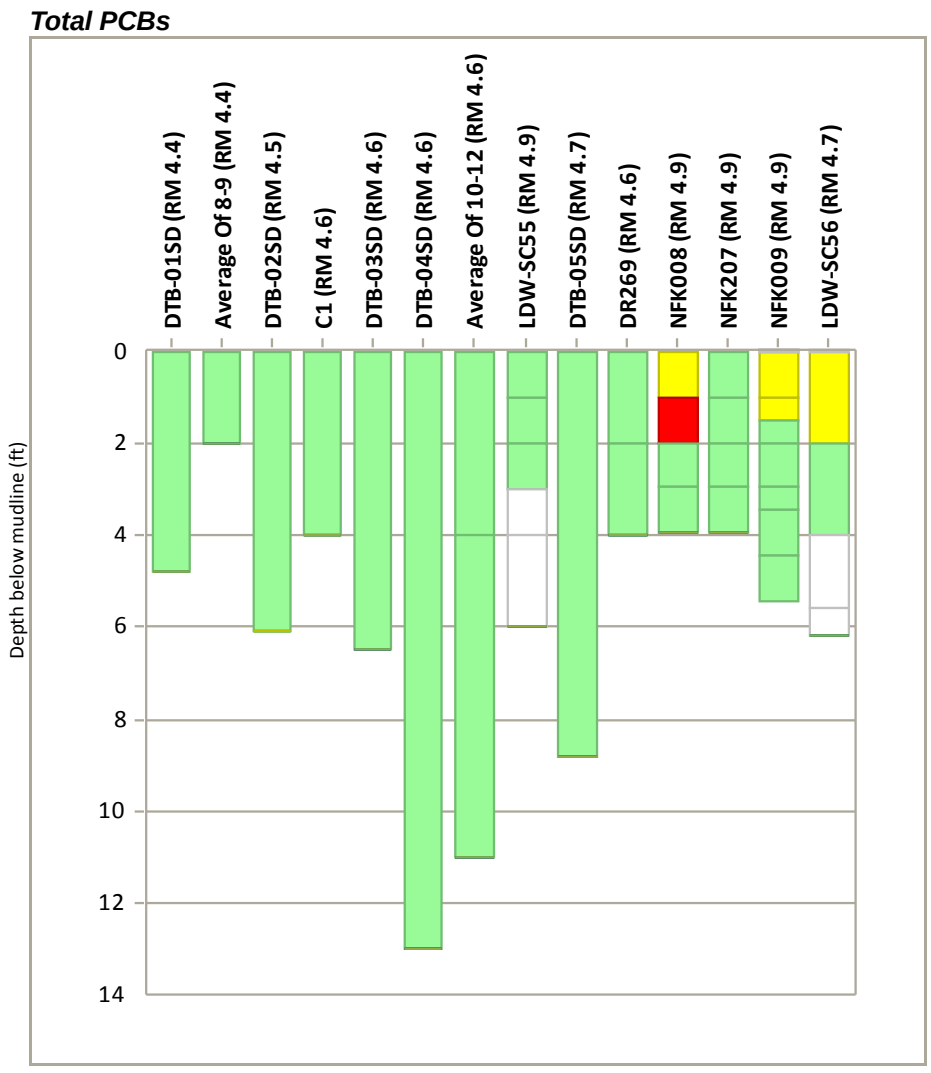
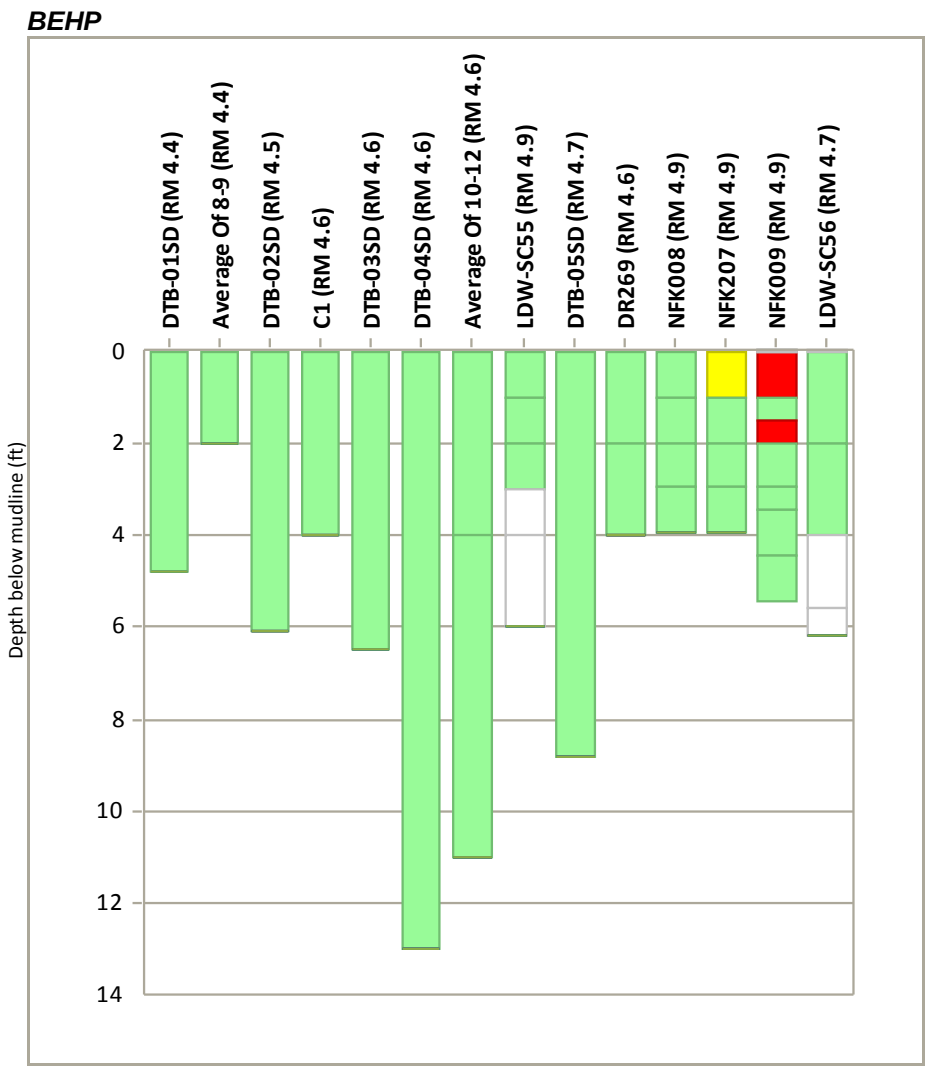
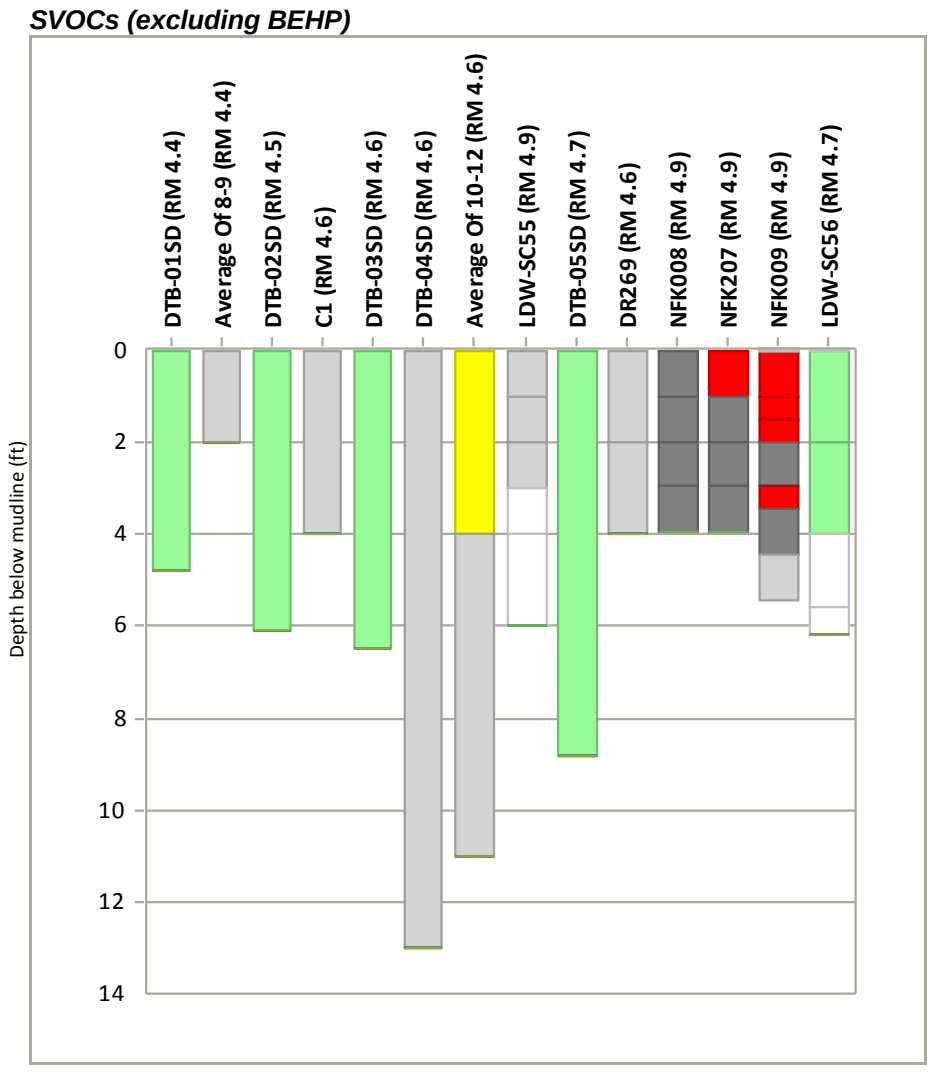
Map 4-17i. Comparisons of concentrations of all SMS chemicals to SMS criteria (SQS or CSL) in subsurface sediment cores, RM 4.3 to RM 5.0

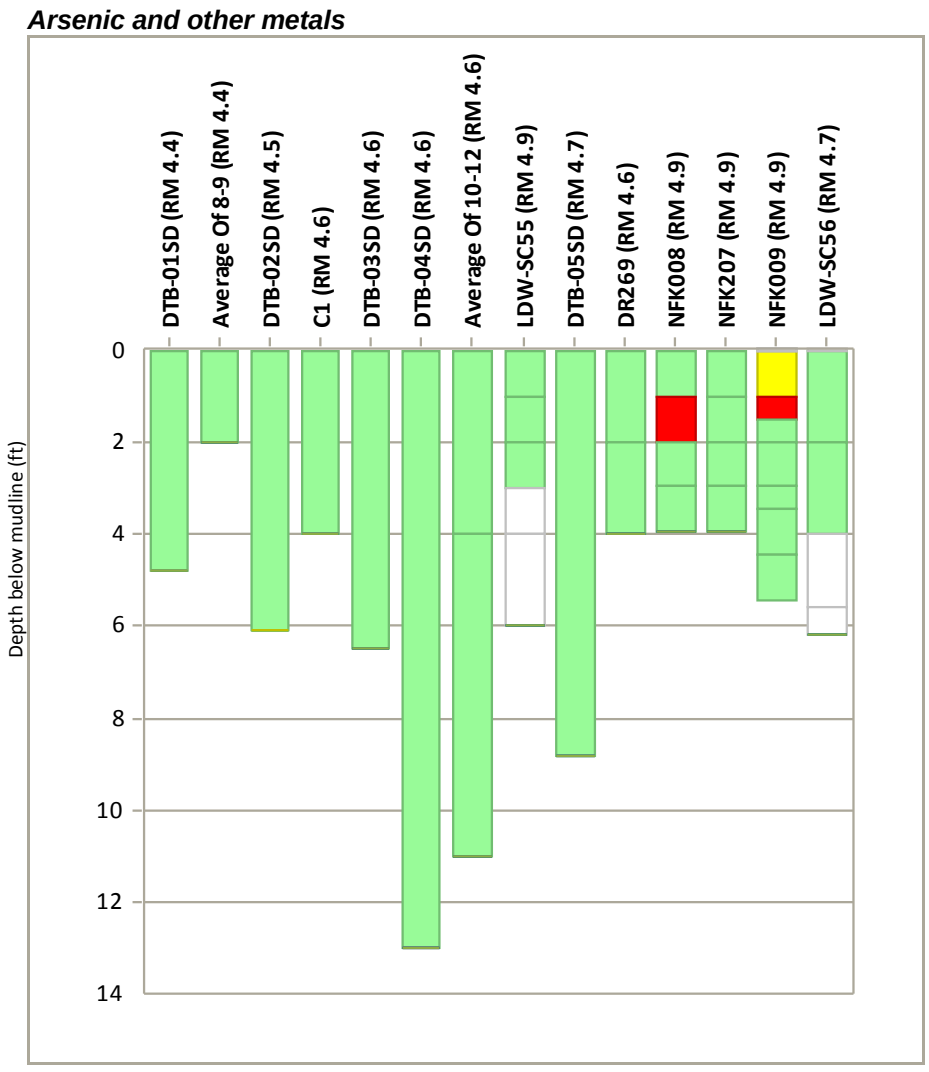
Prepared by CEH, 07/14/2010; MAP 2984; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2_RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.









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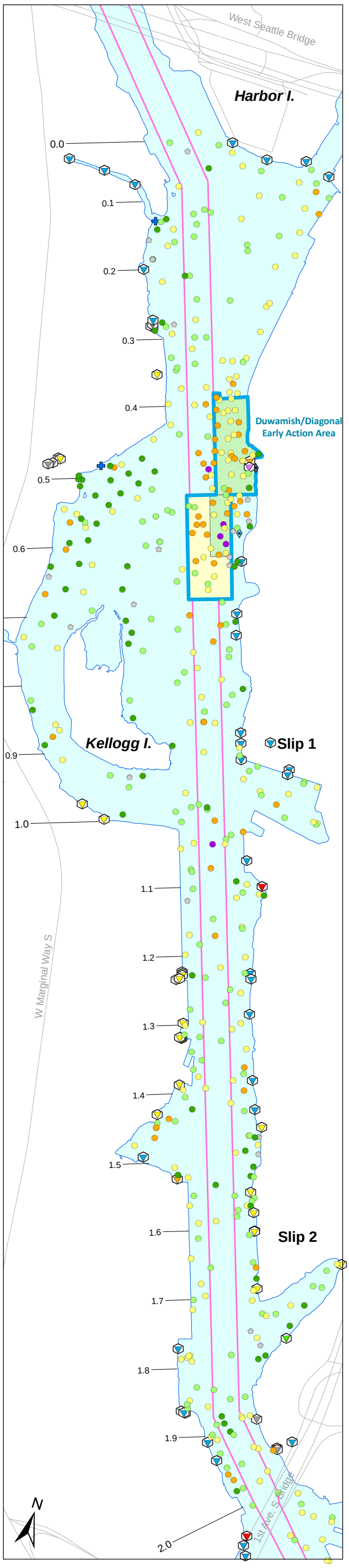
SQS/CSL categories for SMS chemicals in subsurface core intervals[a]

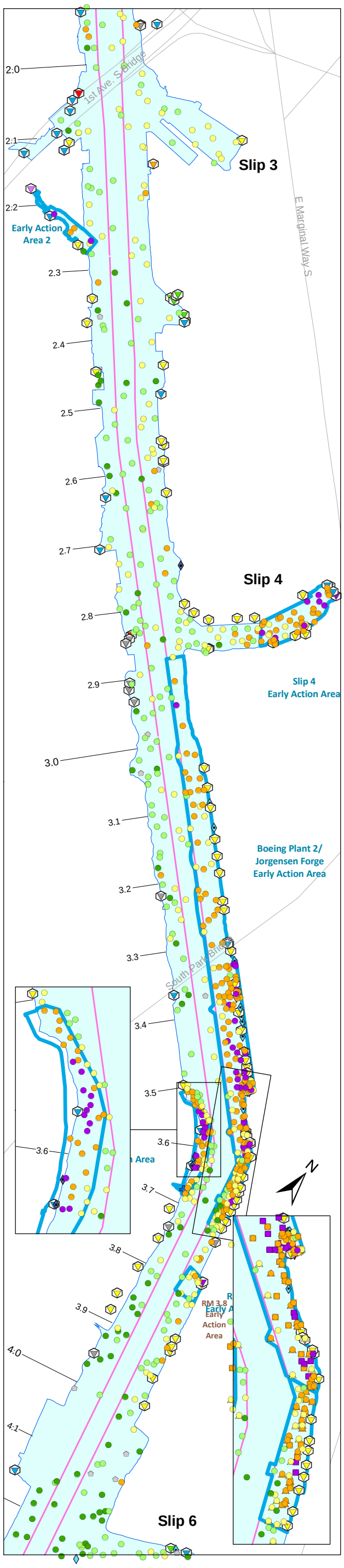
- > CSL, detected
- > SQS and ≤ CSL, detected
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not analyzed

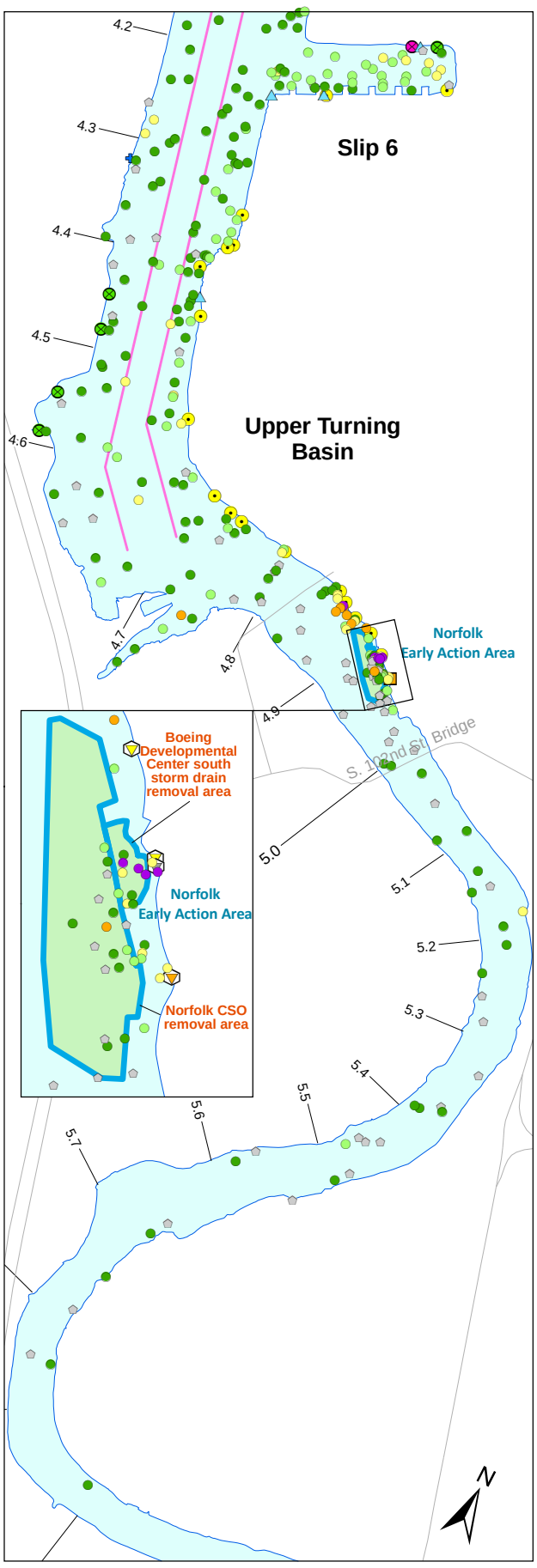
[a] When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations were compared instead to the LAET and 2LAET.

Map 4-17j. Comparisons of concentrations of total PCBs, BEHP, SVOCs, and metals to SMS criteria (SQS or CSL) in subsurface sediment cores, RM 4.5 to RM 5.0

Prepared by CEH, 07/14/2010; MAP 2984; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts







Total PCB concentration (µg/kg dw)[a]

- > 4,300
- > 390 and ≤ 4,300
- > 140 and ≤ 390
- > 58 and ≤ 140
- ≤ 58
- Non-detect
- Early Action Area[b]
- Dredged and capped area[c]
- Thin-layer placement[c]
- Road
- Navigation channel
- River mile

95th percentile = 4,300
75th percentile = 390
50th percentile = 140
25th percentile = 58

Outfall classification[d]

- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. Total PCBs represent the sum of the concentrations of all detected Aroclors. For locations with non-detects for all Aroclors, a value equal to the highest RL of an individual Aroclor at that location was used.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Duwamish/Diagonal early action area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005. For the Norfolk early action area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

[d] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

0 0.1 0.2 Miles

0 0.1 0.2 Kilometers

Scale is the same for each inset map

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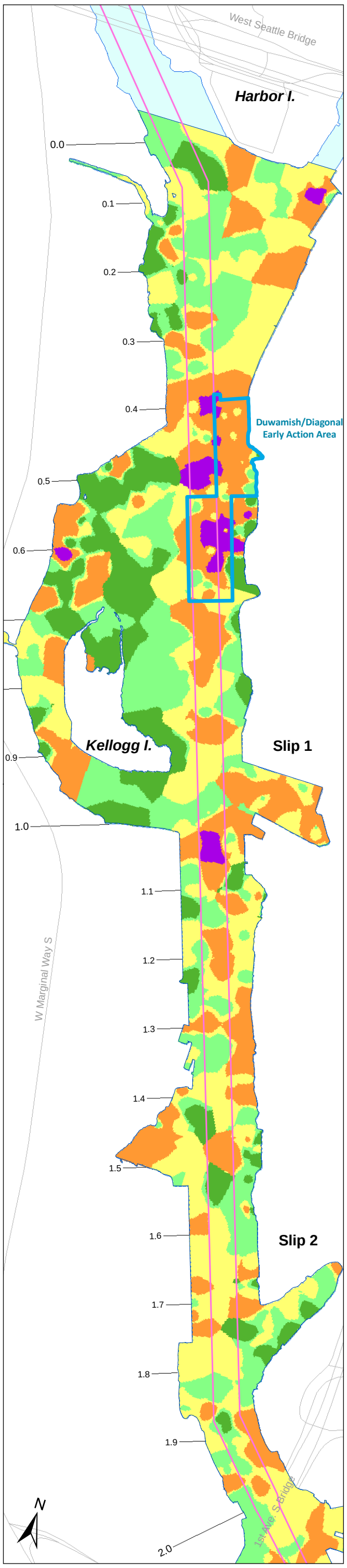
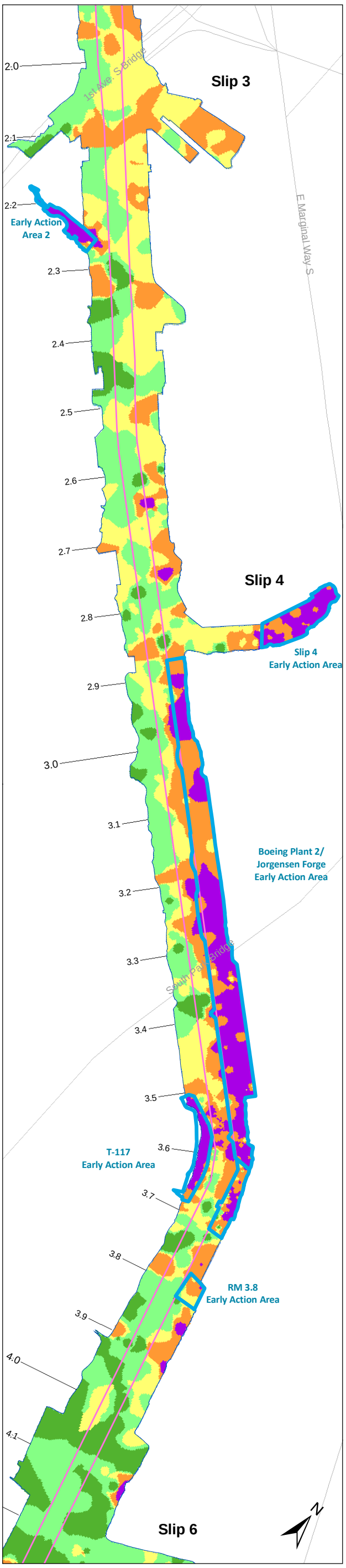
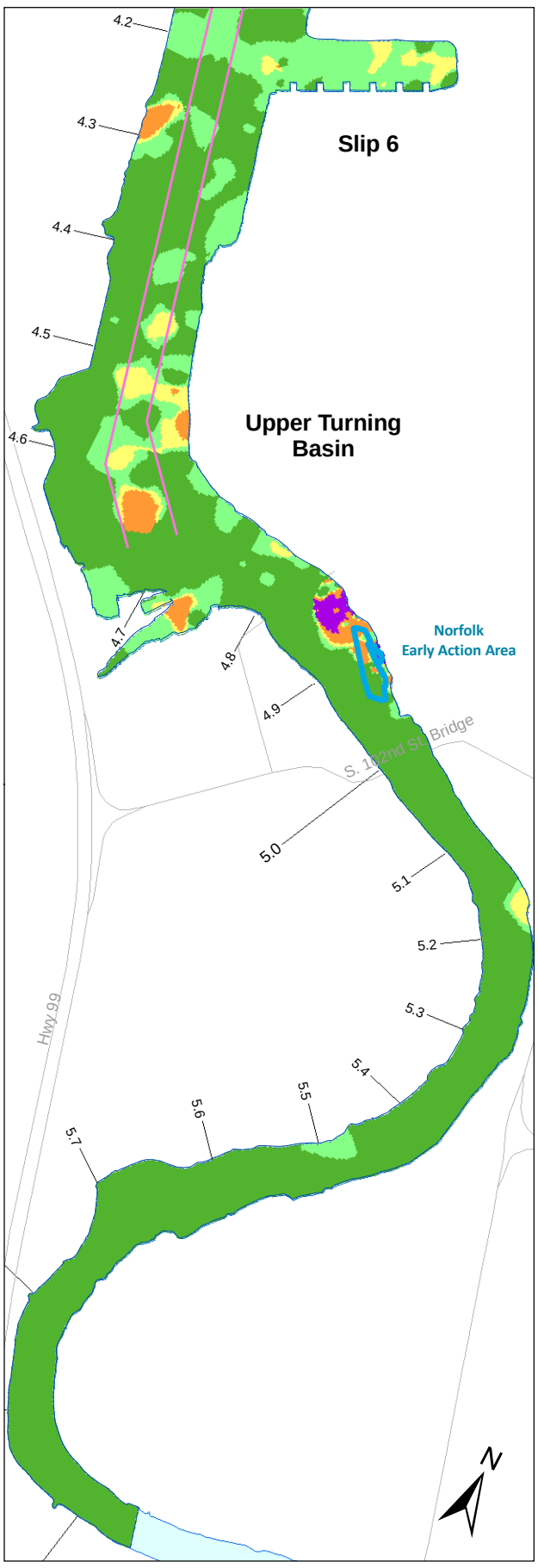
Map 4-18. Total PCB concentrations in surface sediment

Prepared by CEH, 07/14/2010; MAP 2808; W:\Projects\00-08-06 Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\PCBs







Interpolated total PCB concentration (µg/kg dw)[a]

- > 810
- > 210 and ≤ 810
- > 110 and ≤ 210
- > 48 and ≤ 110
- ≤ 48
- Early Action Area[b]
- Navigation channel
- River mile

95th percentile = 810
75th percentile = 210
50th percentile = 110
25th percentile = 48

[a] Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 810 µg/kg dw). Total PCBs represent the sum of the concentrations of all detected Aroclors. For locations with non-detects for all individual Aroclors, a value equal to the highest RL of an individual Aroclor at that location was used.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2. For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer capping in 2003 to 2005. For the Norfolk Early Action Area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

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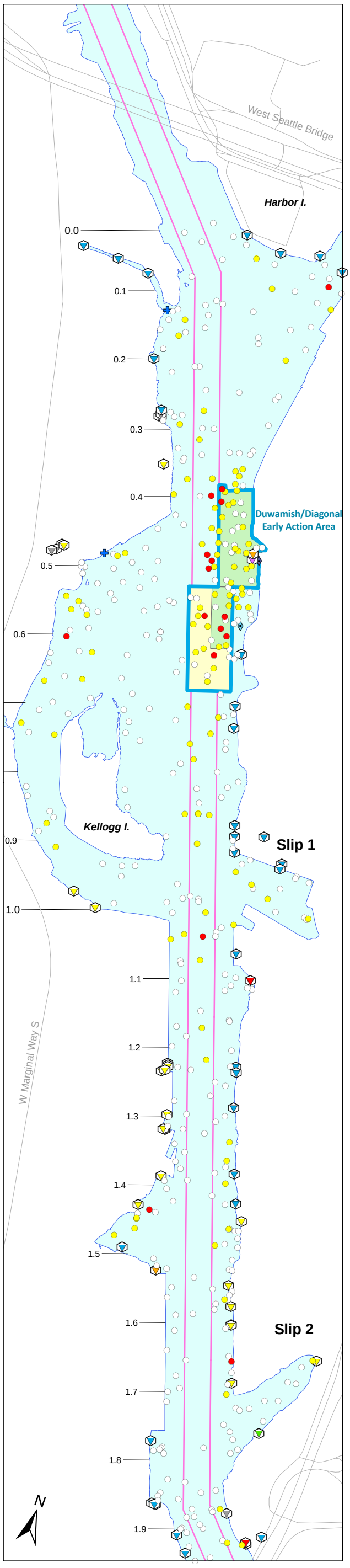
0 0.1 0.2 Miles

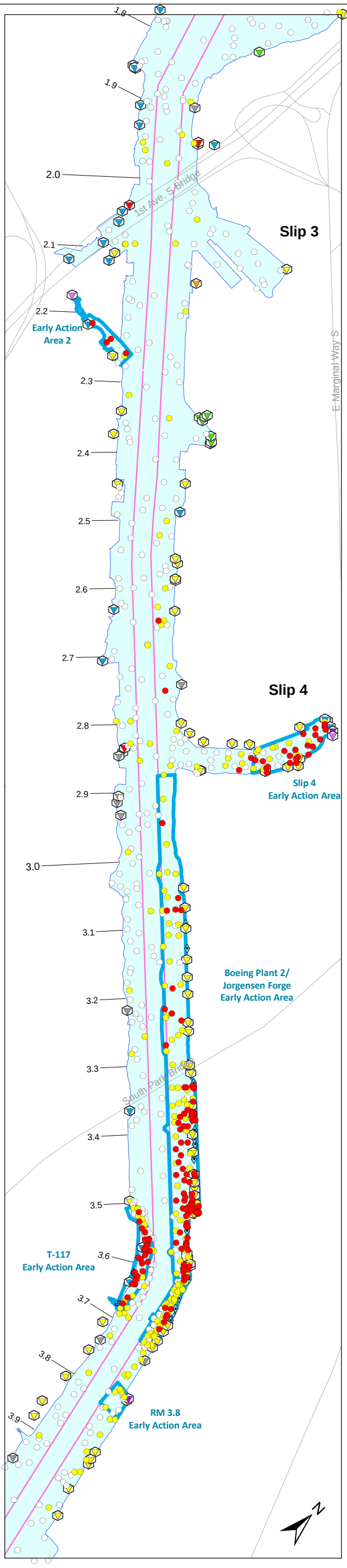
0 0.1 0.2 Kilometers

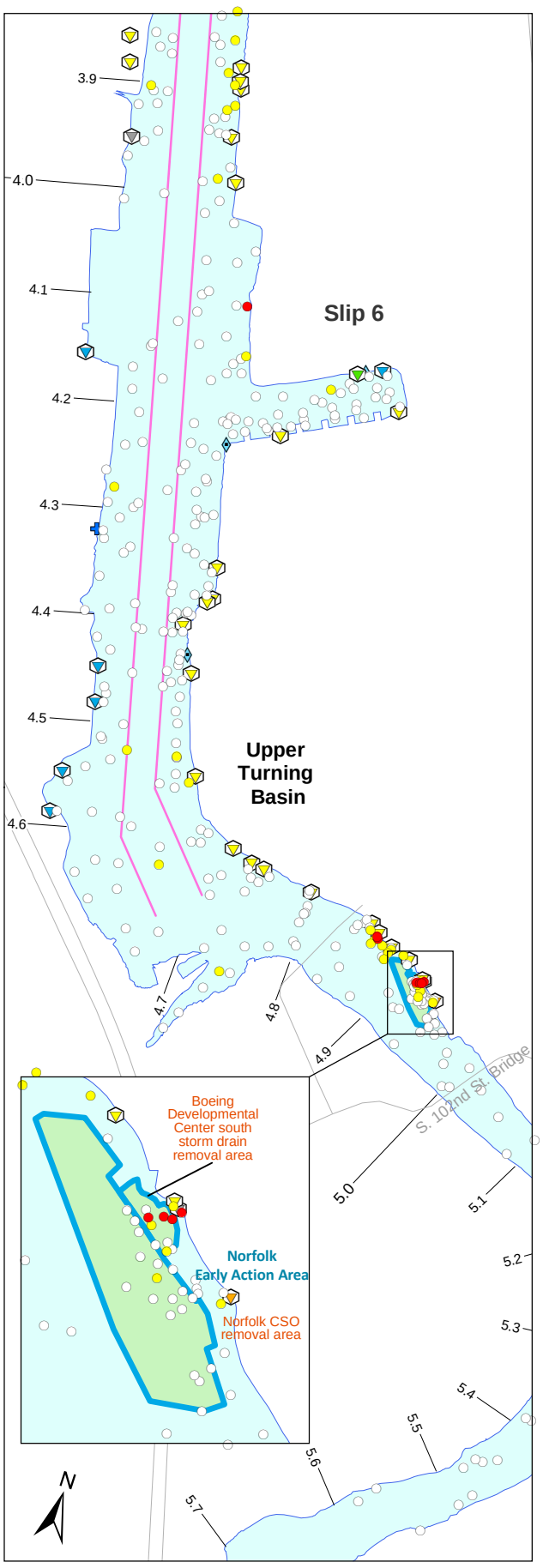
Scale is the same for each inset map

Map 4-19. IDW interpolation of total PCB concentrations in surface sediment

Prepared by CEH, 07/14/2010; MAP 2991; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\PCBs







SQS/CSL categories for total PCBs[a]
- > CSL, detect
- > SQS and ≤ CSL, detect
- ≤ SQS, detect and non-detect
- Early Action Area[b]
- Dredged and capped area[c]
- Thin-layer placement[c]
- Road
- Navigation channel
- River mile

Outfall classification[d]
- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale

[a] When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations were compared instead to the LAET and 2LAET.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer capping in 2003 to 2005. For the Norfolk Early Action Area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

[d] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

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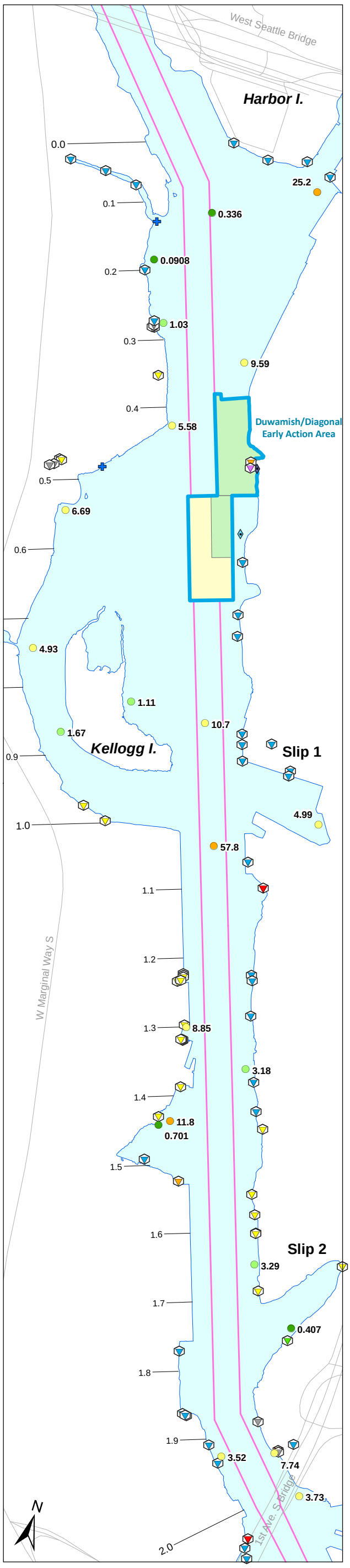
0 0.1 0.2 Miles

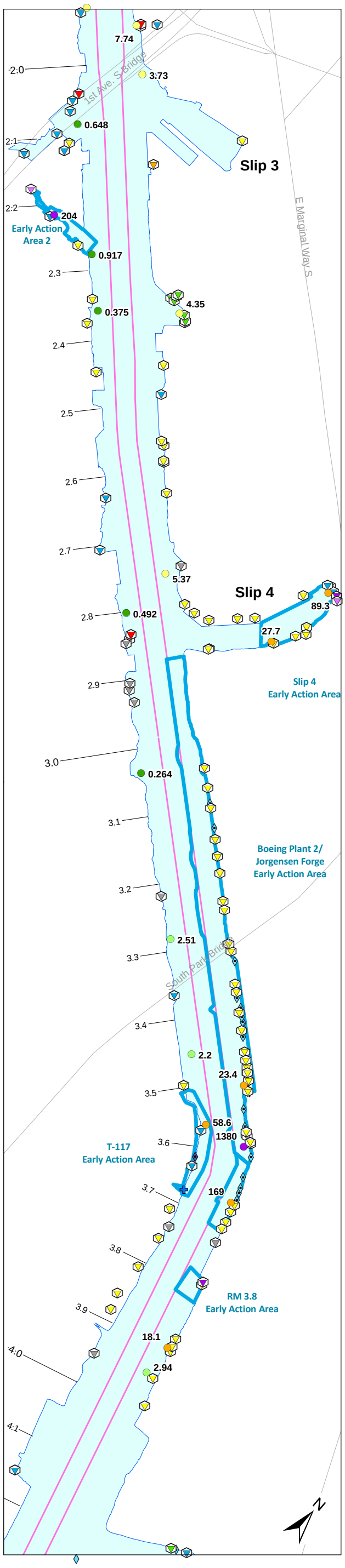
0 0.1 0.2 Kilometers

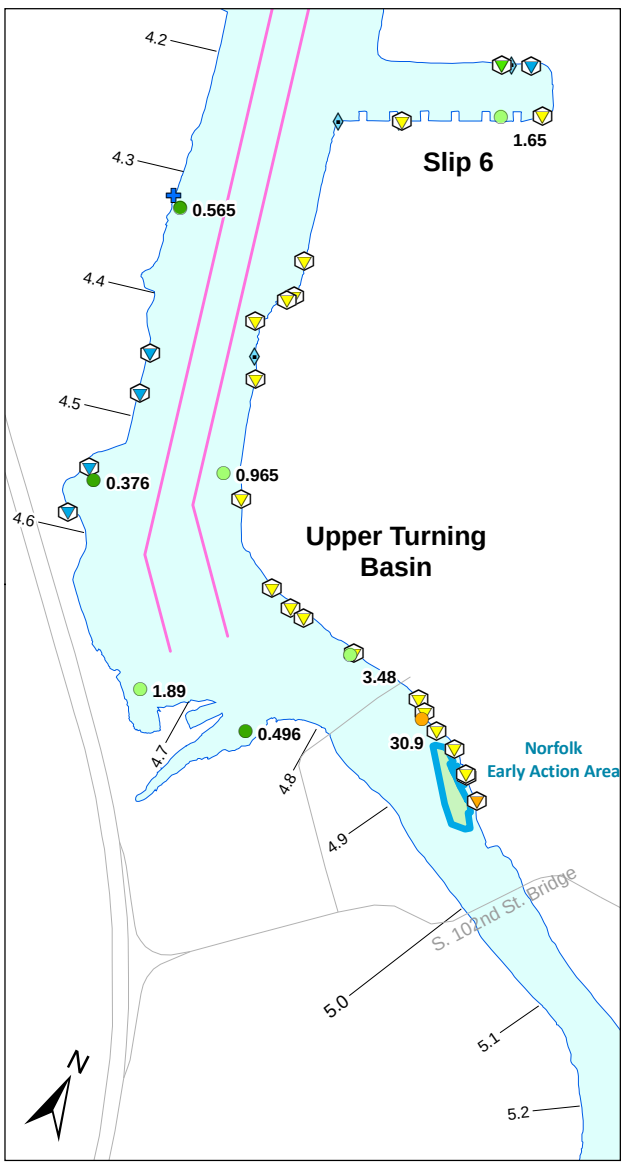
Scale is the same for each inset map

Map 4-20. Exceedances of SMS criteria (SQS or CSL) for total PCBs in surface sediment

Prepared by CEH, 07/14/2010; MAP 2660; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\PCBs







PCB TEQs (ng/kg dw)[a]

95th percentile = 188
75th percentile = 11.5
50th percentile = 3.5
25th percentile = 0.93

- > 188
- > 11.5 and ≤ 188
- > 3.5 and ≤ 11.5
- > 0.93 and ≤ 3.5
- ≤ 0.93
- Early Action Area[b]
- Dredged and capped area[c]
- Thin-layer placement[c]

Outfall classification[d]

- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale
- Road
- Navigation channel
- River mile

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. TEQs were calculated with mammalian TEFs for individual PCB congeners (Van den Berg et al. 2006), using one-half the RL for undetected congeners.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer capping in 2003 to 2005. For the Norfolk Early Action Area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

[d] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

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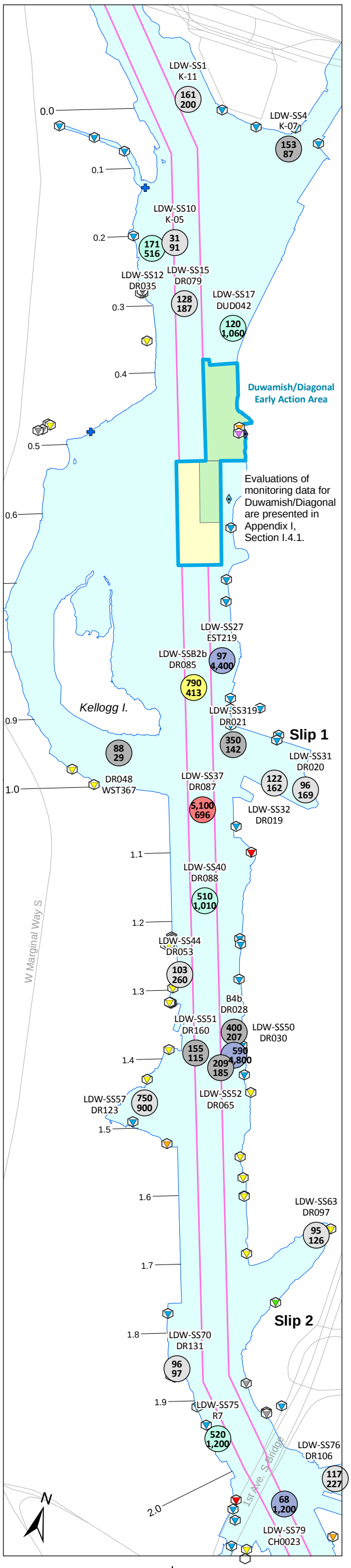
0 0.1 0.2 Miles

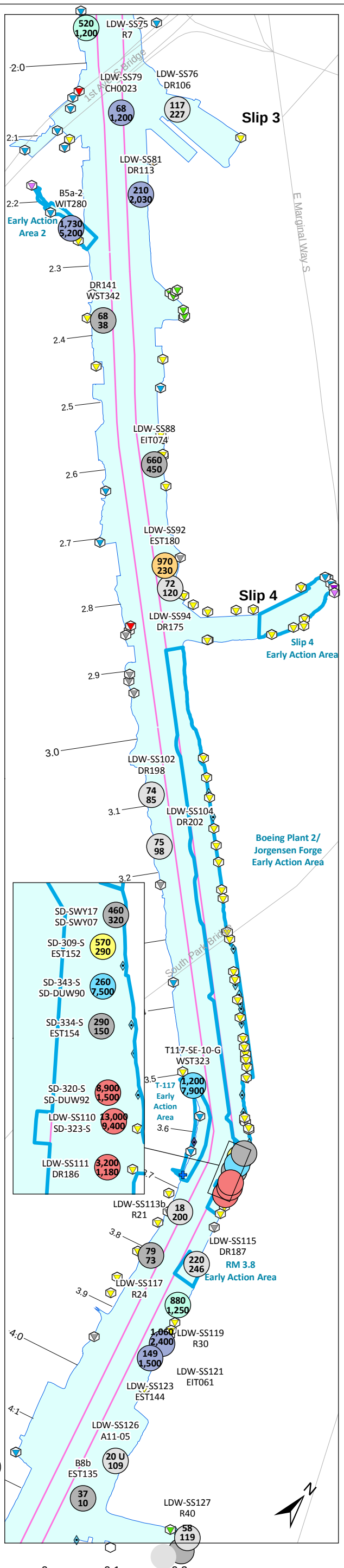
0 0.1 0.2 Kilometers

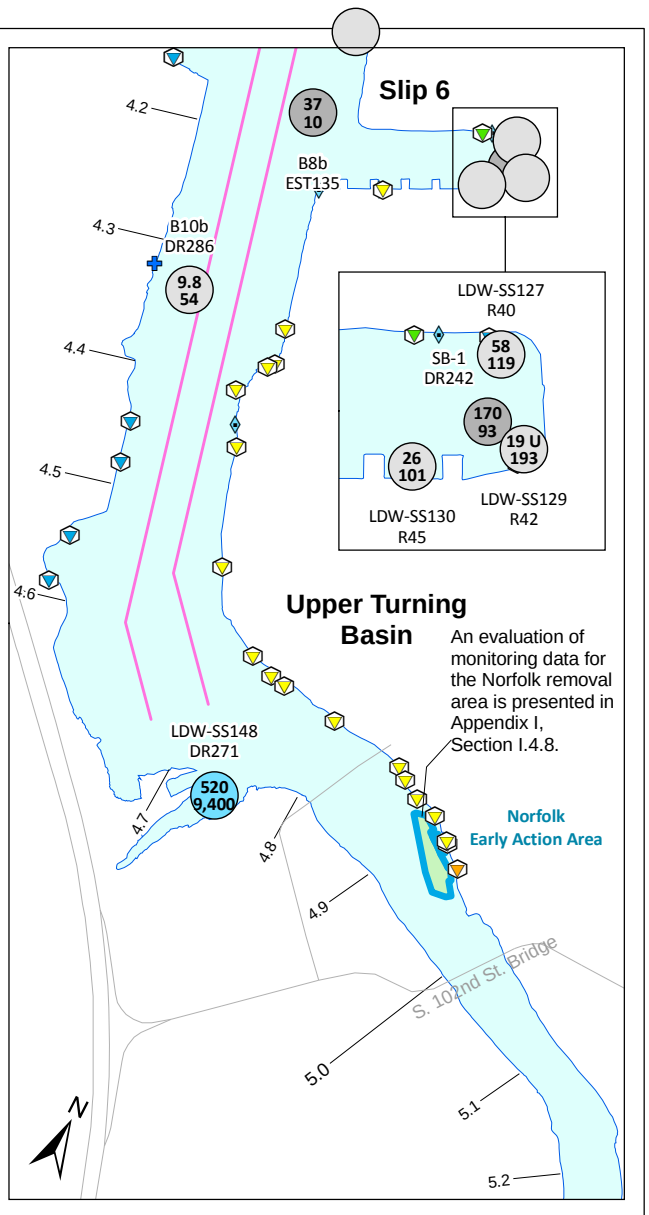
Scale is the same for each inset map

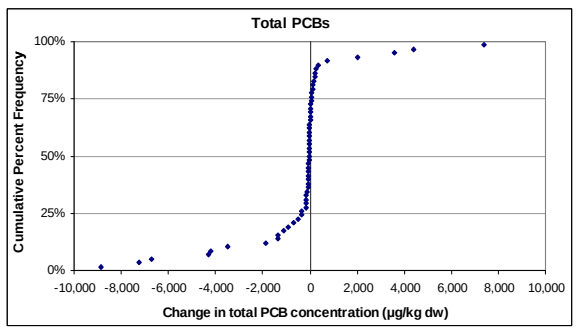
Map 4-21. PCB TEQ values in surface sediment

Prepared by CEH, 07/14/2010, MAP 2785; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\PCBs









Difference in total PCB concentrations (µg/kg dw)[a]
New value minus old value

- ≤ -5,000
- > -5,000 and ≤ -1,000
- > -1,000 and ≤ -250
- > - 250 and ≤ 0
- > 0 and ≤ 250
- > 250 and ≤ 500
- > 500 and ≤ 1,000
- > 1,000
- Early Action Area[b]
- Dredged and capped area
- Thin-layer placement

New value
Old value
New location ID
Old location ID
20U
40U
LDW-SS5
DR076
U = non-detect

Outfall classification[c]

- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale
- Road
- Navigation channel
- River mile

[a] A location was considered to have been resampled if the new location was within 10 ft of the old location.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time of the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

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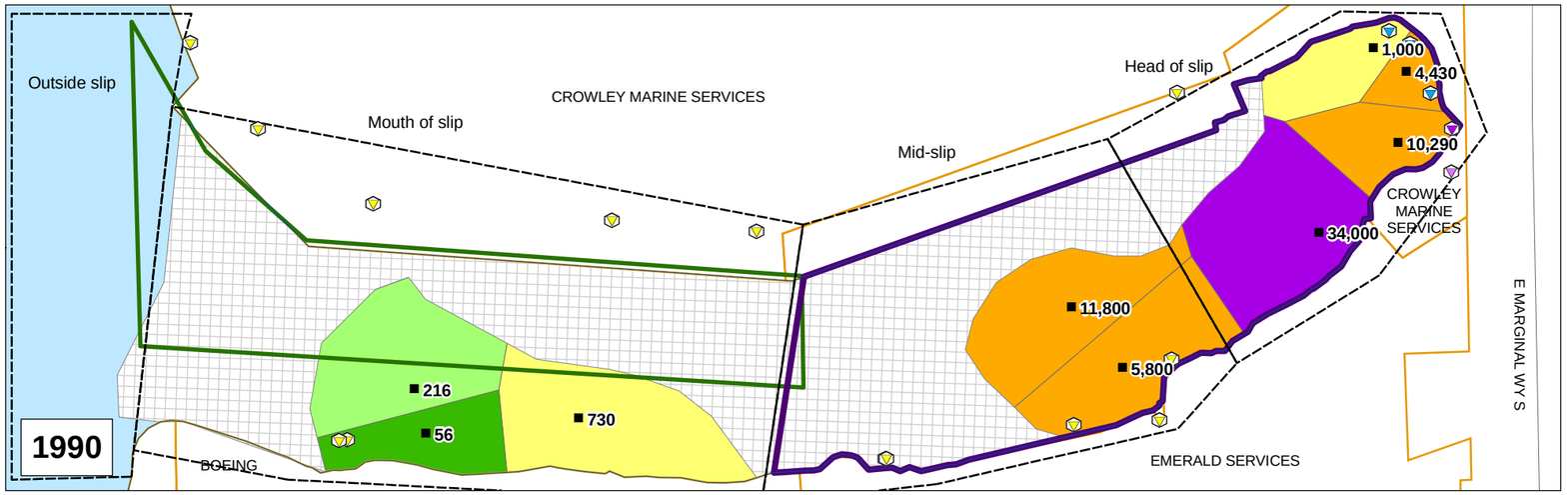
0 0.1 0.2 Miles

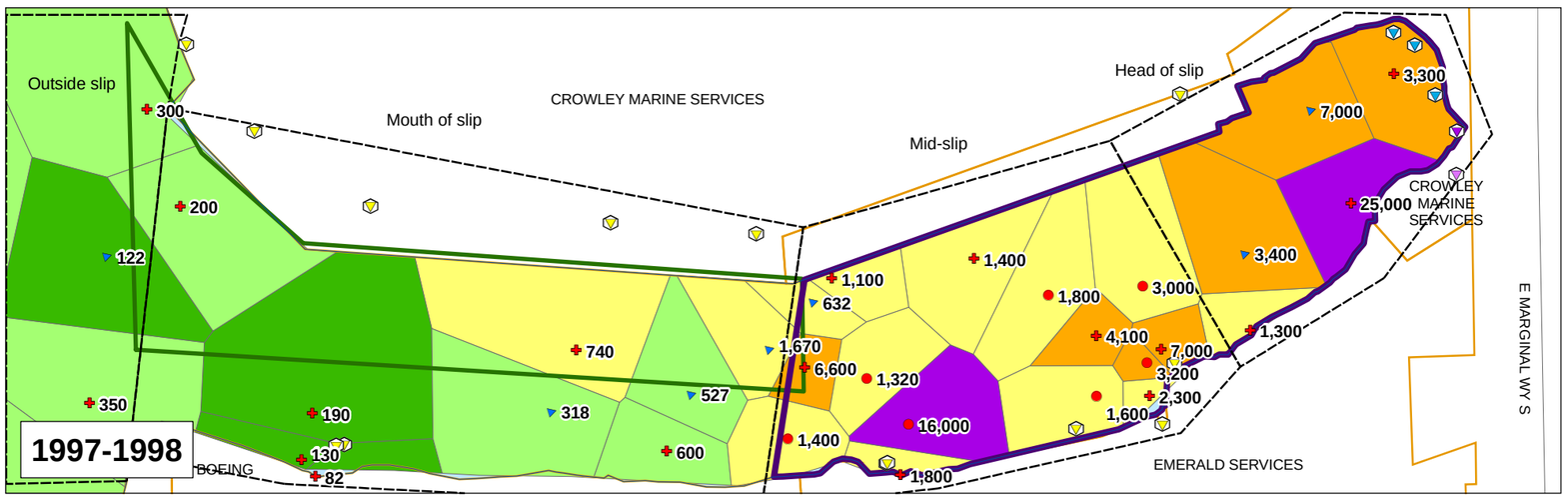
0 0.1 0.2 Kilometers

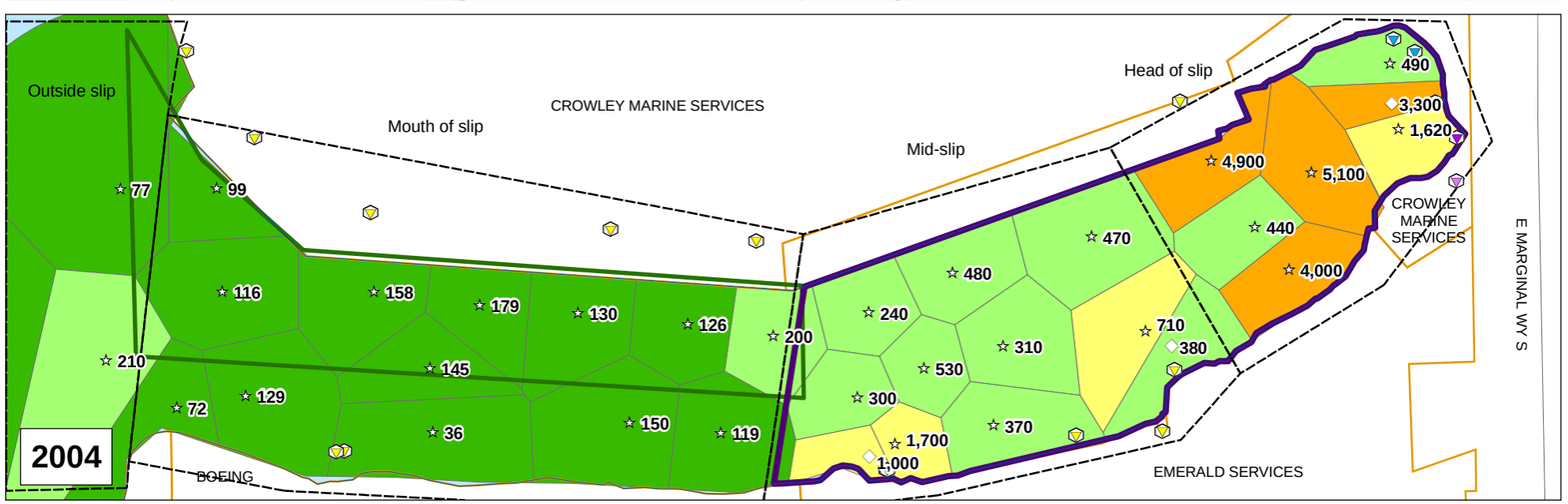
Scale is the same for each inset map

Map 4-22. Differences in total PCB concentrations in surface sediment at locations that have been resampled

Prepared by CEH, 07/14/2010; MAP 2679; W:\Projects\00-08-06 Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Round3 Trumping







Event Name
- Landau (1990)
- Boeing SiteChar (1997)
- NOAA SiteChar (1997)
- EPA SI (1998)
- LDWRI-Benthic (2004)
- Slip4-EarlyAction (2004)

Total PCB concentration (µg/kg dw)[a]
95th percentile = 13,000
75th percentile = 3,100
50th percentile = 620
25th percentile = 200
- > 13,000
- > 3,100 and ≤ 13,000
- > 620 and ≤ 3,100
- > 200 and ≤ 620
- ≤ 200
- Insufficient data for interpolation[b]
- Slip 4 early action area
- Crowley dredged area (1996)
- Areas evaluated in Section 4.2.3.1

Outfall classification[c]
- EOF
- EOF/storm drain
- Permitted private storm drain
- Public storm drain
- Tax parcel[d]
- Road

[a] Percentiles were calculated on a numerical basis for the Slip 4 area using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects for all Aroclors, a value equal to the highest RL of an individual Aroclor at that location was used.

[b] Area with insufficient data was estimated visually based on density of existing data points.

[c] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time of the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

[d] Tax parcel information was provided in 2008 by Seattle Public Utilities and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property-owner records was not conducted.

N

0 75 150 300 Feet

0 25 50 100 Meters

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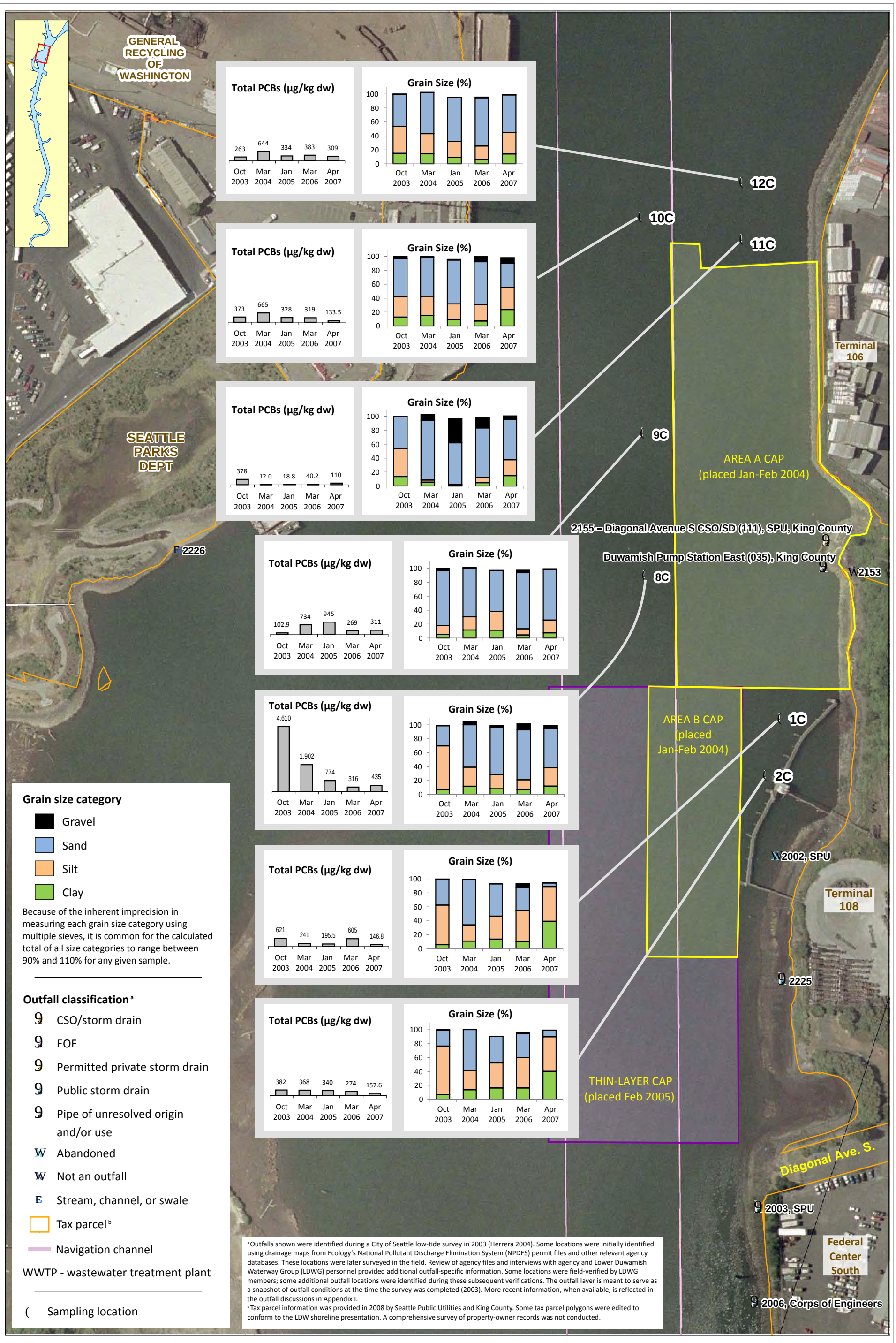
Map 4-23. Total PCB concentrations in surface sediment from Slip 4 in 1990, 1997-1998, and 2004

Prepared by CEH, 07/14/2010; Map 2651; W:\Projects\00-09-06_Duwamish_Ph\data\GIS\Phase2 RI\Nature and Extent\Trends and Trumping\Slip4



Wind Ward environmental LLC

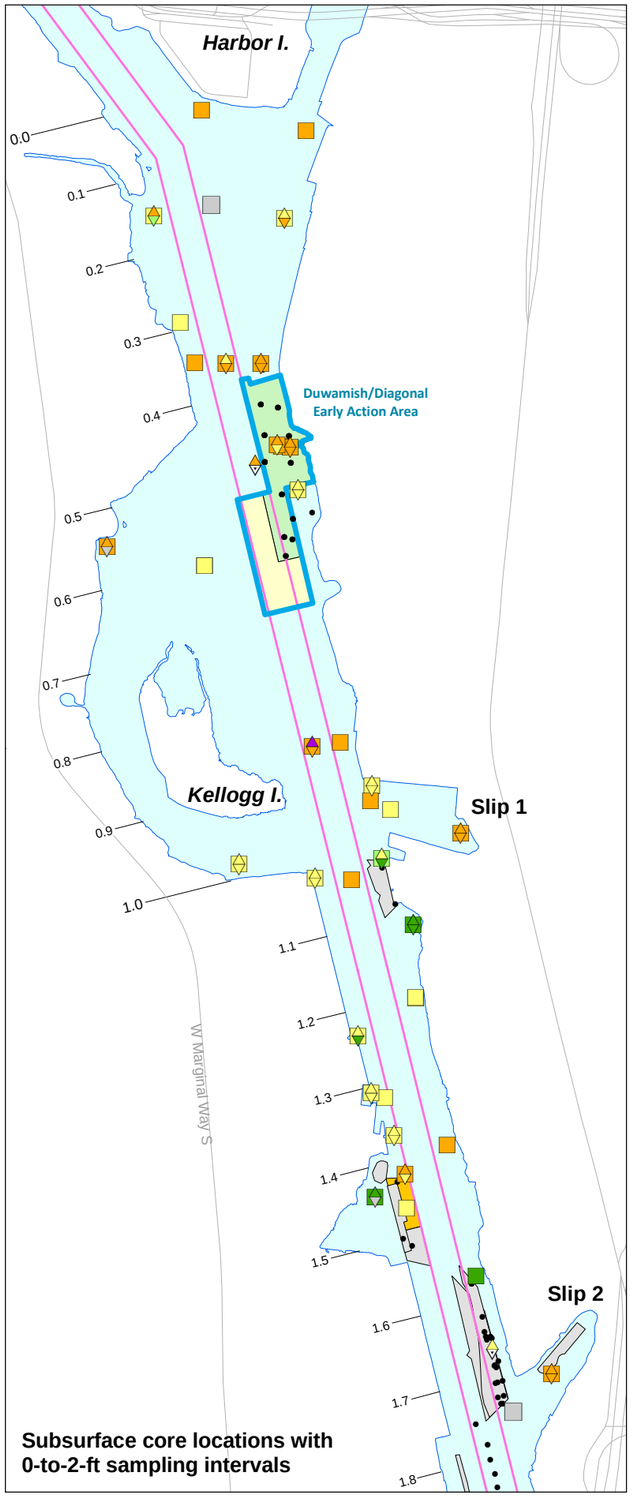
N

0100200 Feet

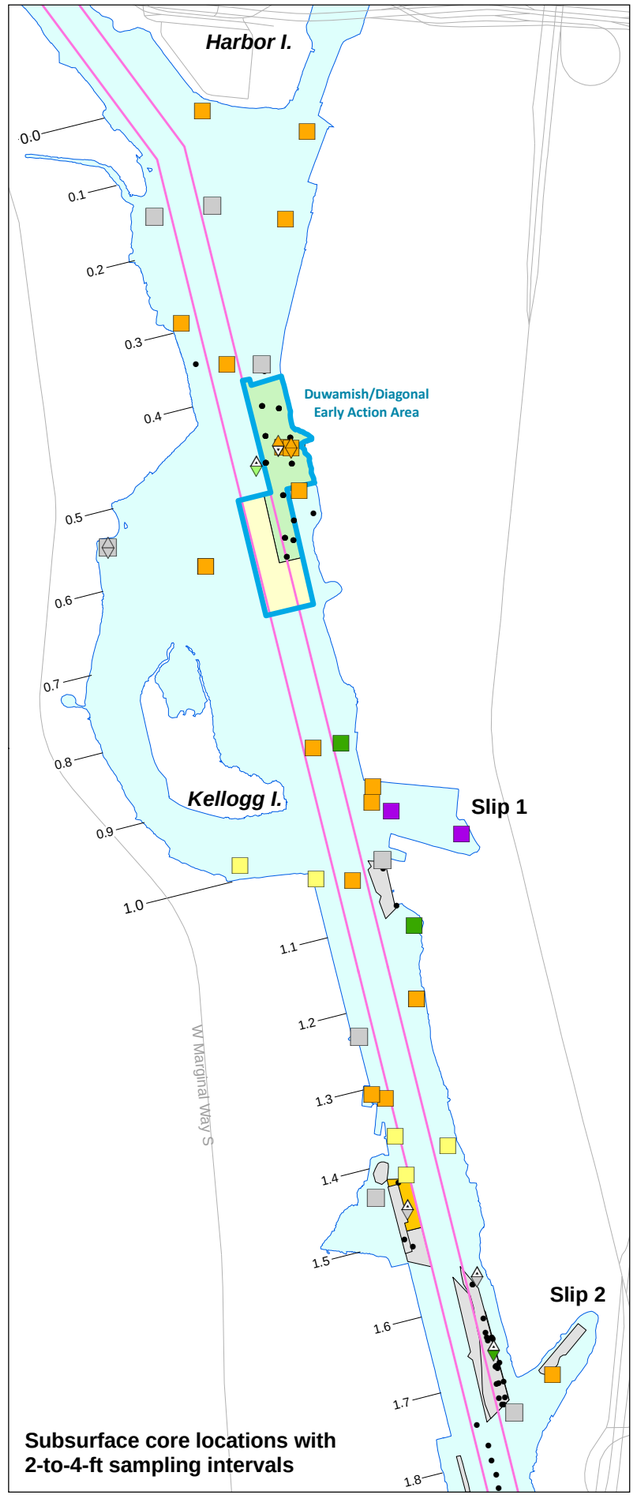
02550 Meters

Map 4-24. Surface sediment data at Duwamish/Diagonal perimeter monitoring locations

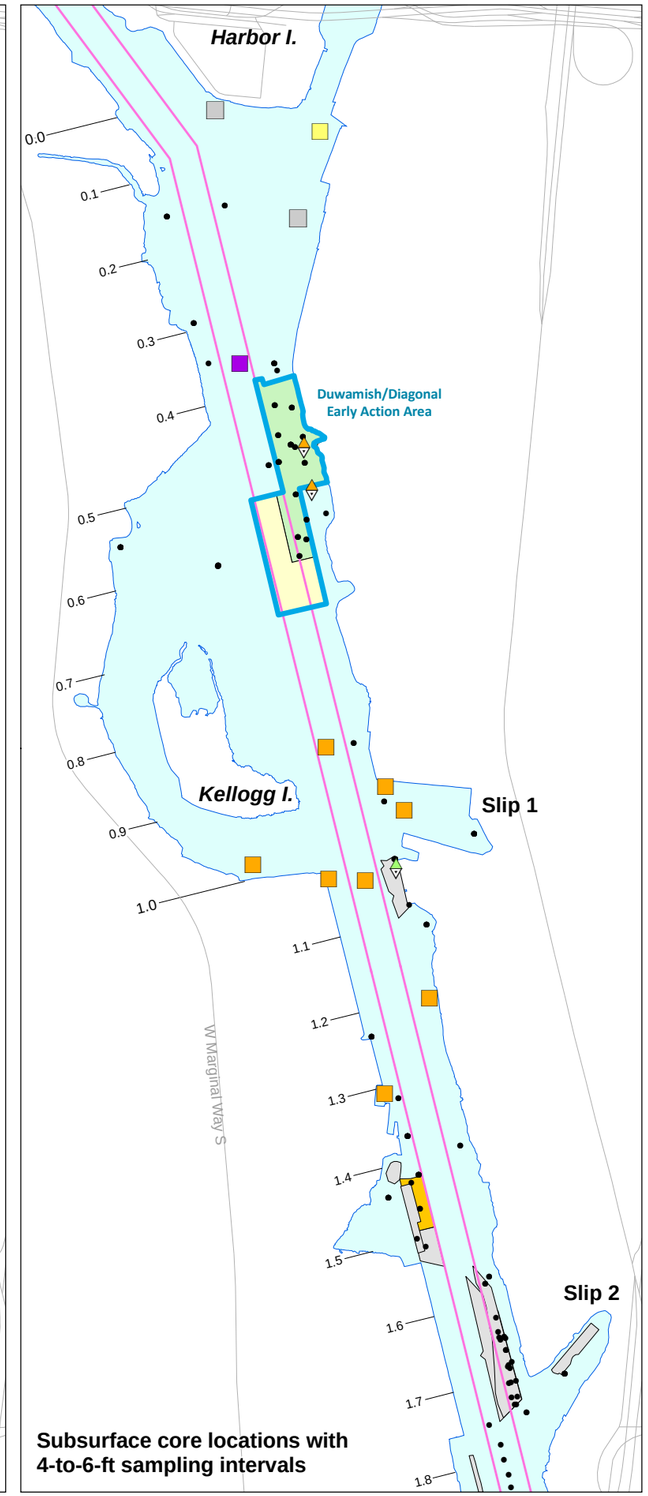
Modified by Zachariah from GIS Map 2853 | May 29, 2009 | Map 4-24 (2583).xar



Subsurface core locations with 0-to-2-ft sampling intervals



Subsurface core locations with 2-to-4-ft sampling intervals



Subsurface core locations with 4-to-6-ft sampling intervals

Total PCB concentration (µg/kg dw)[a]

> 4,300	95th percentile = 4,300
> 390 and ≤ 4,300	75th percentile = 390
> 140 and ≤ 390	50th percentile = 140
> 58 and ≤ 140	25th percentile = 58
≤ 58	
Non-detect	

Sampling interval

	Left panel	Middle panel	Right panel
	0-to-2-ft[b]	2-to-4-ft[b]	4-to-6-ft[b]
	0-to-1-ft[c]	2-to-3-ft[c]	4-to-5-ft[c]
	1-to-2-ft[c]	3-to-4-ft[c]	5-to-6-ft[c]

Not analyzed in that sampling interval

Other subsurface sampling location analyzed for total PCBs, but not in the illustrated sampling interval

Early Action Area[d]

Dredged area[e]

Dredged and capped area[e]

Dredged and thin-layer placement[e]

Thin-layer placement

Road

Navigation channel

River mile

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. Total PCBs represent the sum of the concentrations of all detected Aroclors. For locations with non-detects for all Aroclors, a value equal to the highest RL of an individual Aroclor at that location was used.

[b] Data from 2-foot sampling intervals; some locations show an average of data from both 1-foot intervals within that 2-foot interval at a given location.

[c] Data from 1-foot sampling intervals are shown if available. If both 1-foot intervals within the 2-foot interval were collected, the average of the two intervals is also shown.

[d] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[e] Subsurface sediment data at locations in dredged areas were collected prior to dredging.

N

0 0.1 0.2 Kilometers

0 0.1 0.2 Miles

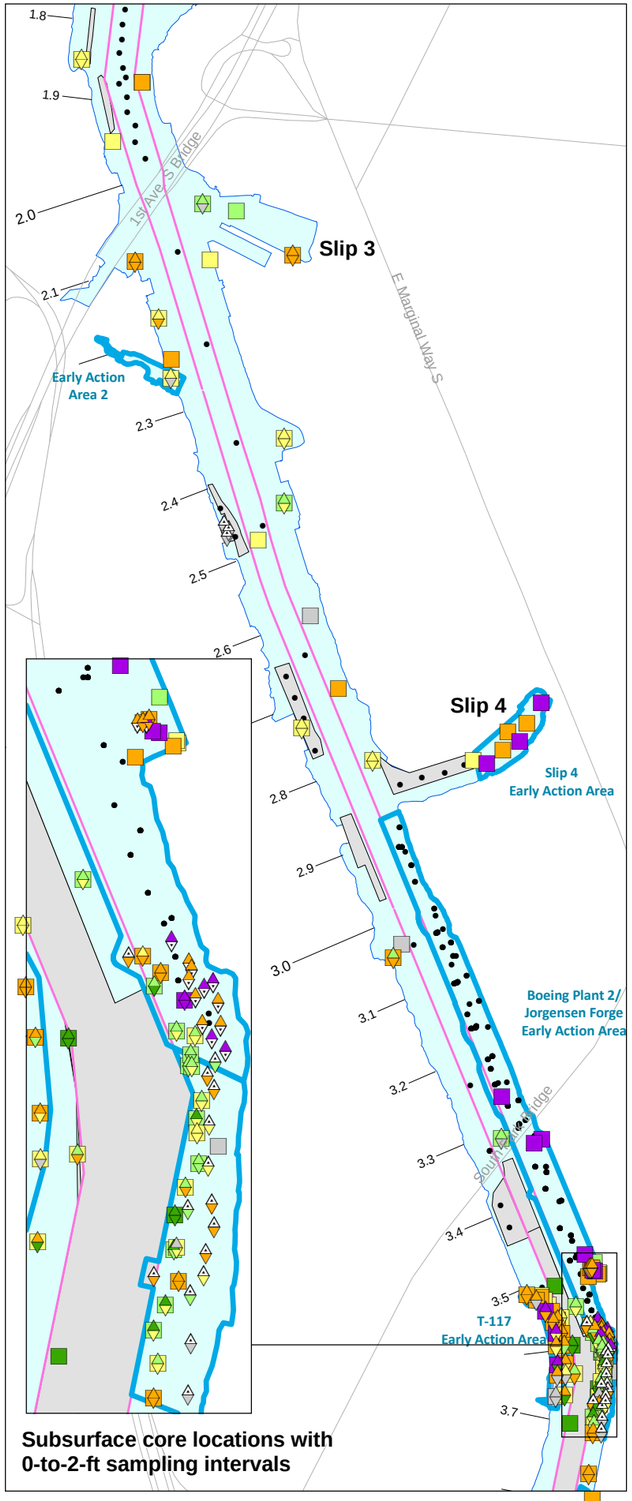
Scale is the same for each map frame

Map 4-25a. Total PCB concentrations in subsurface sediment within the 0-to-2-ft, 2-to-4-ft, and 4-to-6-ft sampling intervals, RM 0.0 to RM 1.8

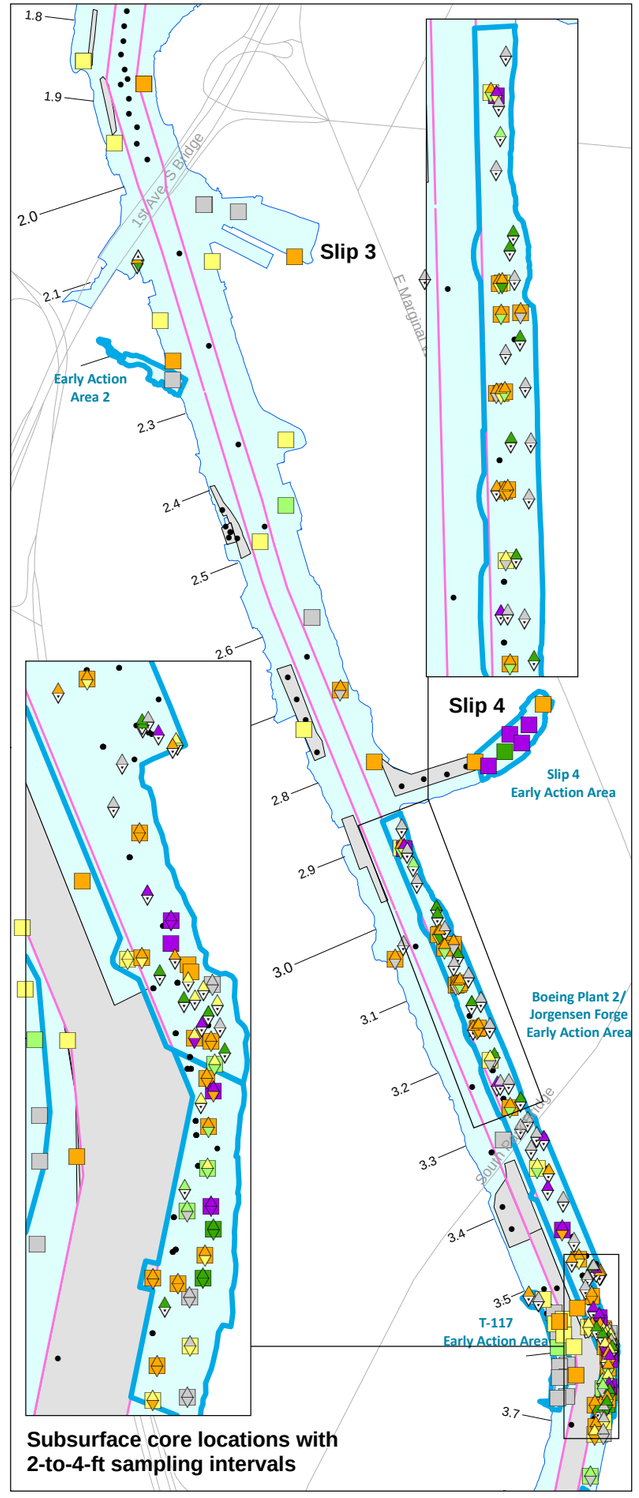
Wind Ward environmental LLC

Prepared by CEH, 07/14/2016, MAP 2804; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2_RI\Nature and Extent\Subsurface\Depth Intervals\PCBs

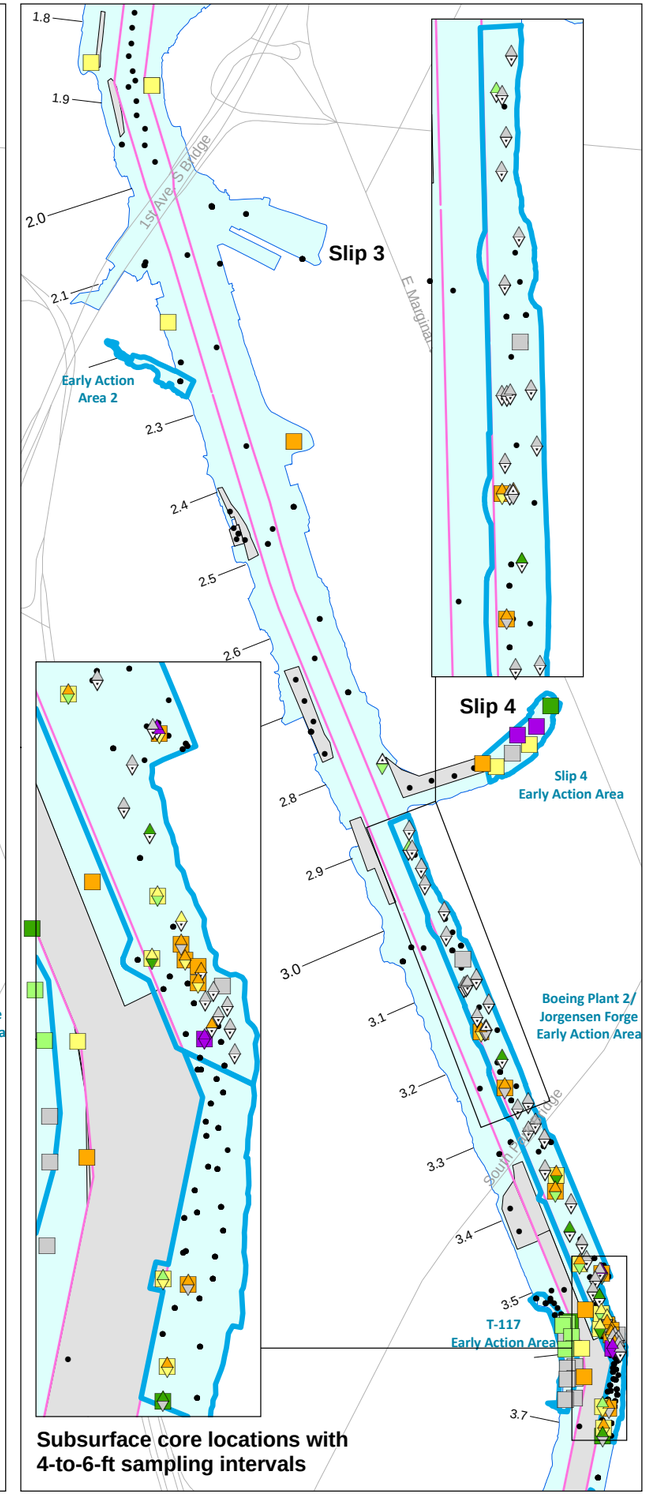
Dredging information provided by AECOM.



Subsurface core locations with 0-to-2-ft sampling intervals



Subsurface core locations with 2-to-4-ft sampling intervals



Subsurface core locations with 4-to-6-ft sampling intervals

Total PCB concentration (µg/kg dw)[a]

- > 4,300 — 95th percentile = 4,300
- > 390 and ≤ 4,300 — 75th percentile = 390
- > 140 and ≤ 390 — 50th percentile = 140
- > 58 and ≤ 140 — 25th percentile = 58
- ≤ 58
- Non-detect

Sampling interval

Left panel	Middle panel	Right panel
0-to-2-ft[b]	2-to-4-ft[b]	4-to-6-ft[b]
0-to-1-ft[c]	2-to-3-ft[c]	4-to-5-ft[c]
1-to-2-ft[c]	3-to-4-ft[c]	5-to-6-ft[c]

- Not analyzed in that sampling interval
- Other subsurface sampling location analyzed for total PCBs, but not in the illustrated sampling interval
- Early Action Area[d]
- Dredged area[e]
- Road
- Navigation channel
- River mile

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. Total PCBs represent the sum of the concentrations of all detected Aroclors. For locations with non-detects for all Aroclors, a value equal to the highest RL of an individual Aroclor at that location was used.

[b] Data from 2-foot sampling intervals; some locations show an average of data from both 1-foot intervals within that 2-foot interval at a given location.

[c] Data from 1-foot sampling intervals are shown if available. If both 1-foot intervals within the 2-foot interval were collected, the average of the two intervals is also shown.

[d] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[e] Subsurface sediment data at locations in dredged areas were collected prior to dredging.

0 0.1 0.2 Kilometers

0 0.1 0.2 Miles

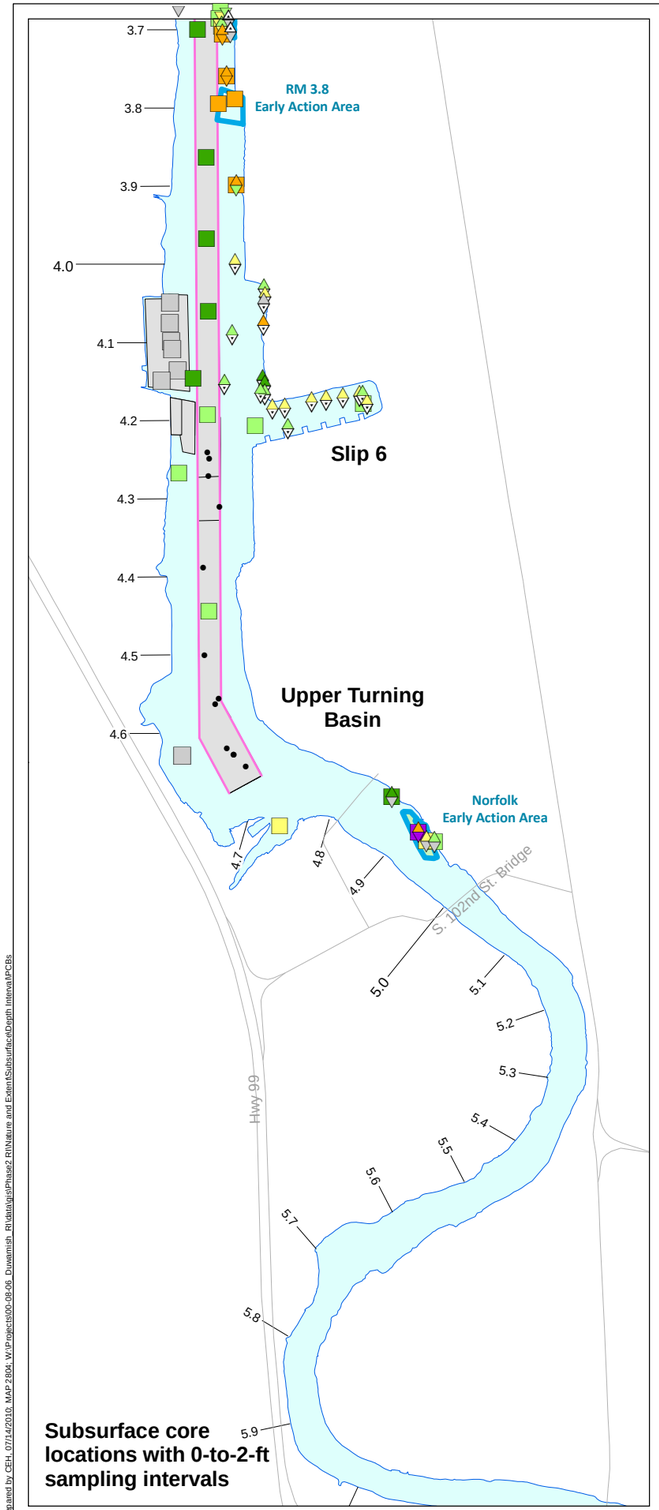
Scale is the same for each map frame

Map 4-25b. Total PCB concentrations in subsurface sediment within the 0-to-2-ft, 2-to-4-ft, and 4-to-6-ft sampling intervals, RM 1.8 to RM 3.7

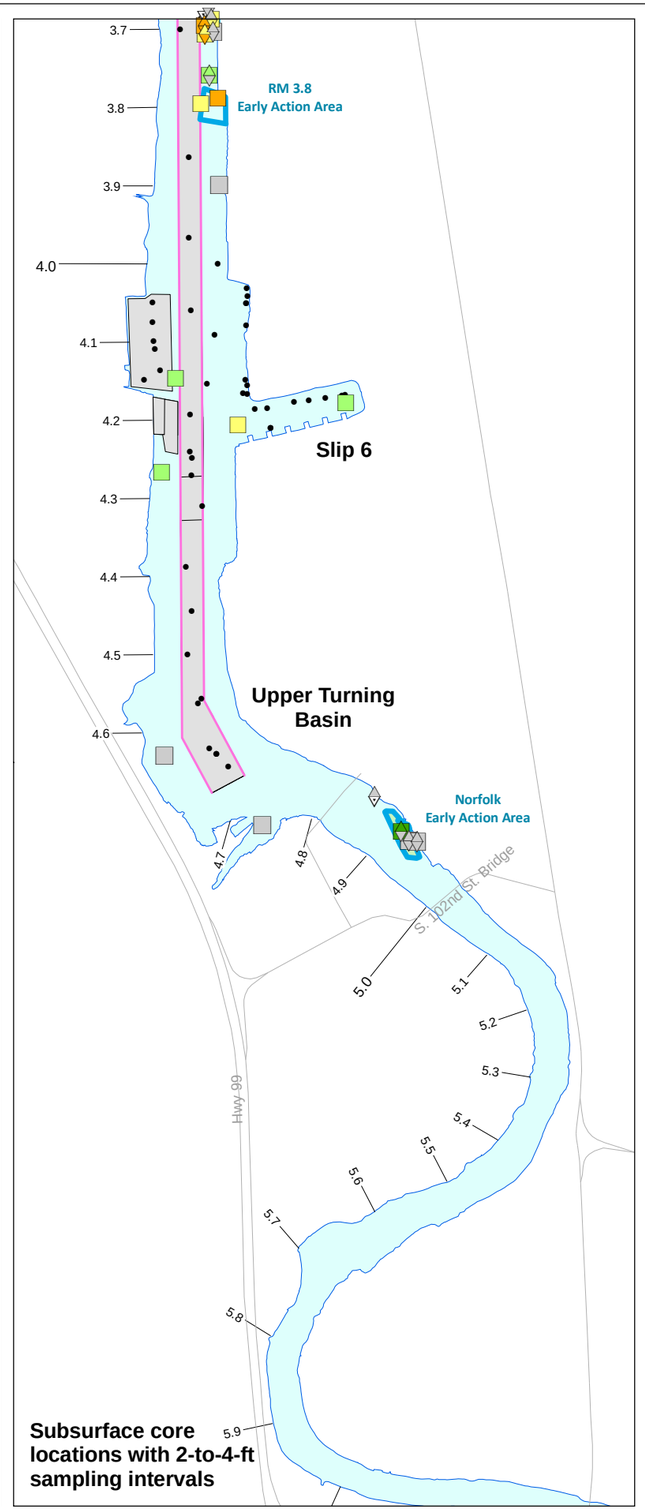
Windward environmental LLC

Prepared by CEH, 07/14/2010. MAP 2804. W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Depth Interval\PCBs

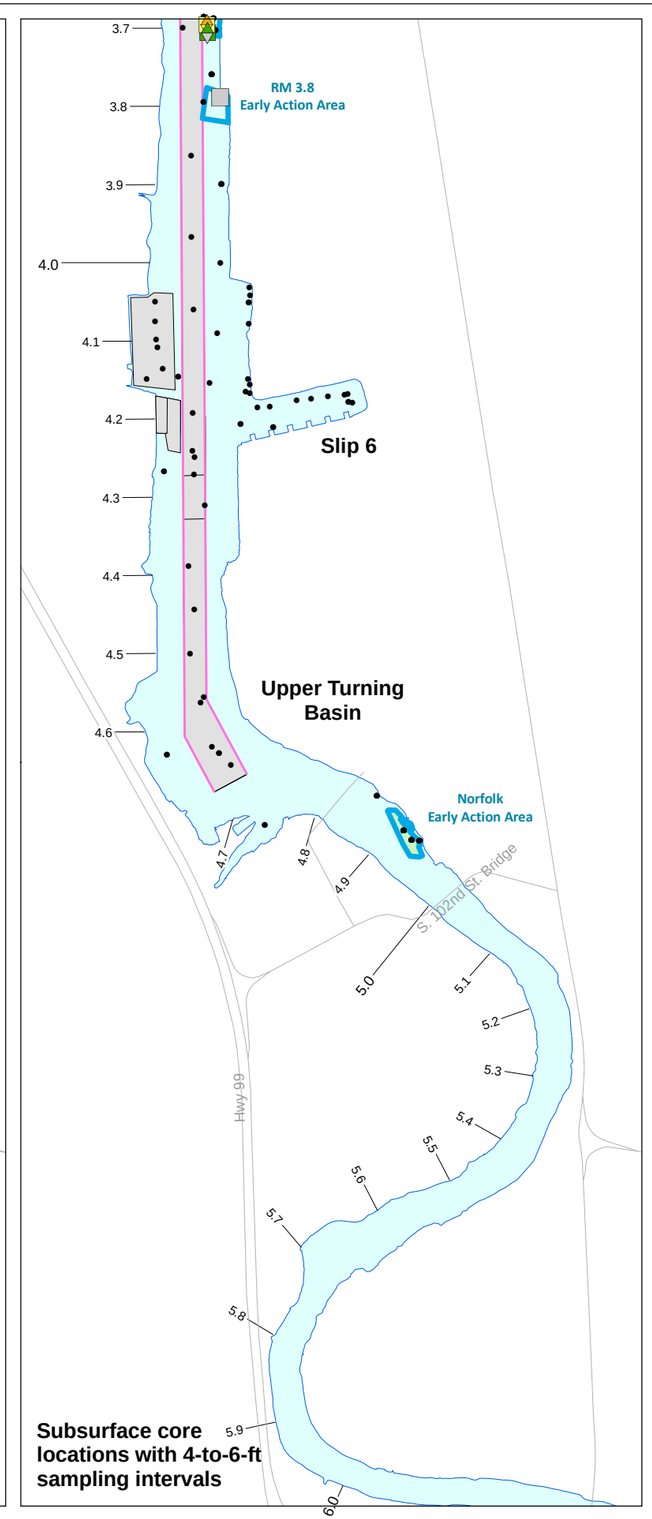
Dredging information provided by AECOM.



Subsurface core locations with 0-to-2-ft sampling intervals



Subsurface core locations with 2-to-4-ft sampling intervals



Subsurface core locations with 4-to-6-ft sampling intervals

Total PCB concentration (µg/kg dw)[a]

- > 4,300 — 95th percentile = 4,300
- > 390 and ≤ 4,300 — 75th percentile = 390
- > 140 and ≤ 390 — 50th percentile = 140
- > 58 and ≤ 140 — 25th percentile = 58
- ≤ 58
- Non-detect

Sampling interval

Left panel	Middle panel	Right panel
0-to-2-ft[b]	2-to-4-ft[b]	4-to-6-ft[b]
0-to-1-ft[c]	2-to-3-ft[c]	4-to-5-ft[c]
1-to-2-ft[c]	3-to-4-ft[c]	5-to-6-ft[c]

- Not analyzed in that sampling interval
- Other subsurface sampling location analyzed for total PCBs, but not in the illustrated sampling interval
- Early Action Area[d]
- Dredged area[e]
- Dredged and capped area[e]
- Road
- Navigation channel
- River mile

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. Total PCBs represent the sum of the concentrations of all detected Aroclors. For locations with non-detects for all Aroclors, a value equal to the highest RL of an individual Aroclor at that location was used.

[b] Data from 2-foot sampling intervals; some locations show an average of data from both 1-foot intervals within that 2-foot interval at a given location.

[c] Data from 1-foot sampling intervals are shown if available. If both 1-foot intervals within the 2-foot interval were collected, the average of the two intervals is also shown.

[d] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[e] Subsurface sediment data at locations in dredged areas were collected prior to dredging.

N

0 0.1 0.2 Kilometers

0 0.1 0.2 Miles

Scale is the same for each map frame

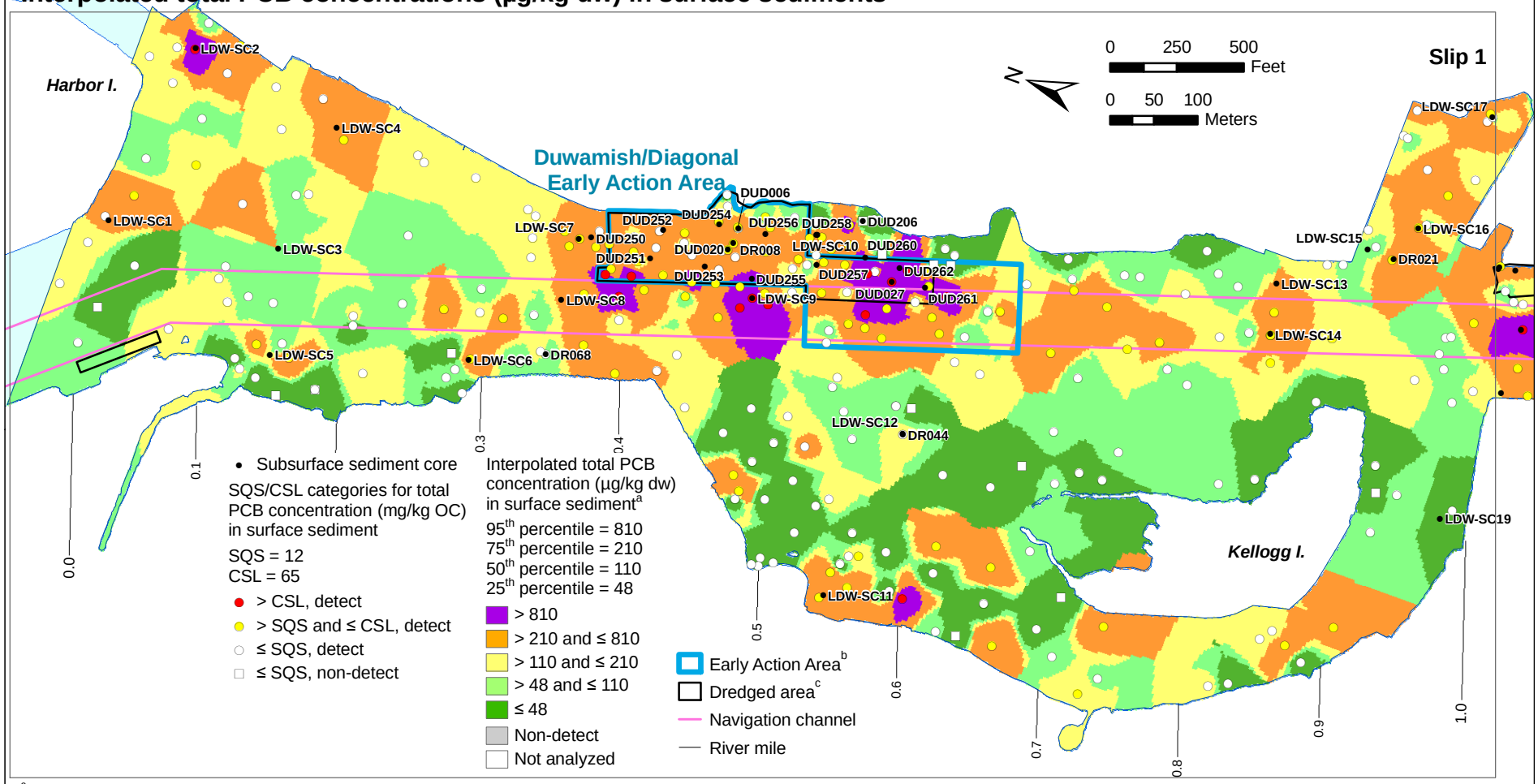
Map 4-25c. Total PCB concentrations in subsurface sediment within the 0-to-2-ft, 2-to-4-ft, and 4-to-6-ft sampling intervals, RM 3.7 to RM 6.0

Wind Ward environmental LLC

Prepared by CEH, 07/14/2016, MAP 2804; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Depth Intervals\PCBs.

Dredging information provided by AECOM.

Interpolated total PCB concentrations (µg/kg dw) in surface sediments



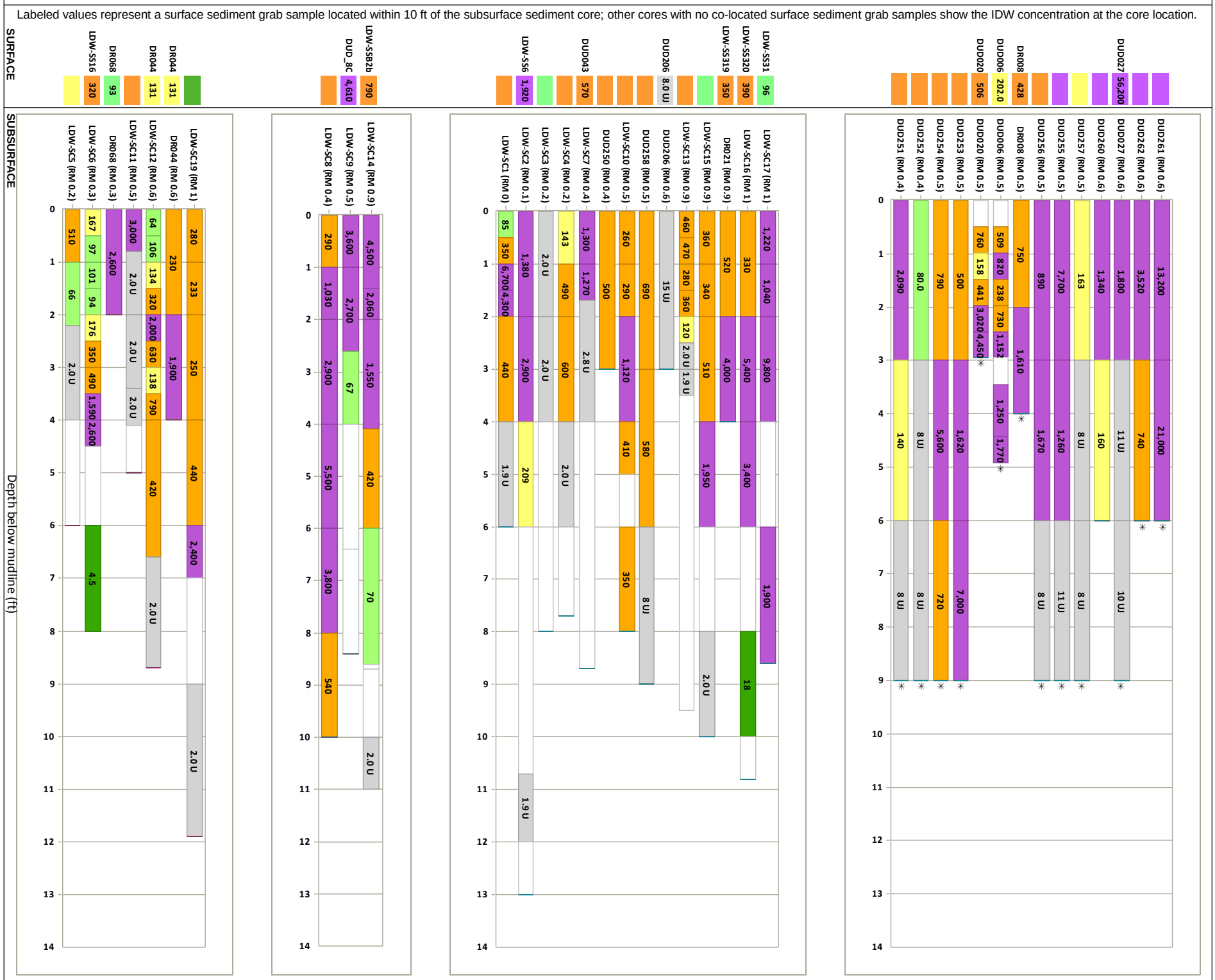
[a] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g. the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 810 µg/kg dw). Total PCBs represent the sum of the concentrations of all detected Aroclors. For locations with non-detects for all individual Aroclors, a value equal to the highest RL of an individual Aroclor at that location was used. Interpolated surface does not show non-detects.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, and thin-layer placement in 2003 to 2005. Subsurface sediment data in dredged areas were collected prior to dredging.

Total PCB concentrations (µg/kg dw) in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment grab sample located within 10 ft of the subsurface sediment core; other cores with no co-located surface sediment grab samples show the IDW concentration at the core location.



✳ This core was collected prior to dredging at that location.

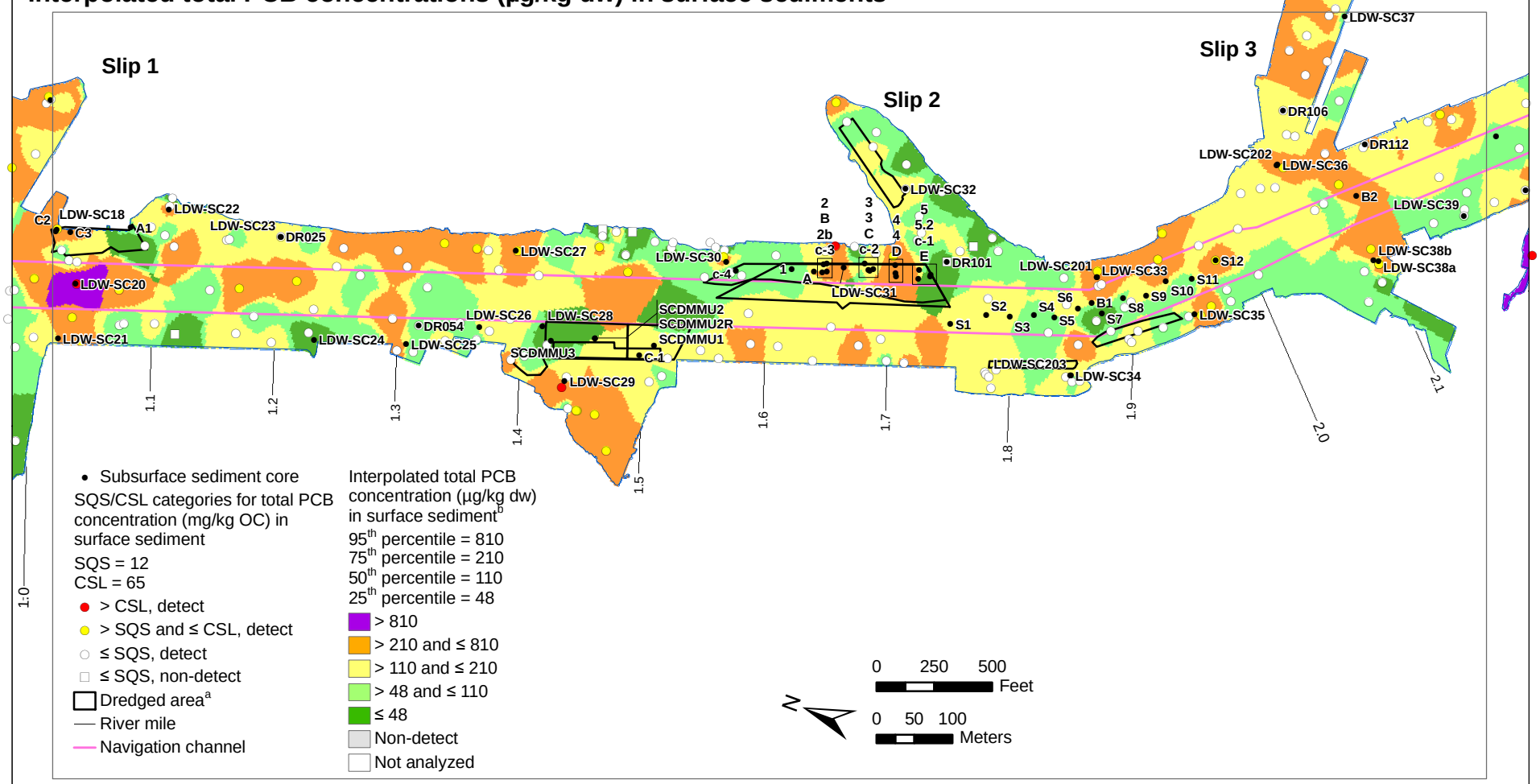
Map 4-26a. Total PCB concentrations in surface sediment and subsurface sediment cores, RM 0.0 to RM 1.0

Wind Ward environmental LLC

Prepared by CEH, 07/14/2010; MAP 3003; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.

Interpolated total PCB concentrations (µg/kg dw) in surface sediments

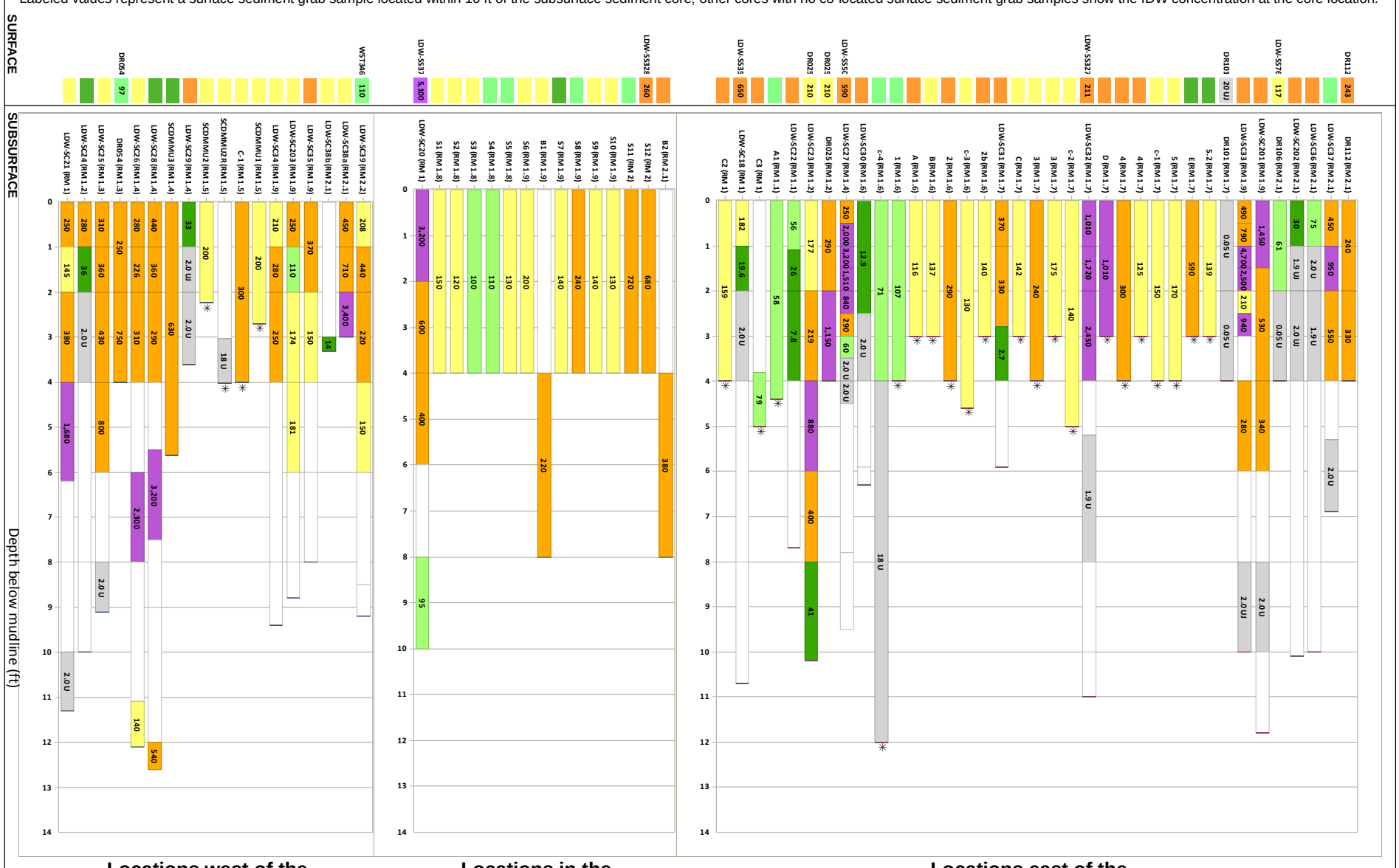


[a] Subsurface sediment data at locations in dredged areas were collected prior to dredging; surface sediment data were collected after dredging.

[b] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 810 µg/kg dw). Total PCBs represent the sum of the concentrations of all detected Aroclors. For locations with non-detects for all individual Aroclors, a value equal to the highest RL of an individual Aroclor at that location was used. Interpolated surface does not show non-detects.

Total PCB concentrations (µg/kg dw) in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment grab sample located within 10 ft of the subsurface sediment core; other cores with no co-located surface sediment grab samples show the IDW concentration at the core location.



✳ This core was collected prior to dredging at that location.

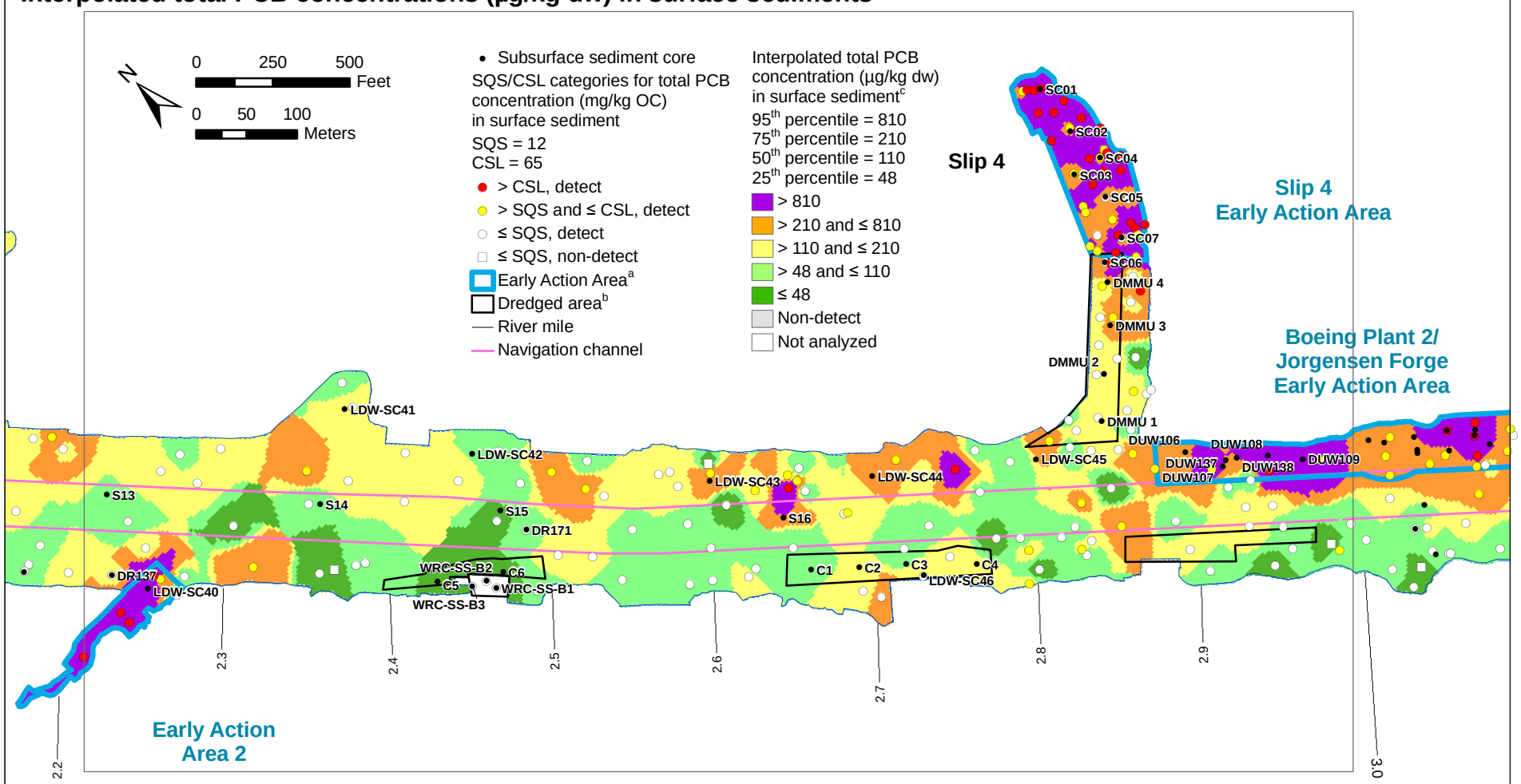
Map 4-26b. Total PCB concentrations in surface sediment and subsurface sediment cores, RM 1.0 to RM 2.2

Wind Ward environmental LLC

Prepared by CEH, 07/14/2010; MAP 3003; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.

Interpolated total PCB concentrations (µg/kg dw) in surface sediments



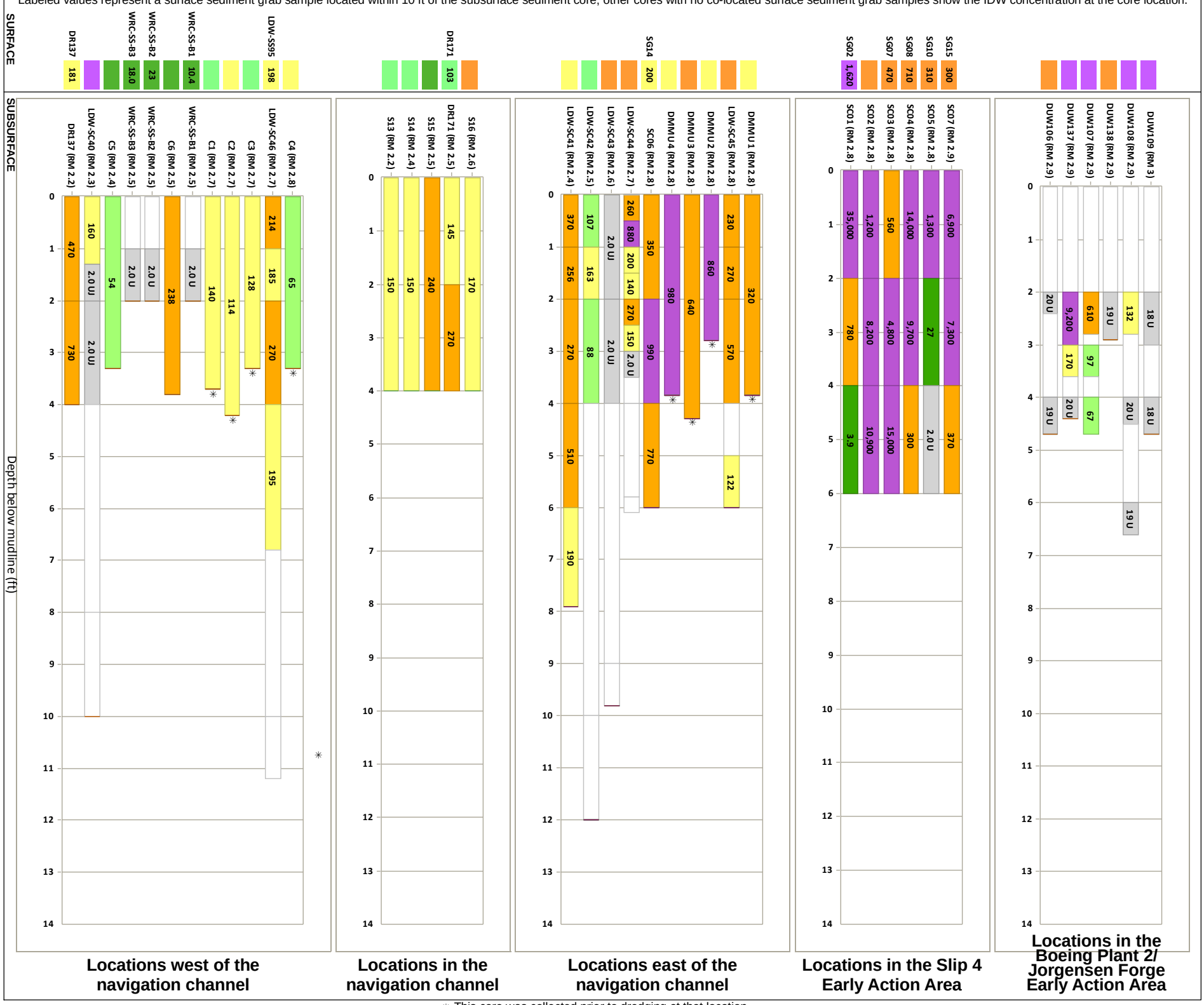
[a] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[b] Subsurface sediment data at locations in dredged areas were collected prior to dredging; surface sediment data were collected after dredging.

[c] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 810 µg/kg dw). Total PCBs represent the sum of the concentrations of all detected Aroclors. For locations with non-detects for all individual Aroclors, a value equal to the highest RL of an individual Aroclor at that location was used. Interpolated surface does not show non-detects.

Total PCB concentrations (µg/kg dw) in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment grab sample located within 10 ft of the subsurface sediment core; other cores with no co-located surface sediment grab samples show the IDW concentration at the core location.



✳ This core was collected prior to dredging at that location.

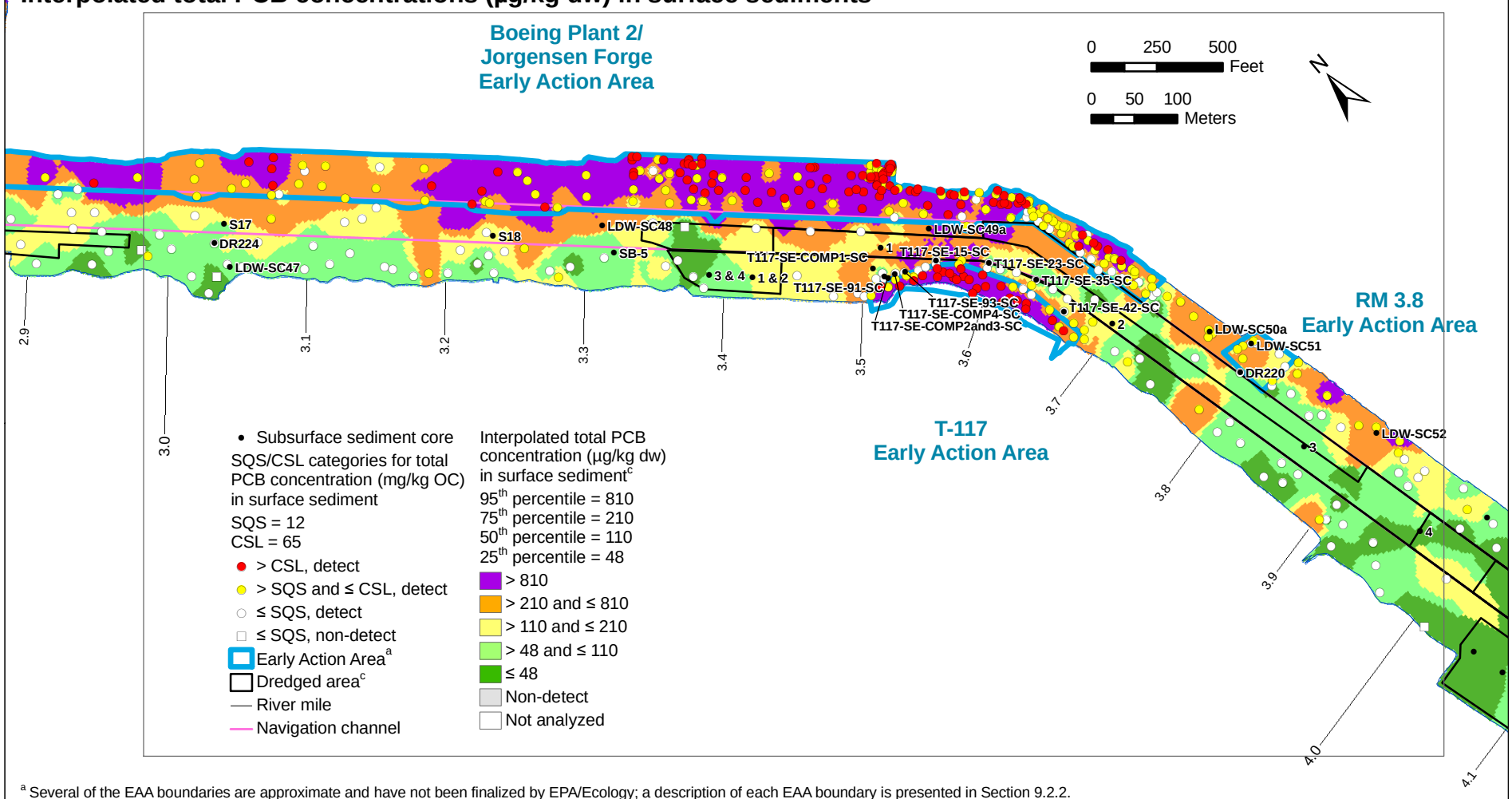
Wind Ward environmental LLC

Map 4-26c. Total PCB concentrations in surface sediment and subsurface sediment cores, RM 2.2 to RM 3.0

Prepared by CEH, 07/14/2010; MAP 3003; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.

Interpolated total PCB concentrations (µg/kg dw) in surface sediments



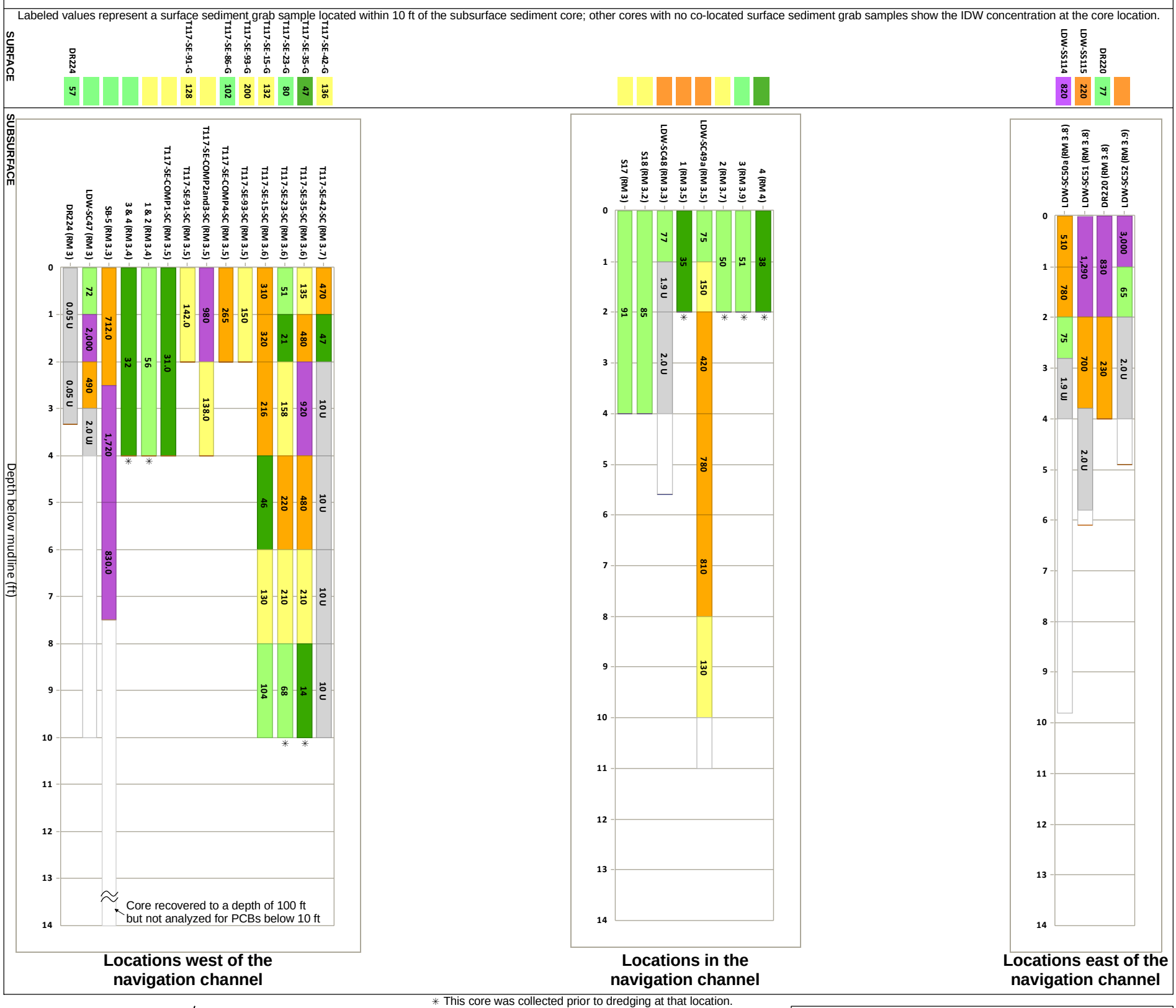
[a] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[b] Subsurface sediment data at locations in dredged areas were collected prior to dredging; surface sediment data were collected after dredging.

[c] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 810 µg/kg dw). Total PCBs represent the sum of the concentrations of all detected Aroclors. For locations with non-detects for all individual Aroclors, a value equal to the highest RL of an individual Aroclor at that location was used. Interpolated surface does not show non-detects.

Total PCB concentrations (µg/kg dw) in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment grab sample located within 10 ft of the subsurface sediment core; other cores with no co-located surface sediment grab samples show the IDW concentration at the core location.



Locations west of the navigation channel

Locations in the navigation channel

Locations east of the navigation channel

✳ This core was collected prior to dredging at that location.

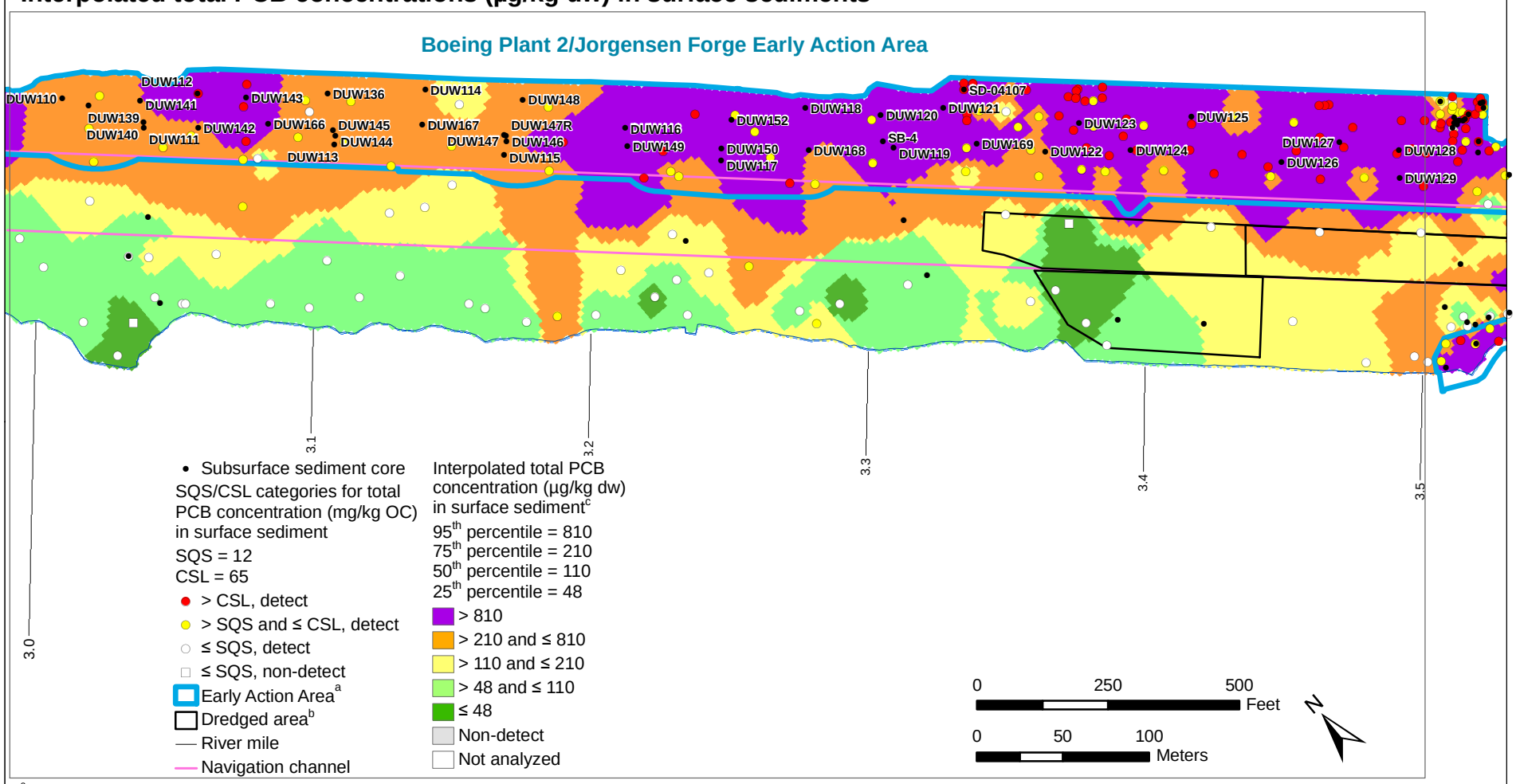
Wind Ward LLC environmental

Map 4-26d. Total PCB concentrations in surface sediment and subsurface sediment cores, RM 3.0 to RM 4.0

Prepared by CEH, 07/14/2010; MAP 3003; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.

Interpolated total PCB concentrations (µg/kg dw) in surface sediments



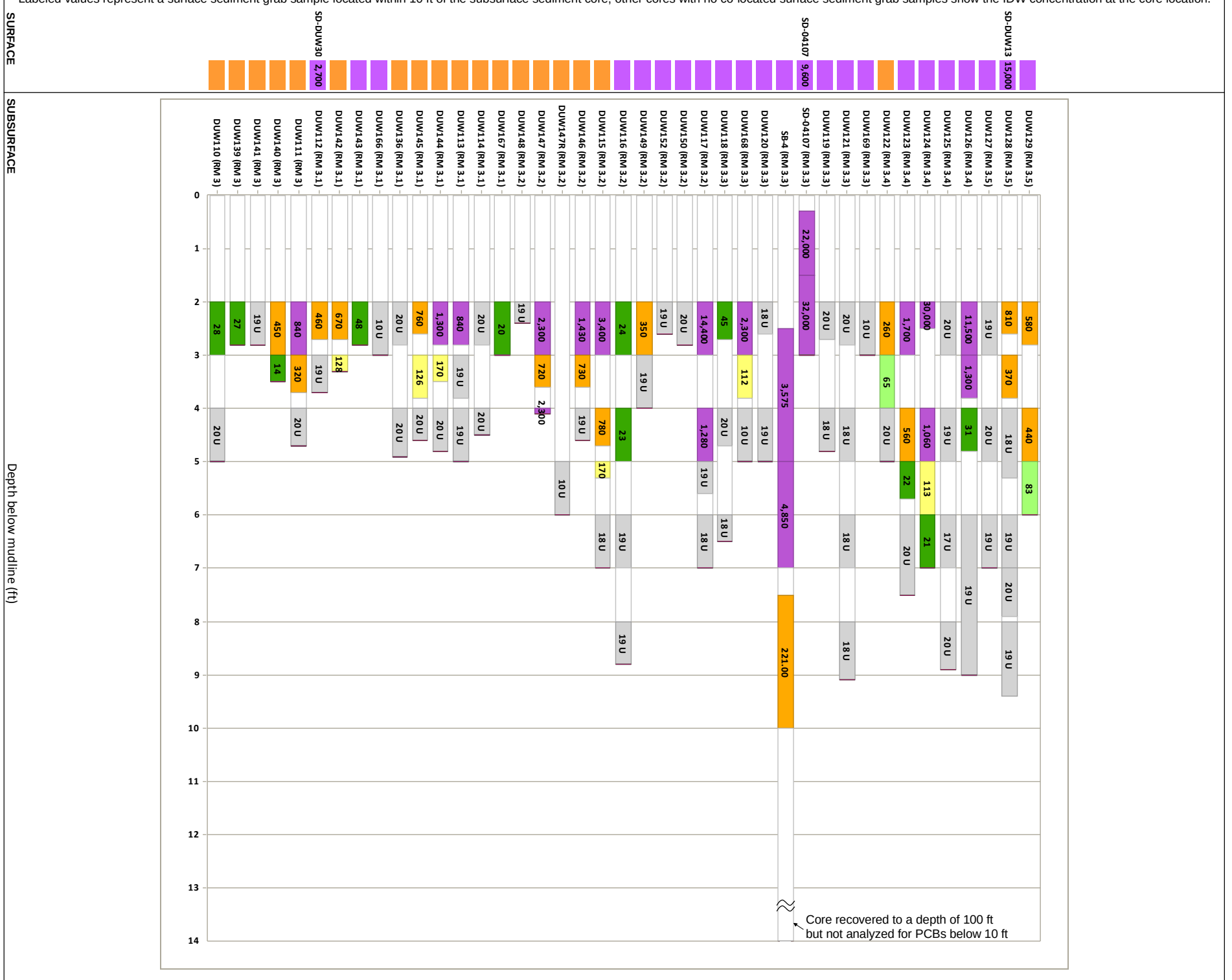
[a] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[b] Subsurface sediment data at locations in dredged areas were collected prior to dredging; surface sediment data were collected after dredging.

[c] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 810 µg/kg dw). Total PCBs represent the sum of the concentrations of all detected Aroclors. For locations with non-detects for all individual Aroclors, a value equal to the highest RL of an individual Aroclor at that location was used. Interpolated surface does not show non-detects.

Total PCB concentrations (µg/kg dw) in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment grab sample located within 10 ft of the subsurface sediment core; other cores with no co-located surface sediment grab samples show the IDW concentration at the core location.



Locations in the Boeing Plant 2/Jorgensen Forge Early Action Area

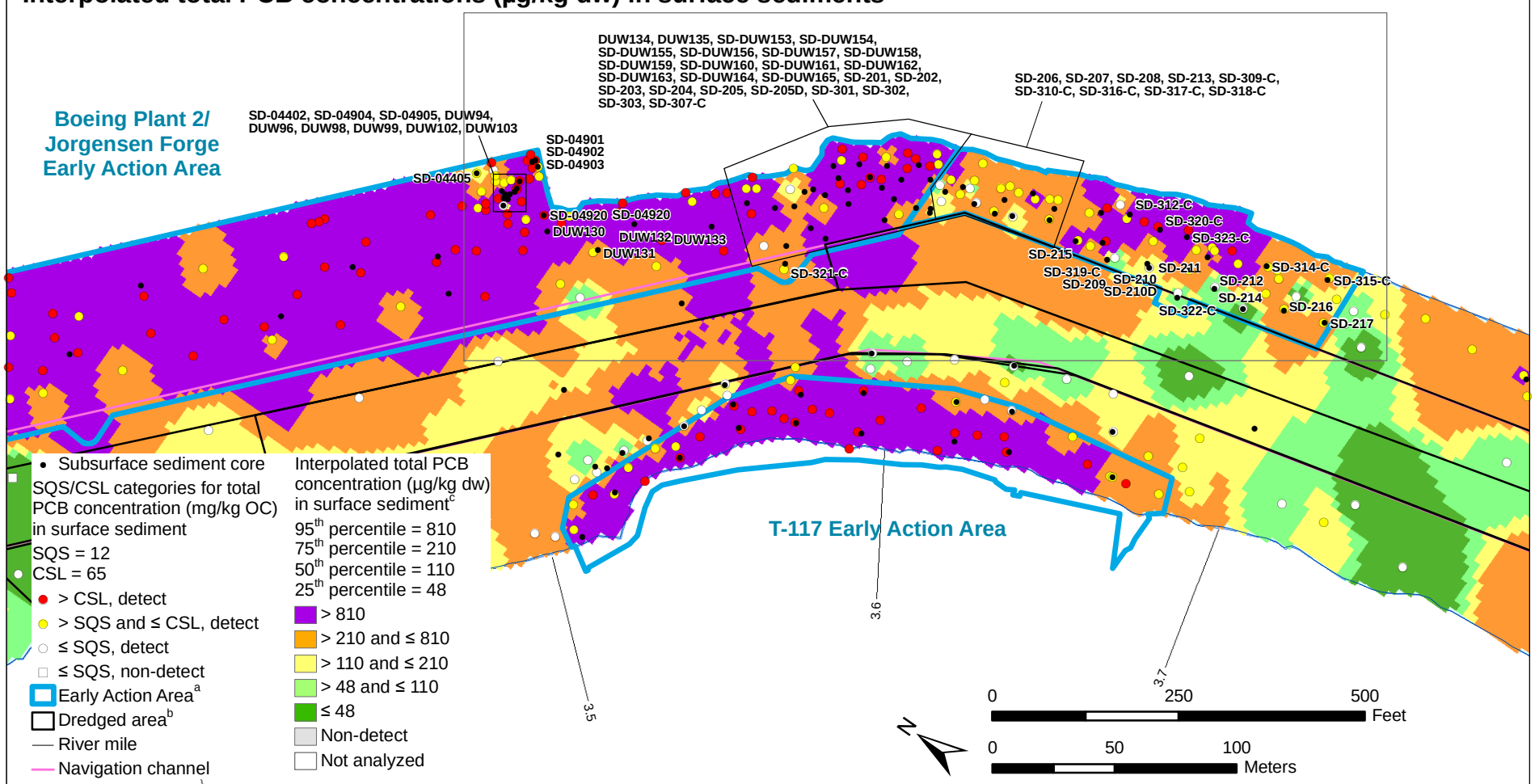
Wind Ward environmental LLC

Map 4-26e. Total PCB concentrations in surface sediment and subsurface sediment cores from the Boeing Plant 2/Jorgensen Forge Early Action Area, RM 3.0 to RM 3.5

Prepared by CEH, 07/14/2010; MAP 3003; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.

Interpolated total PCB concentrations (µg/kg dw) in surface sediments



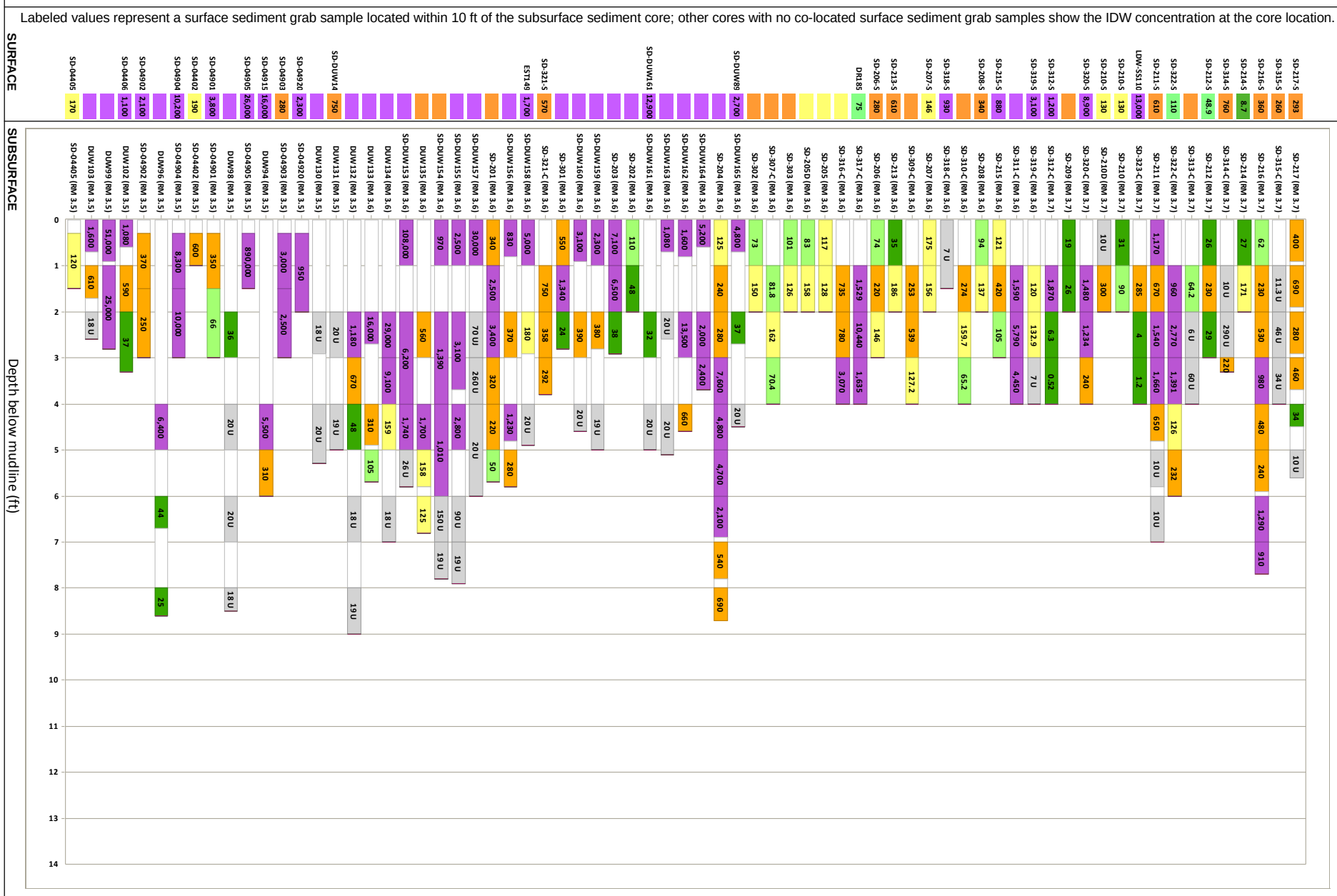
[a] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[b] Subsurface sediment data at locations in dredged areas were collected prior to dredging; surface sediment data were collected after dredging.

[c] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 810 µg/kg dw). Total PCBs represent the sum of the concentrations of all detected Aroclors. For locations with non-detects for all individual Aroclors, a value equal to the highest RL of an individual Aroclor at that location was used. Interpolated surface does not show non-detects.

Total PCB concentrations (µg/kg dw) in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment grab sample located within 10 ft of the subsurface sediment core; other cores with no co-located surface sediment grab samples show the IDW concentration at the core location.



Locations in the Boeing Plant 2/Jorgensen Forge Early Action Area

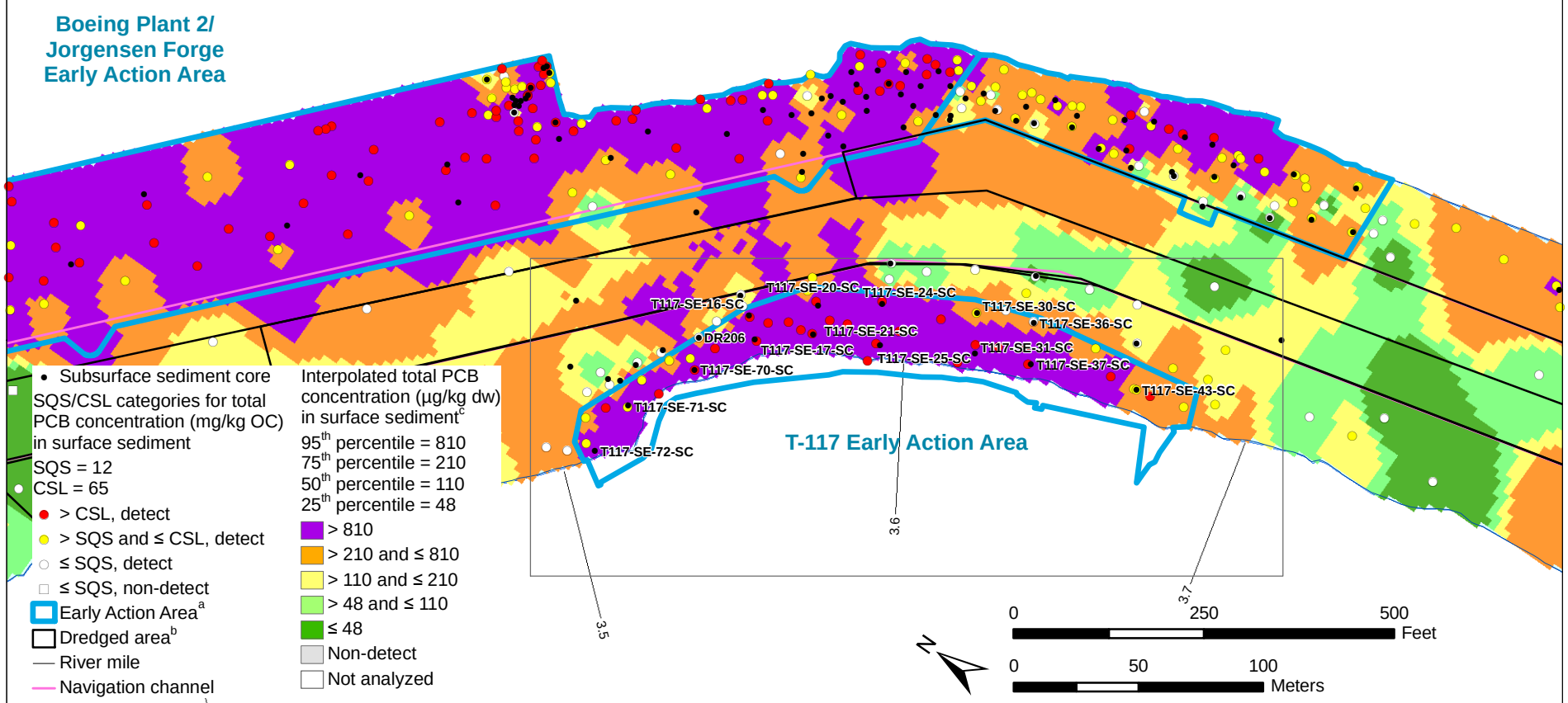
Wind Ward environmental LLC

Map 4-26f. Total PCB concentrations in surface sediment and subsurface sediment cores from the Boeing Plant 2/Jorgensen Forge Early Action Area, RM 3.5 to RM 3.7

Prepared by CEH, 07/14/2010; MAP 3003; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.

Interpolated total PCB concentrations (µg/kg dw) in surface sediments



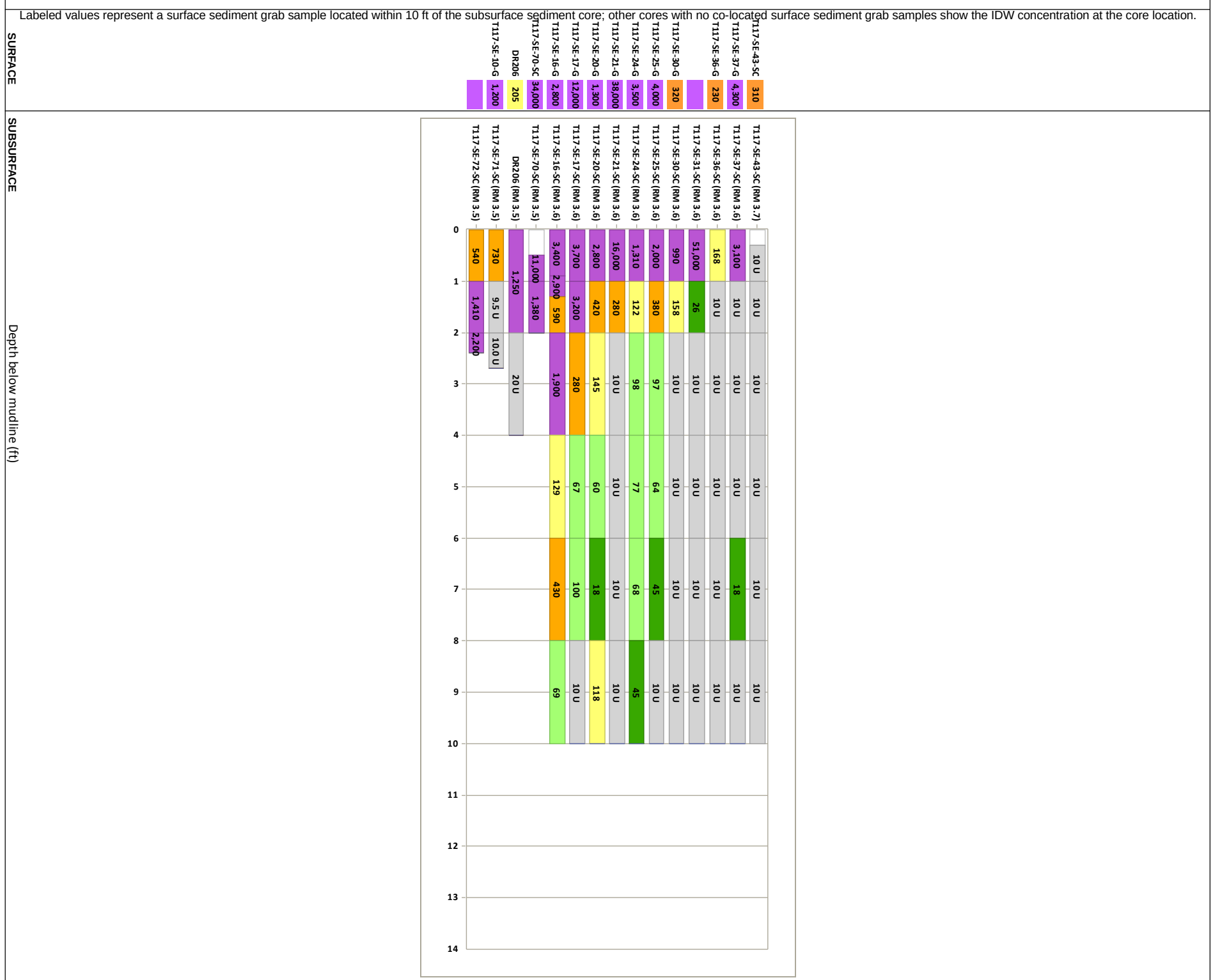
[a] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[b] Subsurface sediment data at locations in dredged areas were collected prior to dredging; surface sediment data were collected after dredging.

[c] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 810 µg/kg dw). Total PCBs represent the sum of the concentrations of all detected Aroclors. For locations with non-detects for all individual Aroclors, a value equal to the highest RL of an individual Aroclor at that location was used. Interpolated surface does not show non-detects.

Total PCB concentrations (µg/kg dw) in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment grab sample located within 10 ft of the subsurface sediment core; other cores with no co-located surface sediment grab samples show the IDW concentration at the core location.



Locations in the T-117 Early Action Area

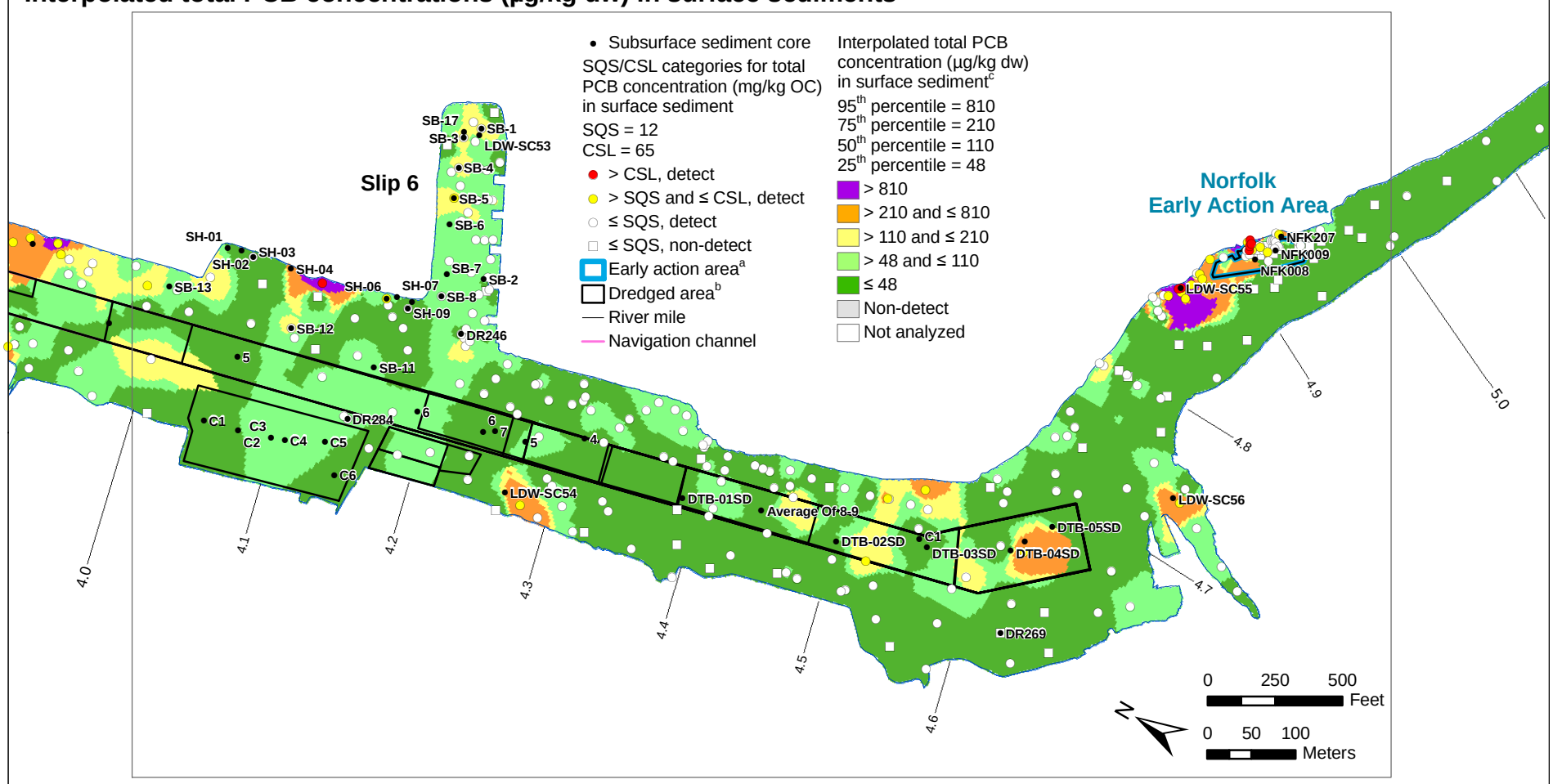
Wind Ward environmental LLC

Map 4-26g. Total PCB concentrations in surface sediment and subsurface sediment cores from the T-117 Early Action Area

Prepared by CEH, 07/14/2010; MAP 3003; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.

Interpolated total PCB concentrations (µg/kg dw) in surface sediments



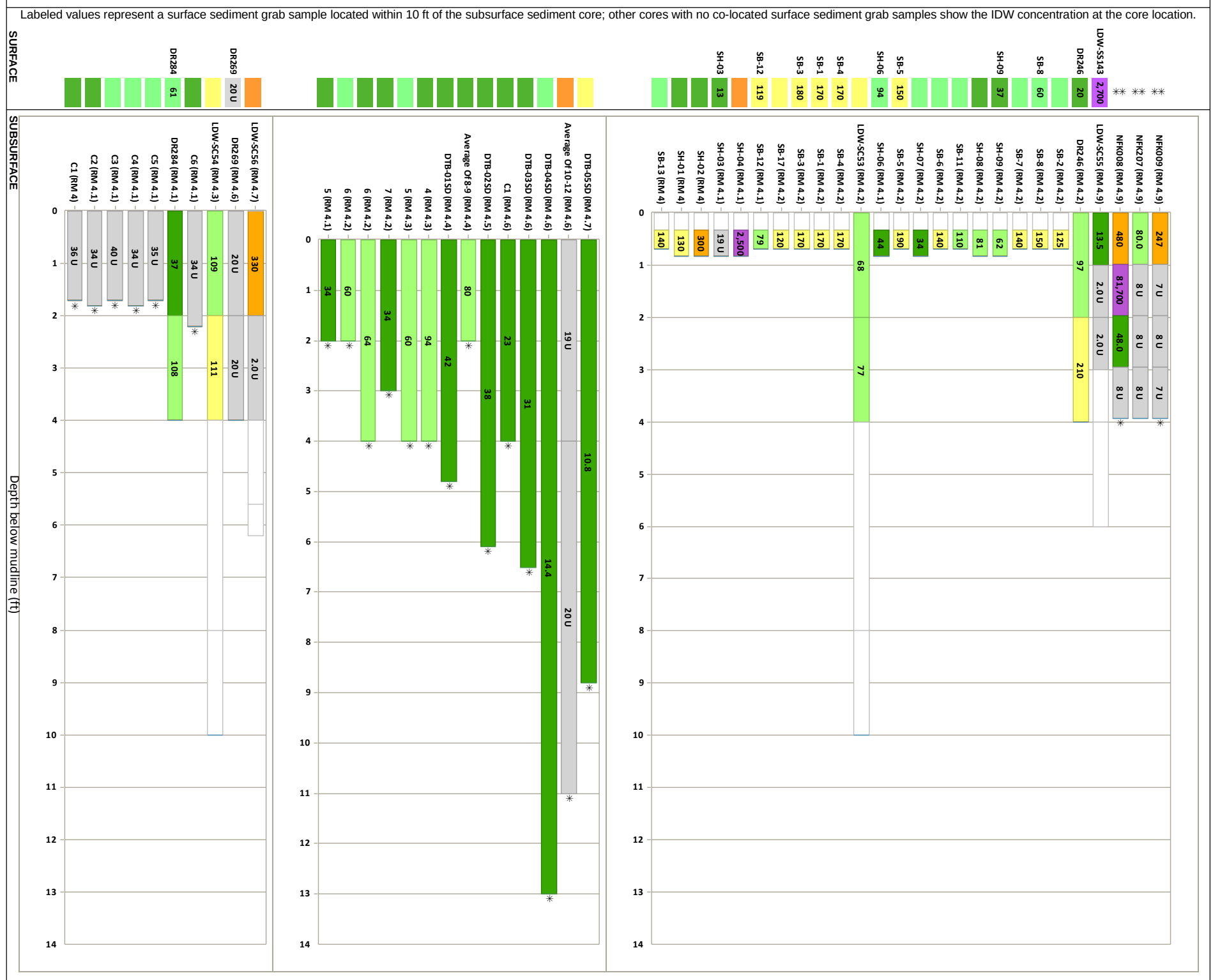
[a] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[b] For the Norfolk Early Action Area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO/SD removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003. Subsurface sediment data at locations in dredged areas were collected prior to dredging.

[c] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated values ≤ 810 µg/kg dw). Total PCBs represent the sum of the concentrations of all detected Aroclors. For locations with non-detects for all individual Aroclors, a value equal to the highest RL of an individual Aroclor at that location was used. Interpolated surface does not show non-detects.

Total PCB concentrations (µg/kg dw) in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment grab sample located within 10 ft of the subsurface sediment core; other cores with no co-located surface sediment grab samples show the IDW concentration at the core location.



∗ This core was collected prior to dredging at that location.

∗∗ At the Norfolk EAA, surface sediment data, which were collected after the removal action at the Norfolk CSO area in 1999 but before the removal action at the BDC south storm drain outfall area in 2003, do not reflect conditions at the time subsurface cores were collected in 1995.

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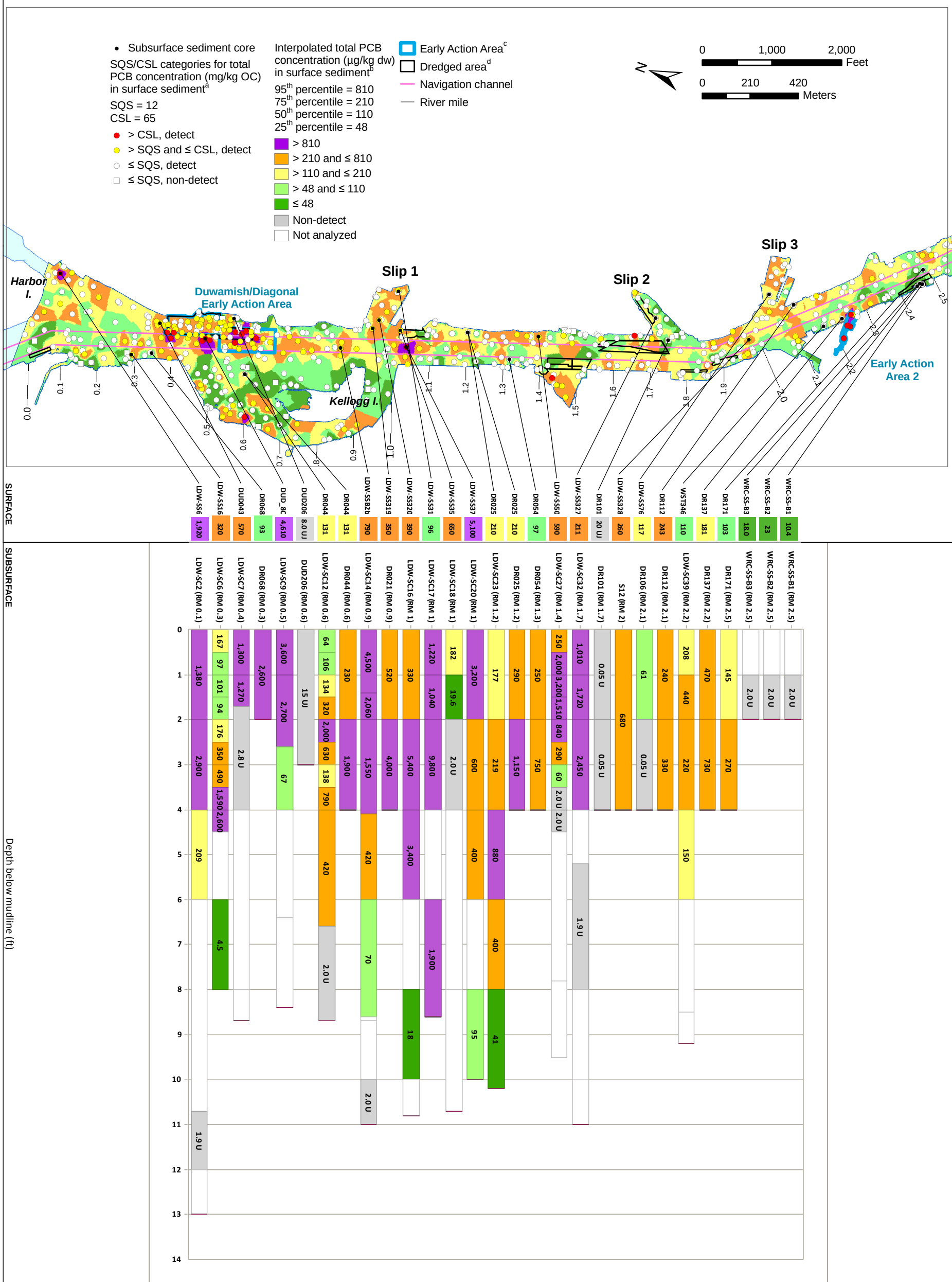
Map 4-26h. Total PCB concentrations in surface sediment and subsurface sediment cores, RM 4.0 to RM 5.0

Prepared by CEH, 07/14/2010; MAP 3003; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.

Total PCB concentrations (µg/kg dw) in surface sediments, subsurface core data, and co-located (within 10 ft) surface sediment data



[a] When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations were compared instead to the LAET and 2LAET.

[b] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 810 µg/kg dw). Total PCBs represent the sum of the concentrations of all detected Aroclors. For locations with non-detects for all individual Aroclors, a value equal to the highest RL of an individual Aroclor at that location was used. Interpolated surface does not show non-detects.

[c] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[d] For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, and thin-layer placement in 2003 to 2005. Subsurface sediment data in dredged areas were collected prior to dredging.

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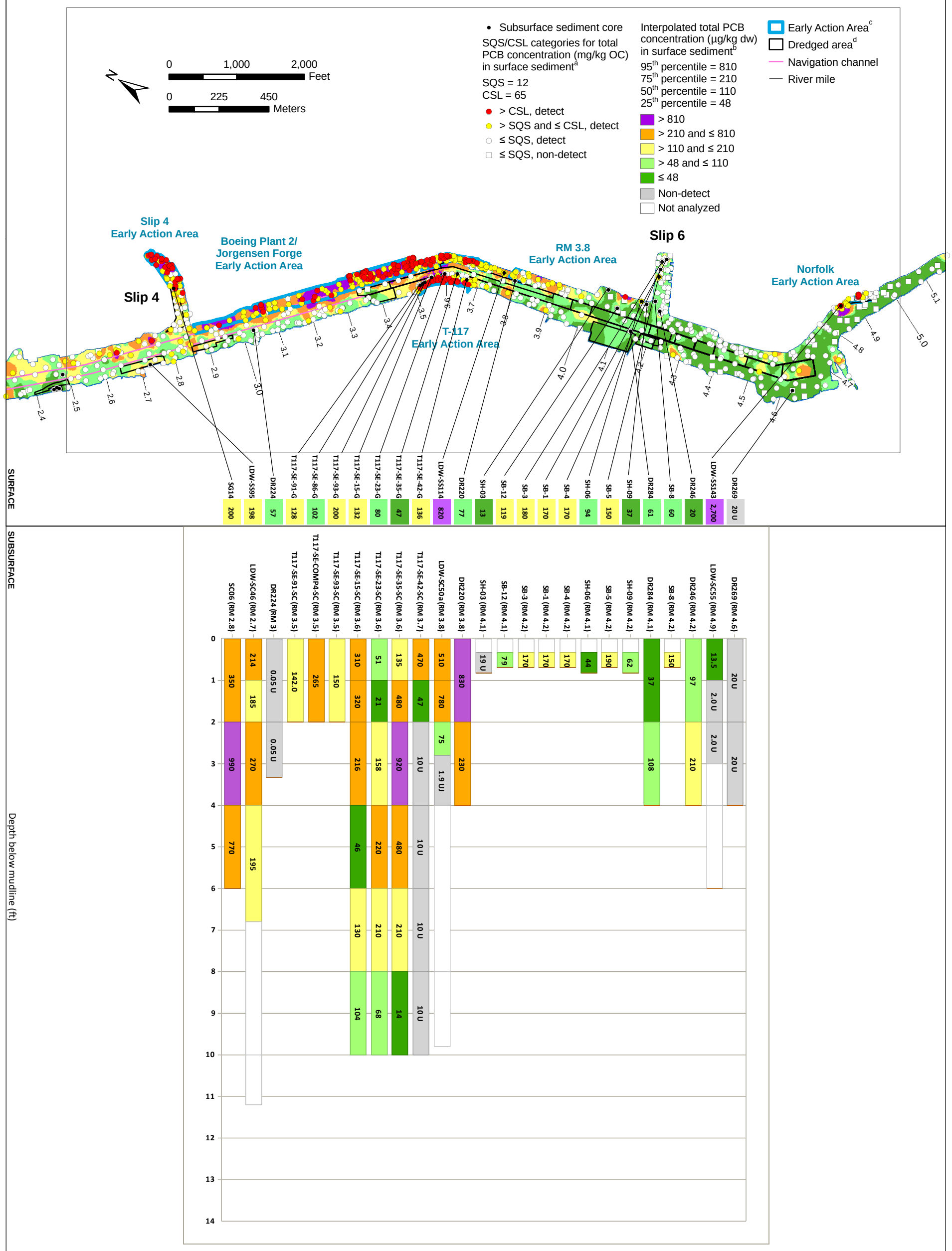
Map 4-27a. Comparison of PCB concentrations in subsurface cores to co-located surface sediment locations, RM 0.0 to RM 2.5

Prepared by CEH, 07/14/2010; MAP 3649; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Nature and Extent\Subsurface\Colocation

Dredging information provided by AECOM.

Total PCB concentrations (µg/kg dw) in surface sediments, subsurface core data, and co-located (within 10 ft) surface sediment data



[a] When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations were compared instead to the LAET and 2LAET.

[b] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 810 µg/kg dw). Total PCBs represent the sum of the concentrations of all detected Aroclors. For locations with non-detects for all individual Aroclors, a value equal to the highest RL of an individual Aroclor at that location was used. Interpolated surface does not show non-detects.

[c] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[d] For the Norfolk Early Action Area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003. Subsurface sediment data in dredged areas were collected prior to dredging.

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Map 4-27b. Comparison of PCB concentrations in subsurface cores to co-located surface sediment locations, RM 2.5 to RM 5.0

Prepared by CEH, 07/14/2010; MAP 3649; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Nature and Extent\Subsurface\Colocation

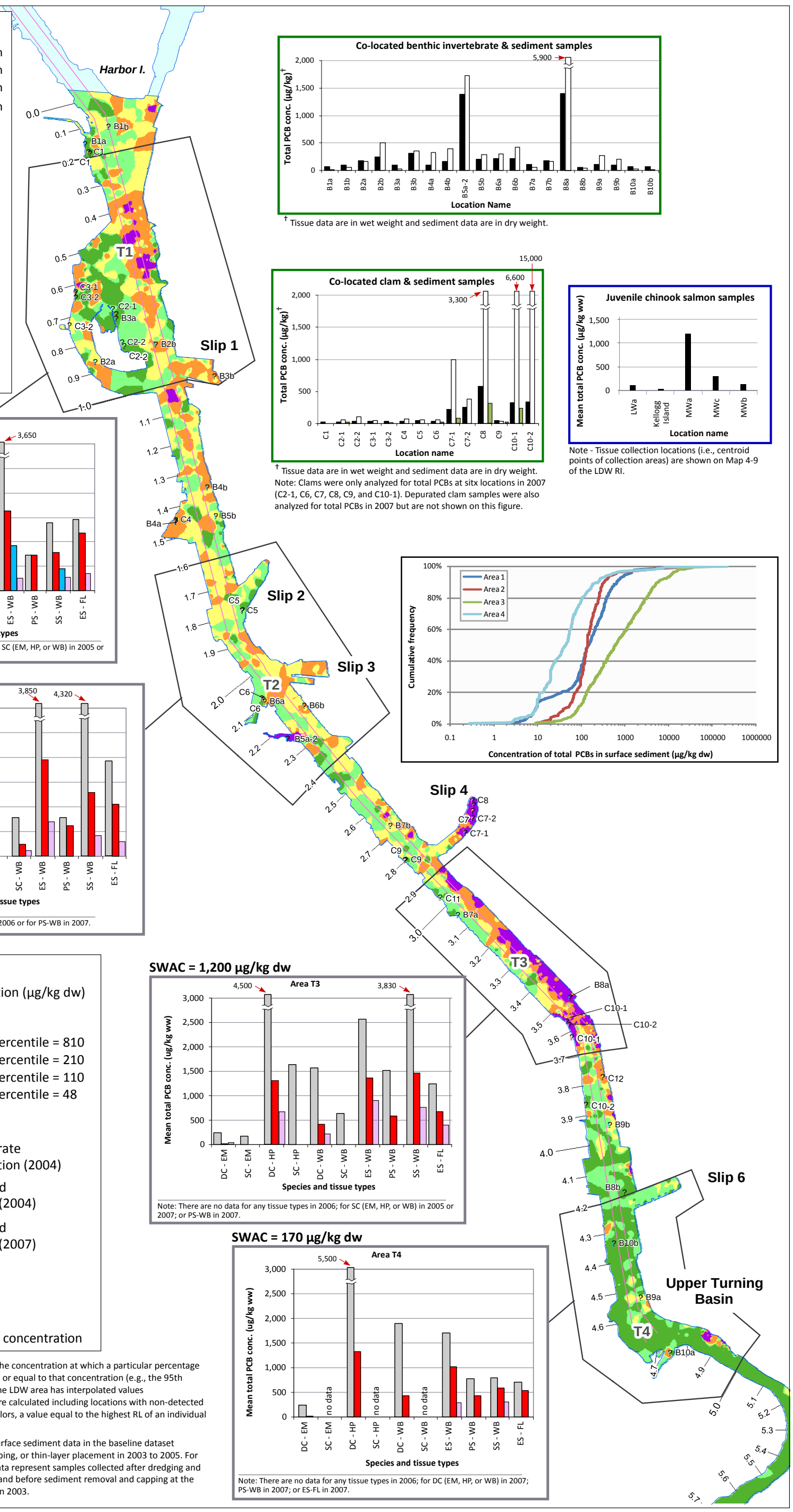
Dredging information provided by AECOM.

Graph Legend

- 2004 fish or crab PCB concentration
- 2005 fish or crab PCB concentration
- 2006 fish or crab PCB concentration
- 2007 fish or crab PCB concentration
- 2004 softshell clam, benthic invertebrate, or salmon PCB concentration
- 2007 softshell clam PCB concentration
- 2004 co-located PCB concentration in sediment

Acronyms for species and tissue type

DC - Dungeness crab
SC - Slender crab
ES - English sole
PS - Pacific staghorn sculpin
SS - Shiner surfperch
EM - Edible meat
FL - Fillet with skin
HP - Hepatopancreas
WB - Whole body

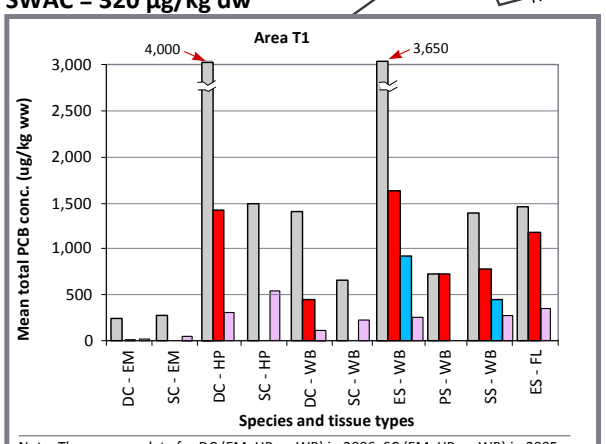


† Tissue data are in wet weight and sediment data are in dry weight.

† Tissue data are in wet weight and sediment data are in dry weight. Note: Clams were only analyzed for total PCBs at sitx locations in 2007 (C2-1, C6, C7, C8, C9, and C10-1). Depurated clam samples were also analyzed for total PCBs in 2007 but are not shown on this figure.

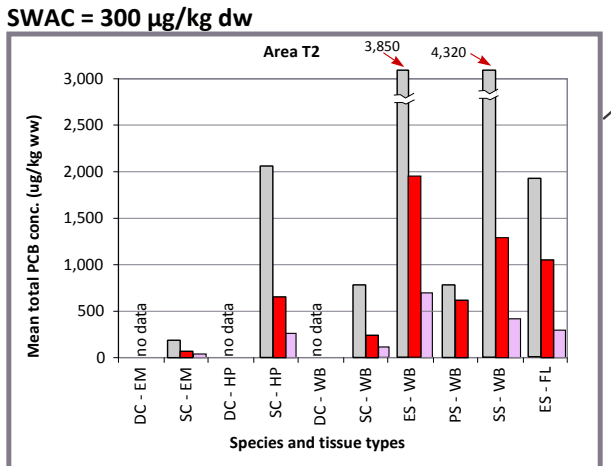
Note - Tissue collection locations (i.e., centroid points of collection areas) are shown on Map 4-9 of the LDW RI.

SWAC = 320 µg/kg dw



Note: There are no data for DC (EM, HP, or WB) in 2006; SC (EM, HP, or WB) in 2005 or 2006; PS-WB in 2006 or 2007; or ES- FL in 2006.

SWAC = 300 µg/kg dw



Note: There are no data for any tissue types in 2006 or for PS-WB in 2007.

SWAC = 1,200 µg/kg dw

Note: There are no data for any tissue types in 2006; for SC (EM, HP, or WB) in 2005 or 2007; or PS-WB in 2007.

SWAC = 170 µg/kg dw

Note: There are no data for any tissue types in 2006; for DC (EM, HP, or WB) in 2007; PS-WB in 2007; or ES-FL in 2007.

Map Legend

Interpolated total PCB concentration (µg/kg dw) in surface sediment [a,b]

- > 810
- > 210 and ≤ 810
- > 110 and ≤ 210
- > 48 and ≤ 110
- ≤ 48

95th percentile = 810
75th percentile = 210
50th percentile = 110
25th percentile = 48

- Co-located benthic invertebrate and sediment sampling location (2004)
- Co-located softshell clam and sediment sampling location (2004)
- Co-located softshell clam and sediment sampling location (2007)
- Tissue sampling area
- Navigation channel
- River mile

SWAC - spatially weighted average concentration

[a] Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated values ≤ 810 µg/kg dw). Interpolated concentrations were calculated including locations with non-detected values. For locations with non-detects for all Aroclors, a value equal to the highest RL of an individual Aroclor at that location was used.

[b] For the Duwamish/Diagonal early action area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005. For the Norfolk early action area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

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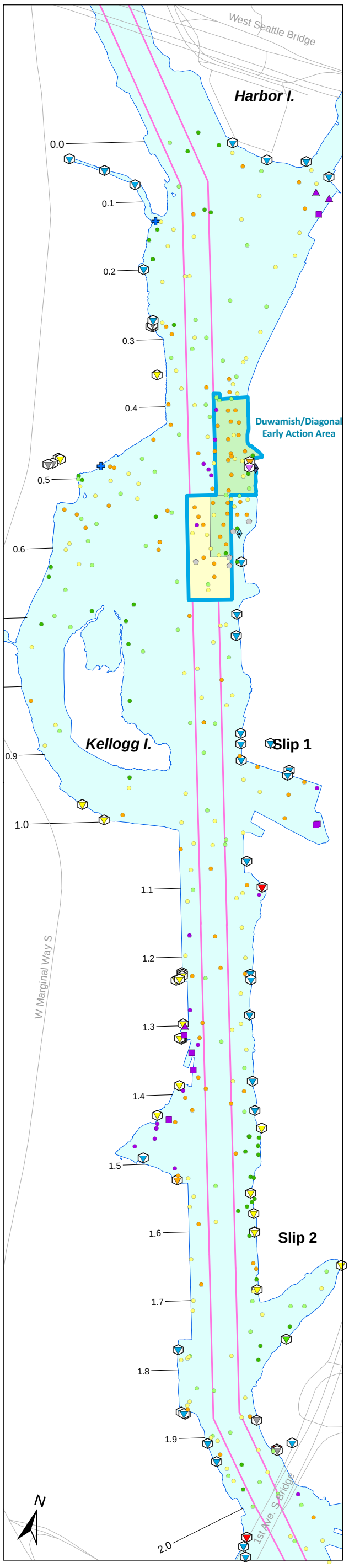
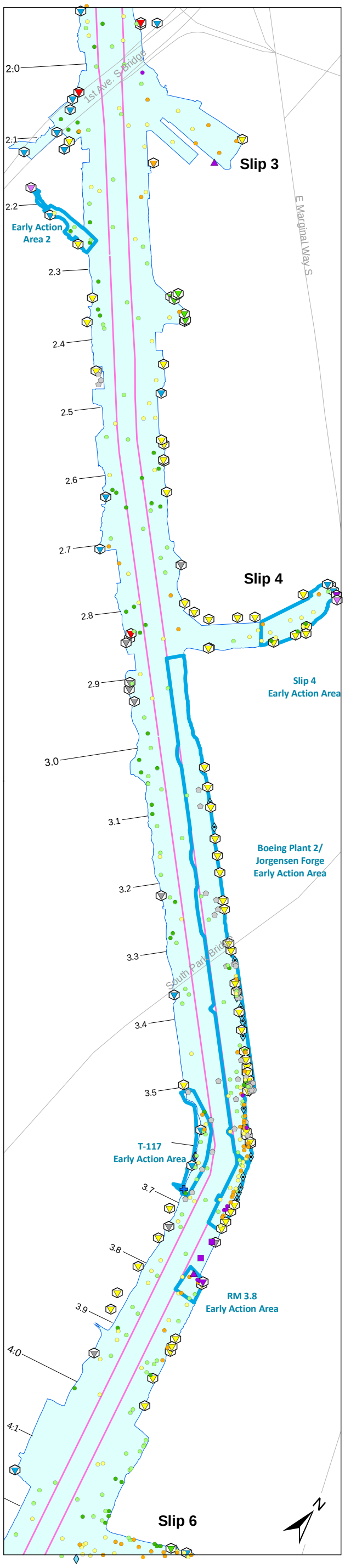
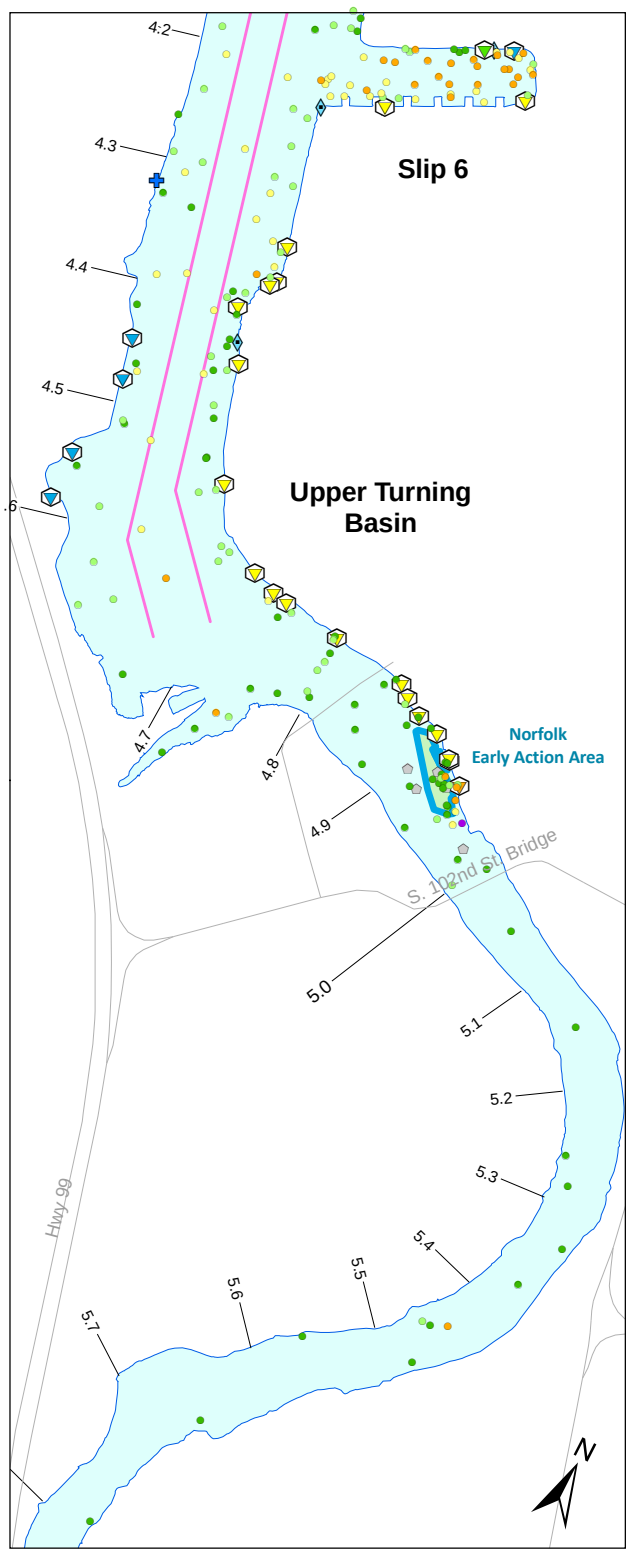
0 0.25 0.5 Miles
0 0.25 0.5 Kilometers

Map 4-28. Total PCB concentrations in composite tissue samples from 2004, 2005, 2006, and 2007 and the IDW interpolation of total PCB concentrations in surface sediment

Modified by Zachariah from GIS Map 2742 | June 30, 2009 | Map 4-28 PCB IDW (2742).xar







Arsenic concentration (mg/kg dw)[a]

- > 30
- > 15 and ≤ 30
- > 11 and ≤ 15
- > 7.9 and ≤ 11
- > 1.2 and ≤ 7.9
- Non-detect

Exceedance

- > CSL
- > SQS and ≤ CSL
- ≤ SQS
- Early Action Area[b]
- Dredged and capped area[c]
- Thin-layer placement[c]
- Road
- Navigation channel
- River mile

95th percentile = 30
75th percentile = 15
50th percentile = 11
25th percentile = 7.9
CSL = 93
SQS = 57

Outfall classification[d]

- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, a value of one-half the RL at that location was used.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer capping in 2003 to 2005. For the Norfolk Early Action Area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

[d] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

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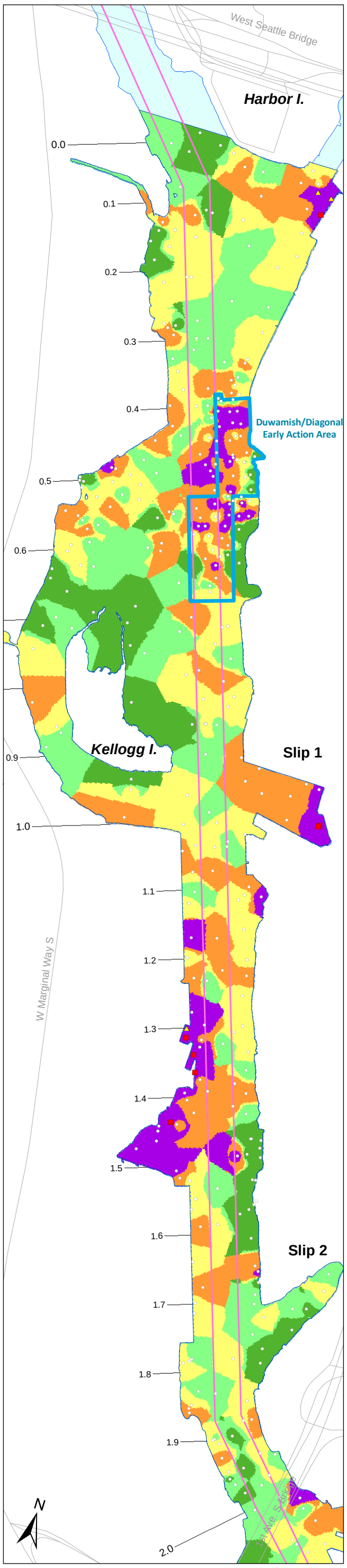
0 0.1 0.2 Miles

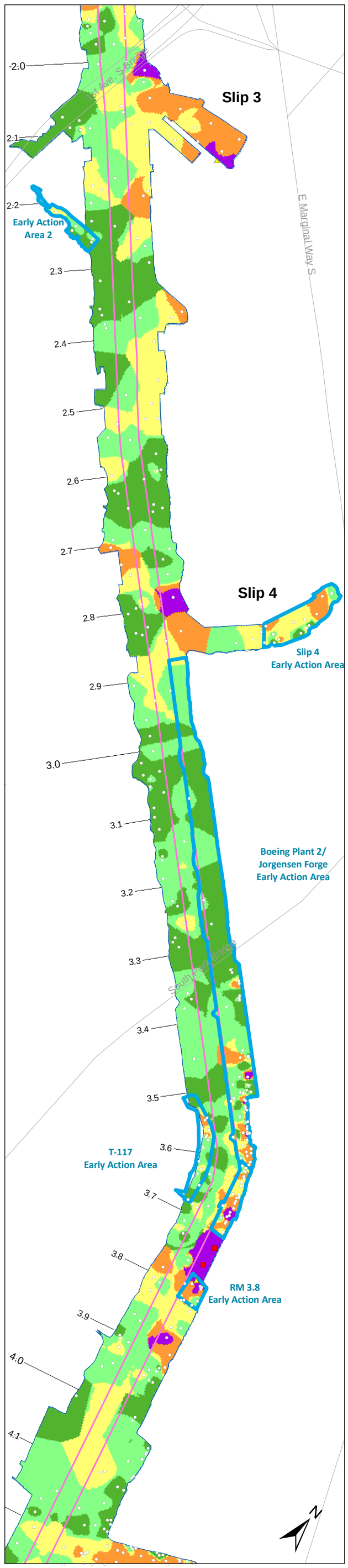
0 0.1 0.2 Kilometers

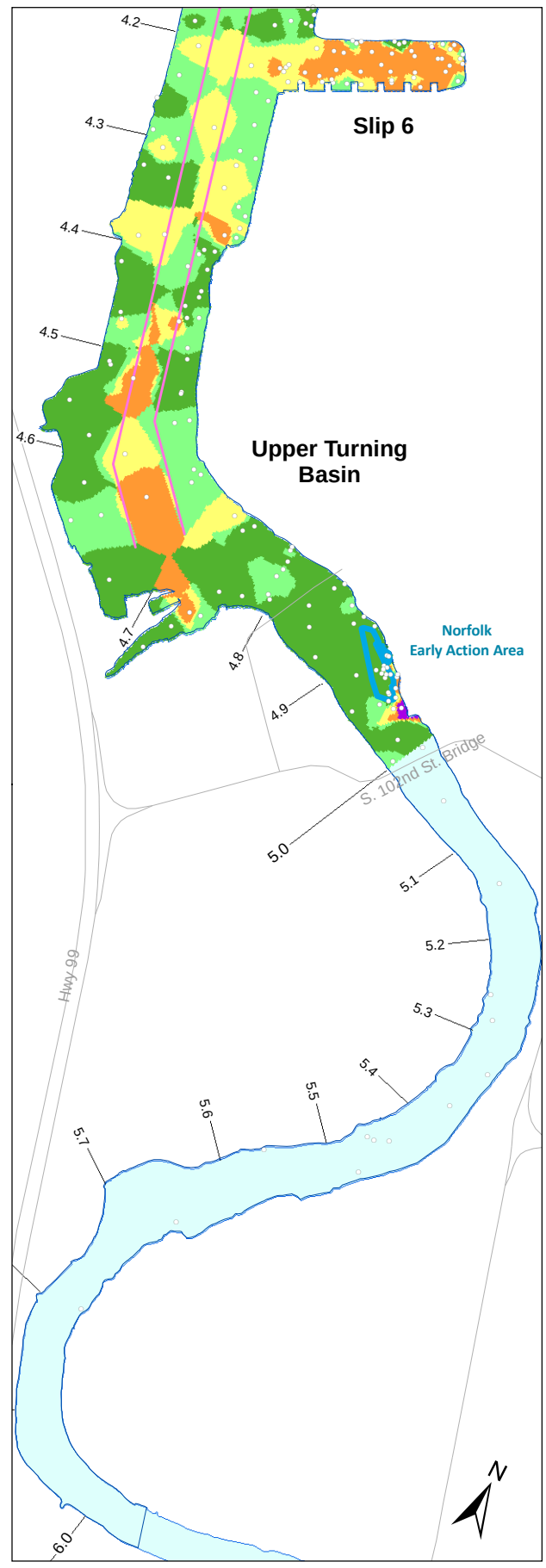
Scale is the same for each inset map

Map 4-29. Arsenic concentrations in surface sediment

Prepared by CEH, 07/15/2010; MAP 2747; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\Arsenic







Arsenic concentration (mg/kg dw)[a]

- > 25
- > 14 and ≤ 25
- > 11 and ≤ 14
- > 8.6 and ≤ 11
- ≤ 8.6

95th percentile = 25
75th percentile = 14
50th percentile = 11
25th percentile = 8.6
CSL = 93
SQS = 57

SQS/CSL categories for arsenic

- > CSL
- > SQS and ≤ CSL
- ≤ SQS
- Early Action Area[b]
- Road
- Navigation channel
- River mile

[a] Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 25 mg/kg dw). Interpolated concentrations were calculated including locations with non-detected values. For locations with non-detects, a value of one-half the RL at that location was used.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2. For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer capping in 2003 to 2005. For the Norfolk Early Action Area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

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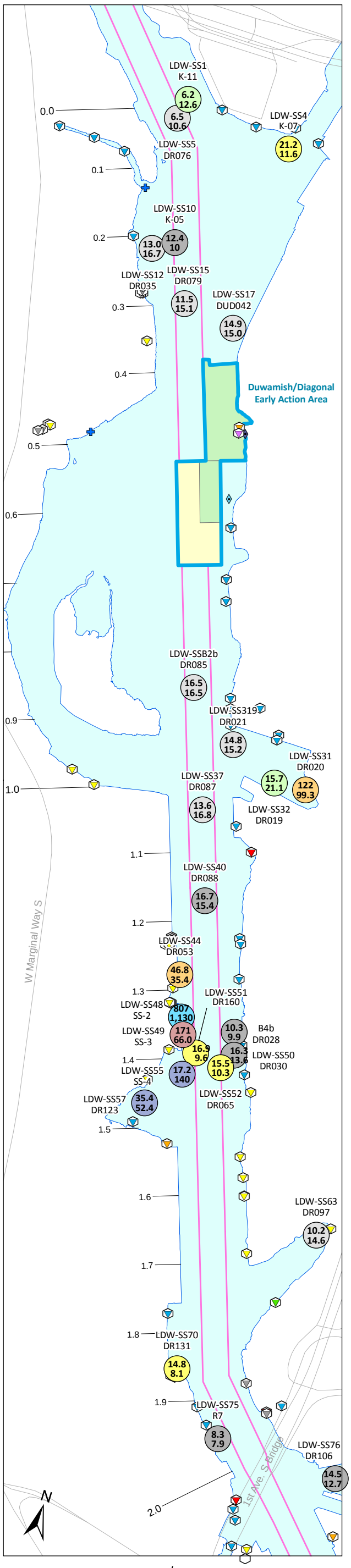
0 0.1 0.2 Miles

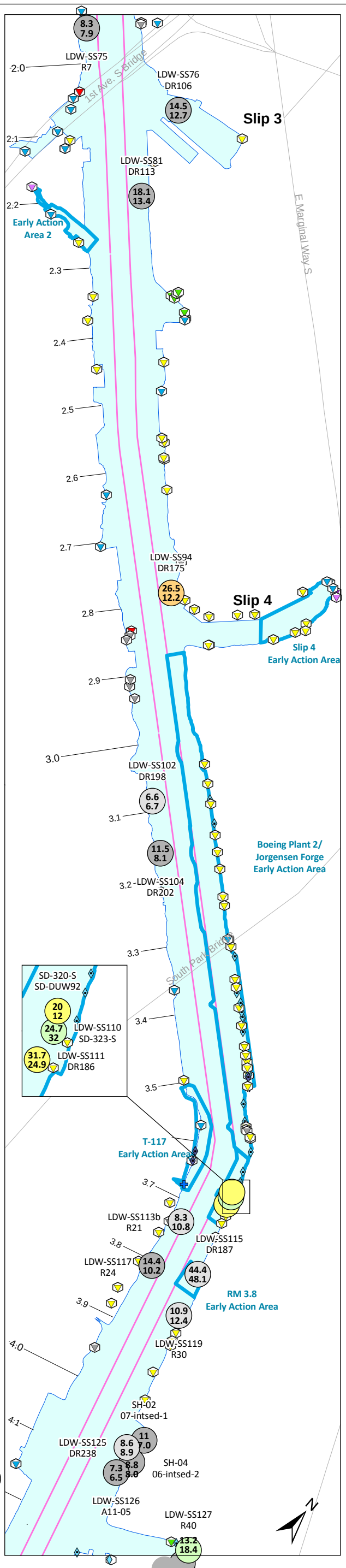
0 0.1 0.2 Kilometers

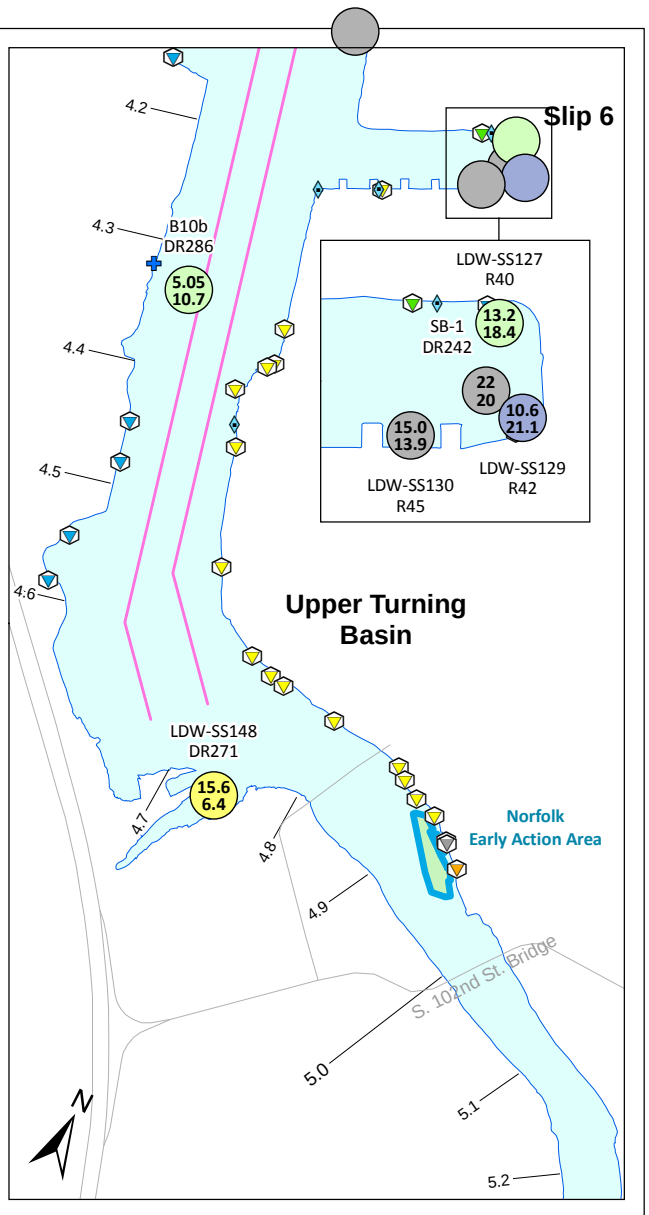
Scale is the same for each inset map

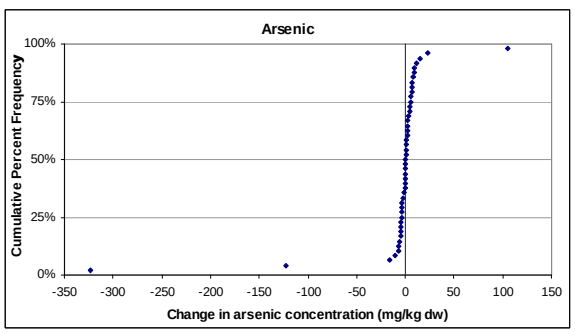
Map 4-30. IDW interpolation of arsenic concentrations in surface sediment

Prepared by CEH, 07/15/2010, MAP 2708; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\Arsenic









Difference in arsenic dry weight values (mg/kg dw)[a]

New value minus old value

- ≤ -150
- > -150 and ≤ -10
- > -10 and ≤ -5
- > -5 and ≤ 0
- > 0 and ≤ 5
- > 5 and ≤ 10
- > 10 and ≤ 25
- > 25
- Early Action Area[b]
- Dredged and capped area
- Thin-layer placement

New value / Old value / New location ID / Old location ID

6.5 / 11 — LDW-SS5 DR076

U = non-detect

Outfall classification[c]

- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale
- Road
- Navigation channel
- River mile

[a] A location was considered to have been resampled if the new location was within 10 ft of the old location.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time of the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

Note: Samples collected in the Duwamish/Diagonal and Norfolk EAAs were not included in this evaluation.

0 0.1 0.2 Miles

0 0.1 0.2 Kilometers

Scale is the same for each inset map

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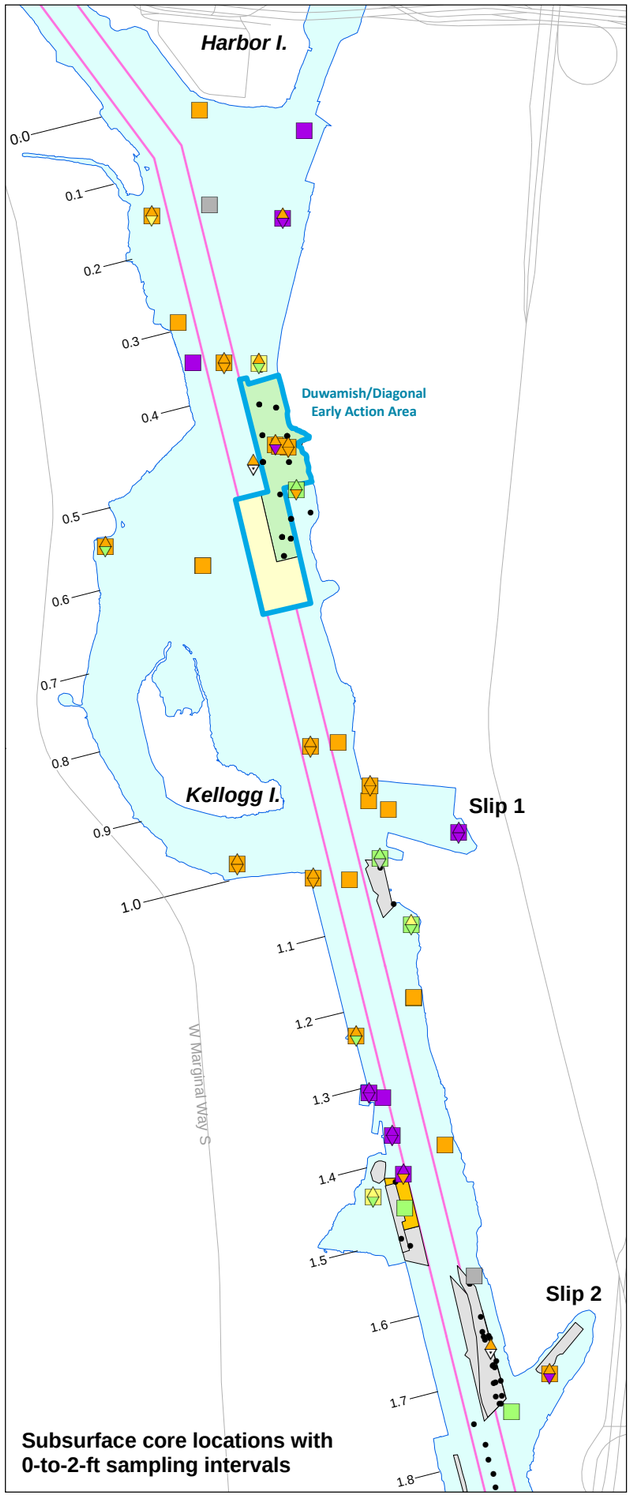
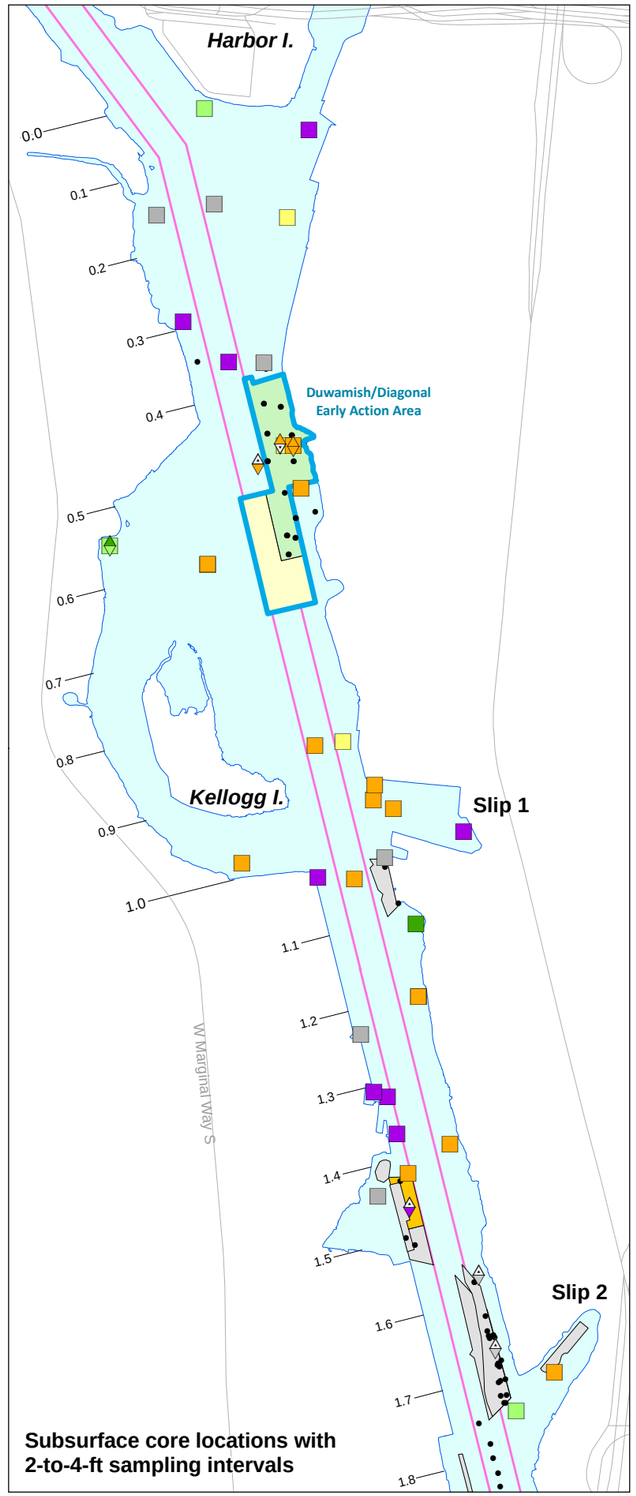
Map 4-31. Differences in arsenic concentrations in surface sediment at locations that have been resampled

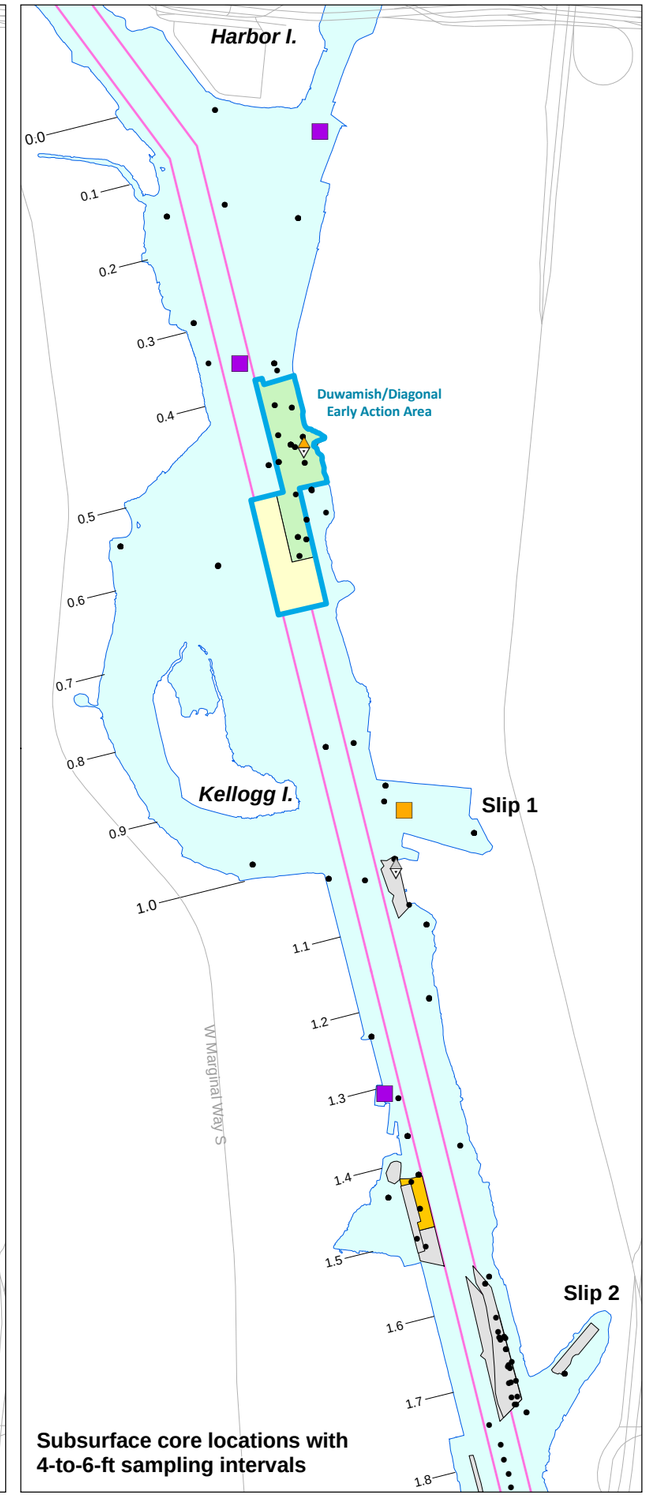
Prepared by CEH, 07/15/2010; MAP 2689; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Round3 Trumping



Subsurface core locations with 0-to-2-ft sampling intervals



Subsurface core locations with 2-to-4-ft sampling intervals



Subsurface core locations with 4-to-6-ft sampling intervals

Arsenic concentration (mg/kg dw)[a]

- > 30 — 95th percentile = 30
- > 15 and ≤ 30 — 75th percentile = 15
- > 11 and ≤ 15 — 50th percentile = 11
- > 7.9 and ≤ 11 — 25th percentile = 7.9
- ≤ 7.9
- Non-detect

Sampling interval

Left panel	Middle panel	Right panel
0-to-2-ft[b]	2-to-4-ft[b]	4-to-6-ft[b]
0-to-1-ft[c]	2-to-3-ft[c]	4-to-5-ft[c]
1-to-2-ft[c]	3-to-4-ft[c]	5-to-6-ft[c]

- Not analyzed in that sampling interval
- Other subsurface sampling location analyzed for arsenic, but not in the illustrated sampling interval
- Early Action Area[d]
- Dredged area[e]
- Dredged and capped area[e]
- Dredged and thin-layer placement[e]
- Thin-layer placement
- Road
- Navigation channel
- River mile

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, a value of one-half the RL at that location was used.

[b] Data from 2-foot sampling intervals; some locations show an average of data from both 1-foot intervals within that 2-foot interval at a given location.

[c] Data from 1-foot sampling intervals are shown if available. If both 1-foot intervals within the 2-foot interval were collected, the average of the two intervals is also shown.

[d] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[e] Subsurface sediment data at locations in dredged areas were collected prior to dredging.

N

0 0.1 0.2 Kilometers

0 0.1 0.2 Miles

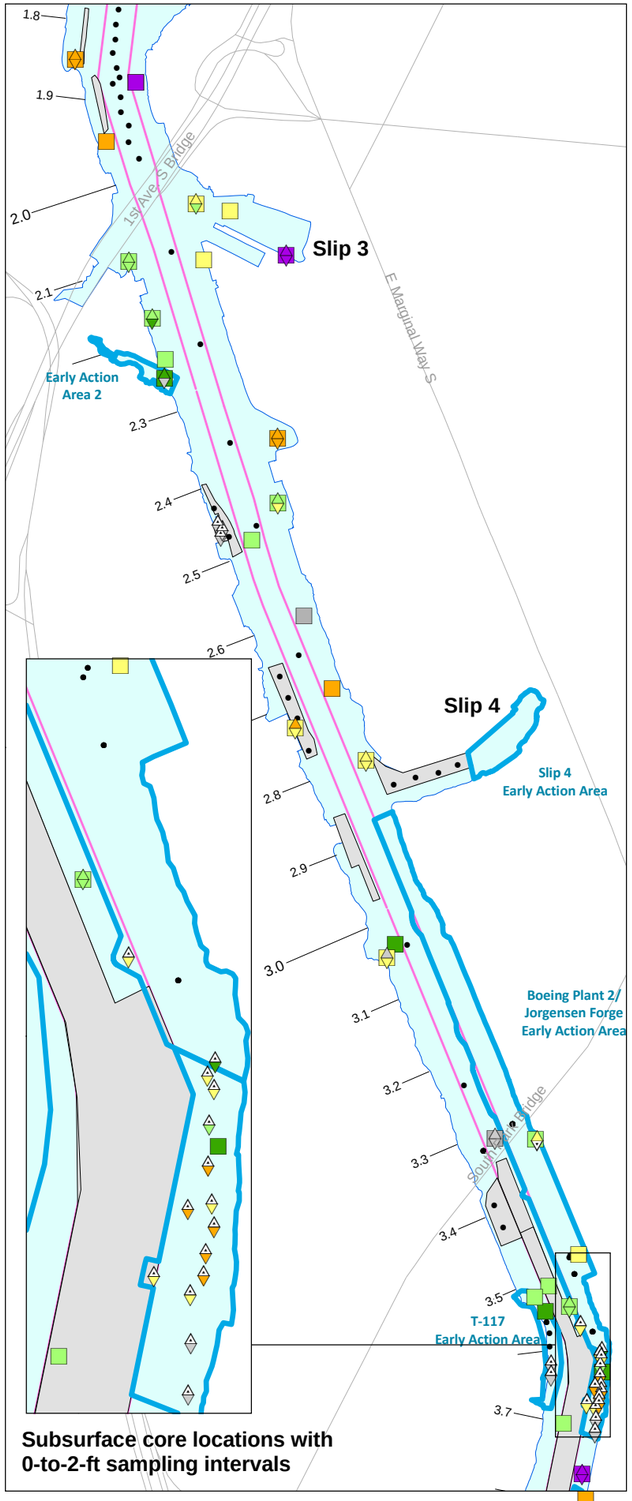
Scale is the same for each map frame

Map 4-32a. Arsenic concentrations in subsurface sediment within the 0-to-2-ft, 2-to-4-ft, and 4-to-6-ft sampling intervals, RM 0.0 to RM 1.8

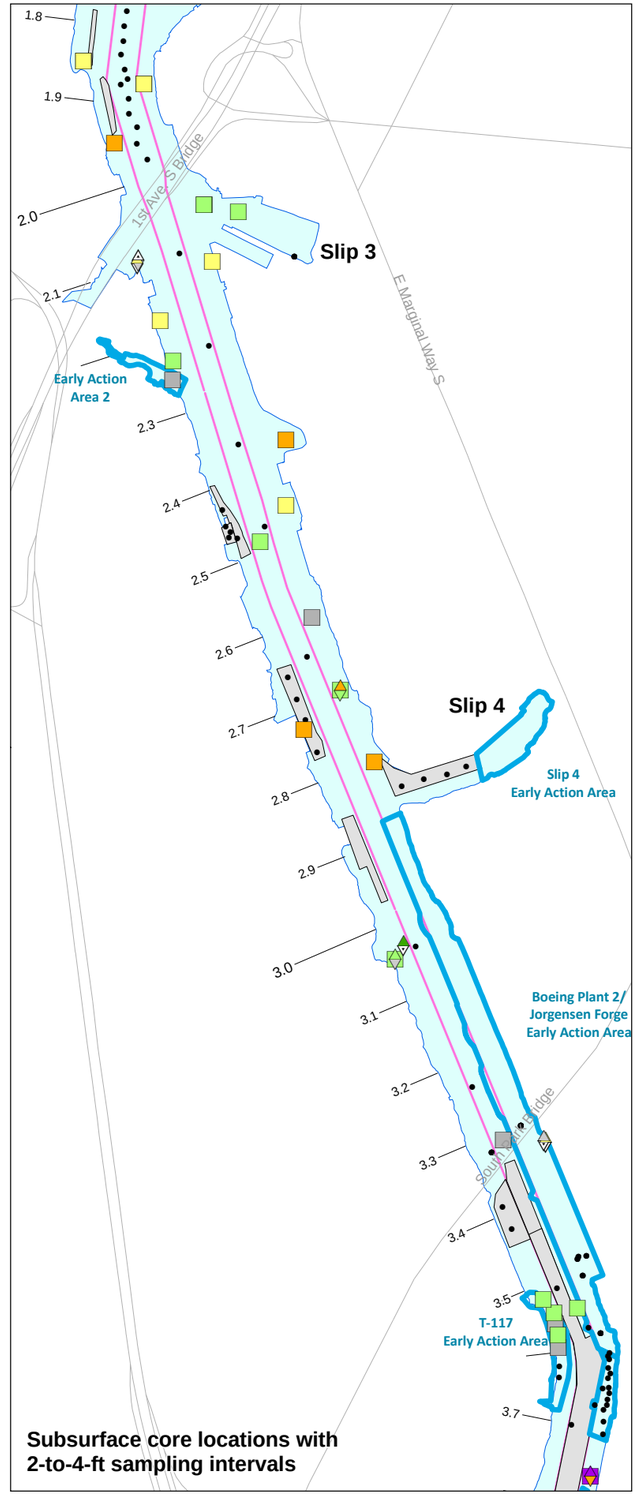
Wind Ward environmental LLC

Prepared by CEH, 07/15/2010, MAP 2813, W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Depth Interval\Arsenic

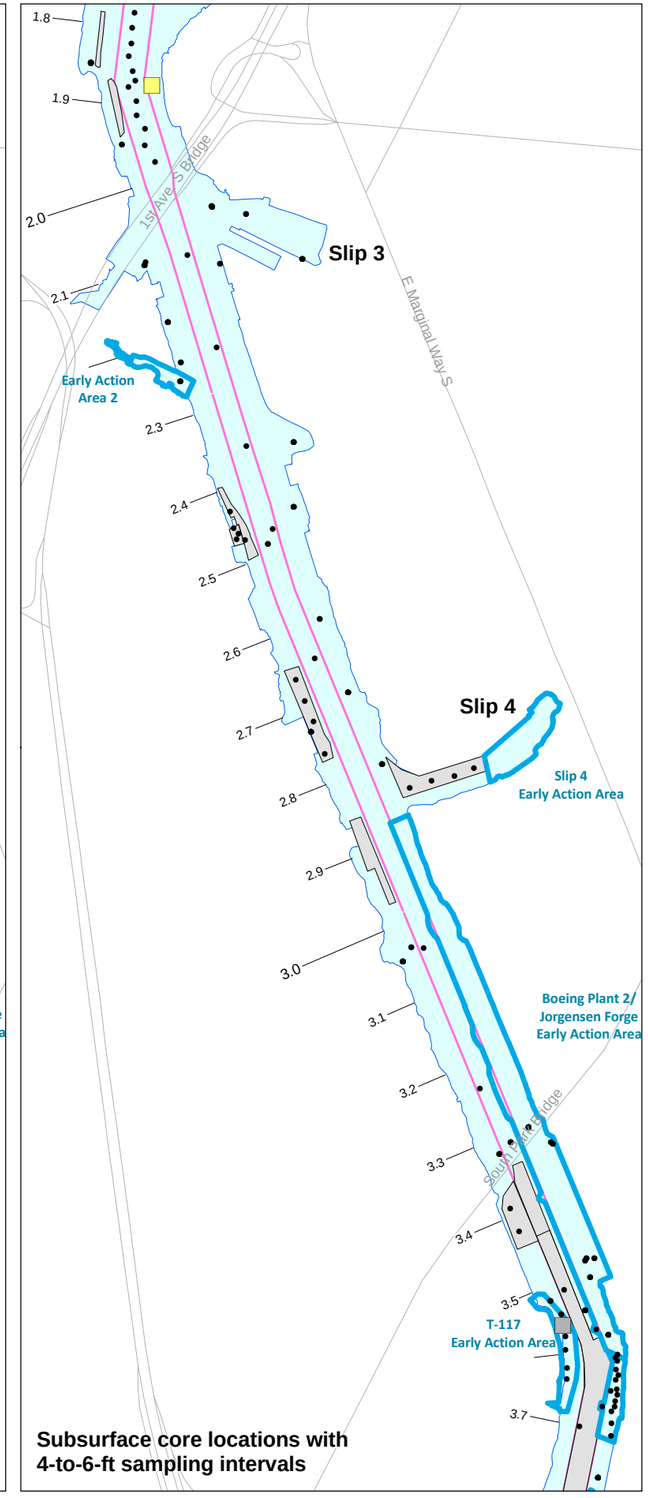
Dredging information provided by AECOM.



Subsurface core locations with 0-to-2-ft sampling intervals



Subsurface core locations with 2-to-4-ft sampling intervals



Subsurface core locations with 4-to-6-ft sampling intervals

Arsenic concentration (mg/kg dw)[a]

- > 30 — 95th percentile = 30
- > 15 and ≤ 30 — 75th percentile = 15
- > 11 and ≤ 15 — 50th percentile = 11
- > 7.9 and ≤ 11 — 25th percentile = 7.9
- ≤ 7.9
- Non-detect

Sampling interval

	Left panel	Middle panel	Right panel
	0-to-2-ft[b]	2-to-4-ft[b]	4-to-6-ft[b]
	0-to-1-ft[c]	2-to-3-ft[c]	4-to-5-ft[c]
	1-to-2-ft[c]	3-to-4-ft[c]	5-to-6-ft[c]

- Not analyzed in that sampling interval
- Other subsurface sampling location analyzed for arsenic, but not in the illustrated sampling interval
- Early Action Area[d]
- Dredged area[e]
- Road
- Navigation channel
- River mile

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, a value of one-half the RL at that location was used.

[b] Data from 2-foot sampling intervals; some locations show an average of data from both 1-foot intervals within that 2-foot interval at a given location.

[c] Data from 1-foot sampling intervals are shown if available. If both 1-foot intervals within the 2-foot interval were collected, the average of the two intervals is also shown.

[d] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[e] Subsurface sediment data at locations in dredged areas were collected prior to dredging.

N

0 0.1 0.2 Kilometers

0 0.1 0.2 Miles

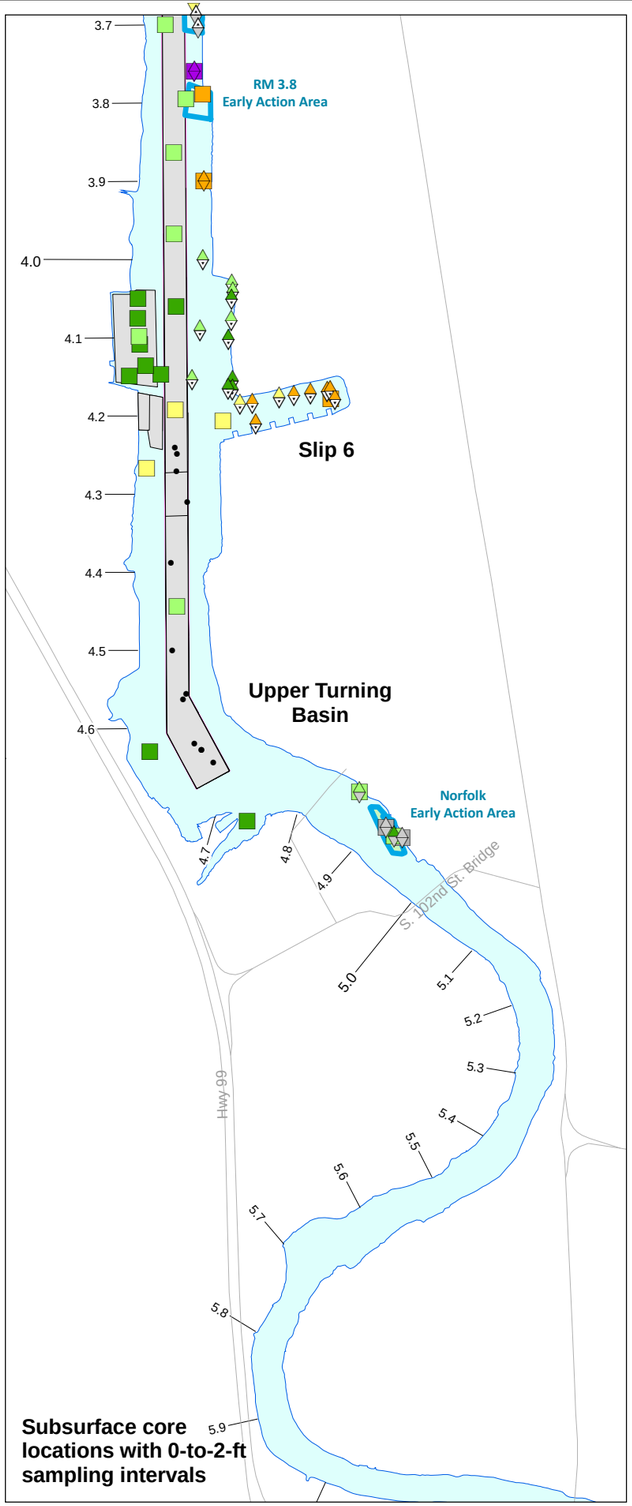
Scale is the same for each map frame

Map 4-32b. Arsenic concentrations in subsurface sediment within the 0-to-2-ft, 2-to-4-ft, and 4-to-6-ft sampling intervals, RM 1.8 to RM 3.7

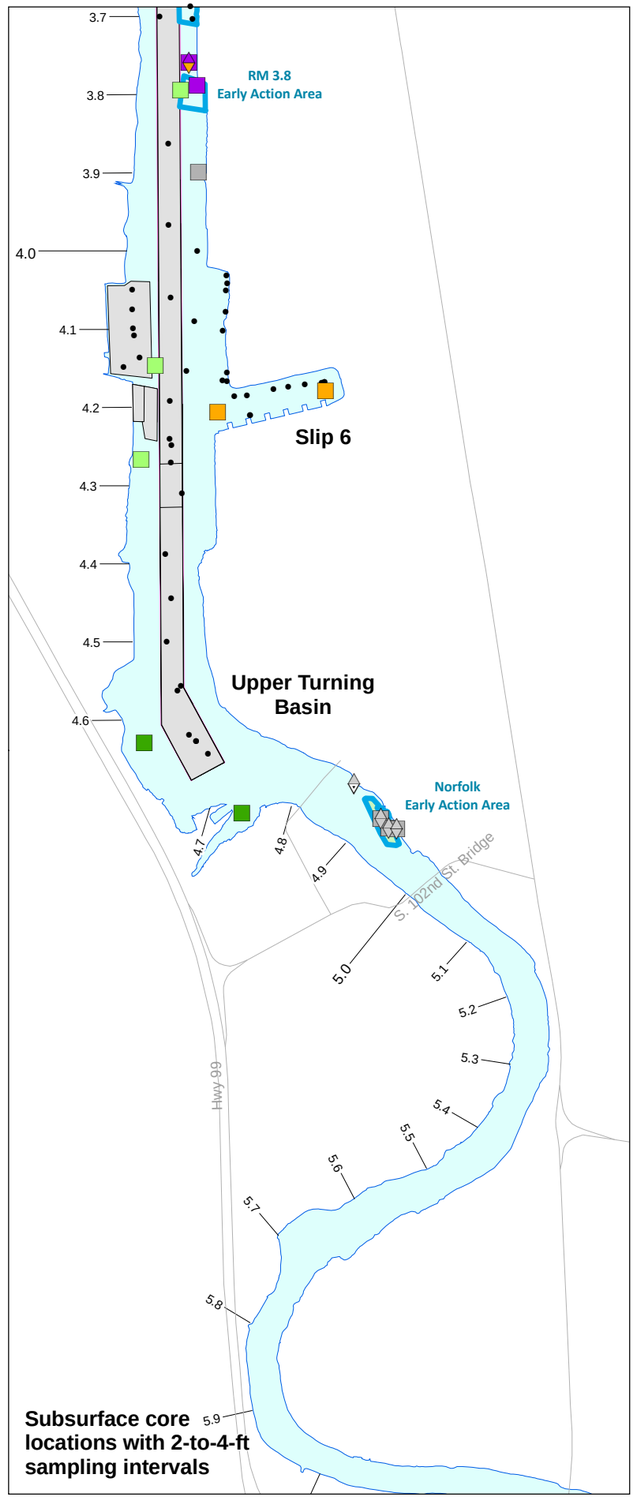
Wind Ward environmental LLC

Prepared by CEH, 07/15/2010, MAP 2813, W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Depth Intervals\Arsenic

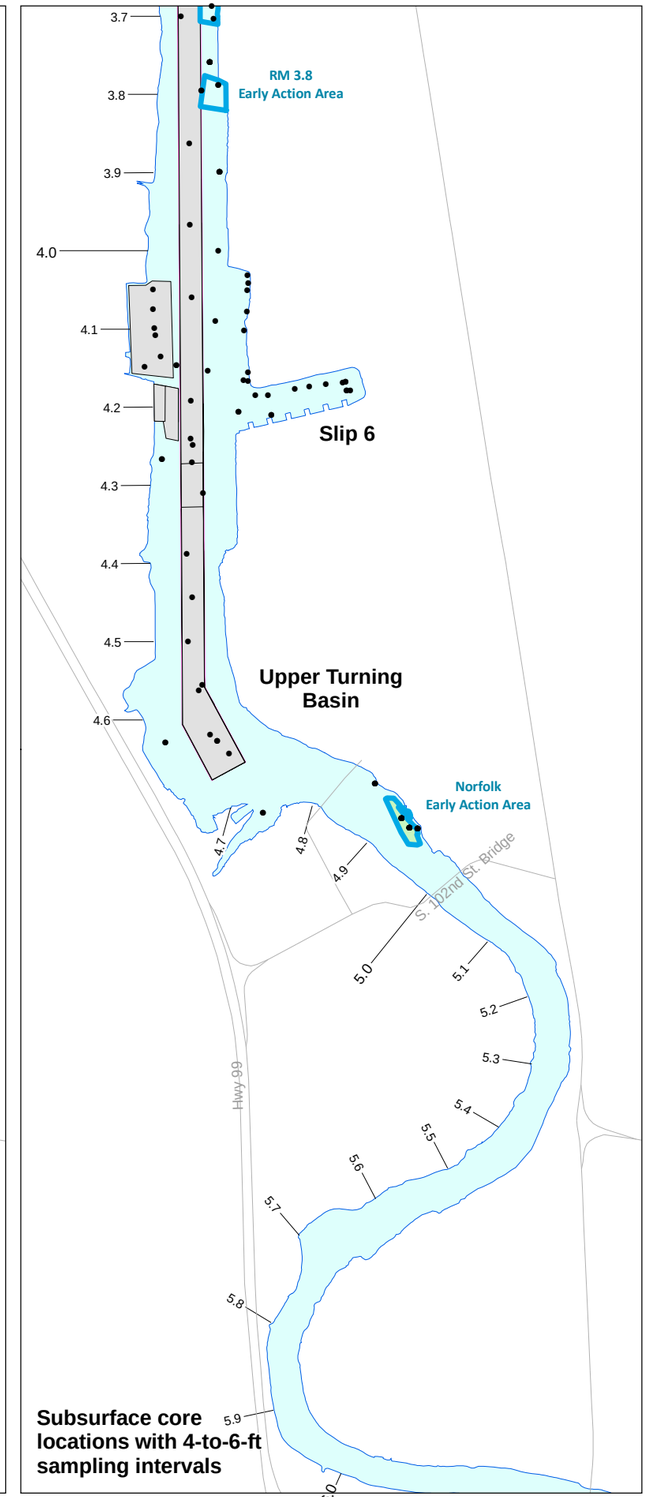
Dredging information provided by AECOM.



Subsurface core locations with 0-to-2-ft sampling intervals



Subsurface core locations with 2-to-4-ft sampling intervals



Subsurface core locations with 4-to-6-ft sampling intervals

Arsenic concentration (mg/kg dw)[a]

- > 30 — 95th percentile = 30
- > 15 and ≤ 30 — 75th percentile = 15
- > 11 and ≤ 15 — 50th percentile = 11
- > 7.9 and ≤ 11 — 25th percentile = 7.9
- ≤ 7.9
- Non-detect

Sampling interval

	Left panel	Middle panel	Right panel
	0-to-2-ft[b]	2-to-4-ft[b]	4-to-6-ft[b]
	0-to-1-ft[c]	2-to-3-ft[c]	4-to-5-ft[c]
	1-to-2-ft[c]	3-to-4-ft[c]	5-to-6-ft[c]

- Not analyzed in that sampling interval
- Other subsurface sampling location analyzed for arsenic, but not in the illustrated sampling interval
- Early Action Area[d]
- Dredged area[e]
- Dredged and capped area[e]
- Road
- Navigation channel
- River mile

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, a value of one-half the RL at that location was used.

[b] Data from 2-foot sampling intervals; some locations show an average of data from both 1-foot intervals within that 2-foot interval at a given location.

[c] Data from 1-foot sampling intervals are shown if available. If both 1-foot intervals within the 2-foot interval were collected, the average of the two intervals is also shown.

[d] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[e] Subsurface sediment data at locations in dredged areas were collected prior to dredging.

N

0 0.1 0.2 Kilometers

0 0.1 0.2 Miles

Scale is the same for each map frame

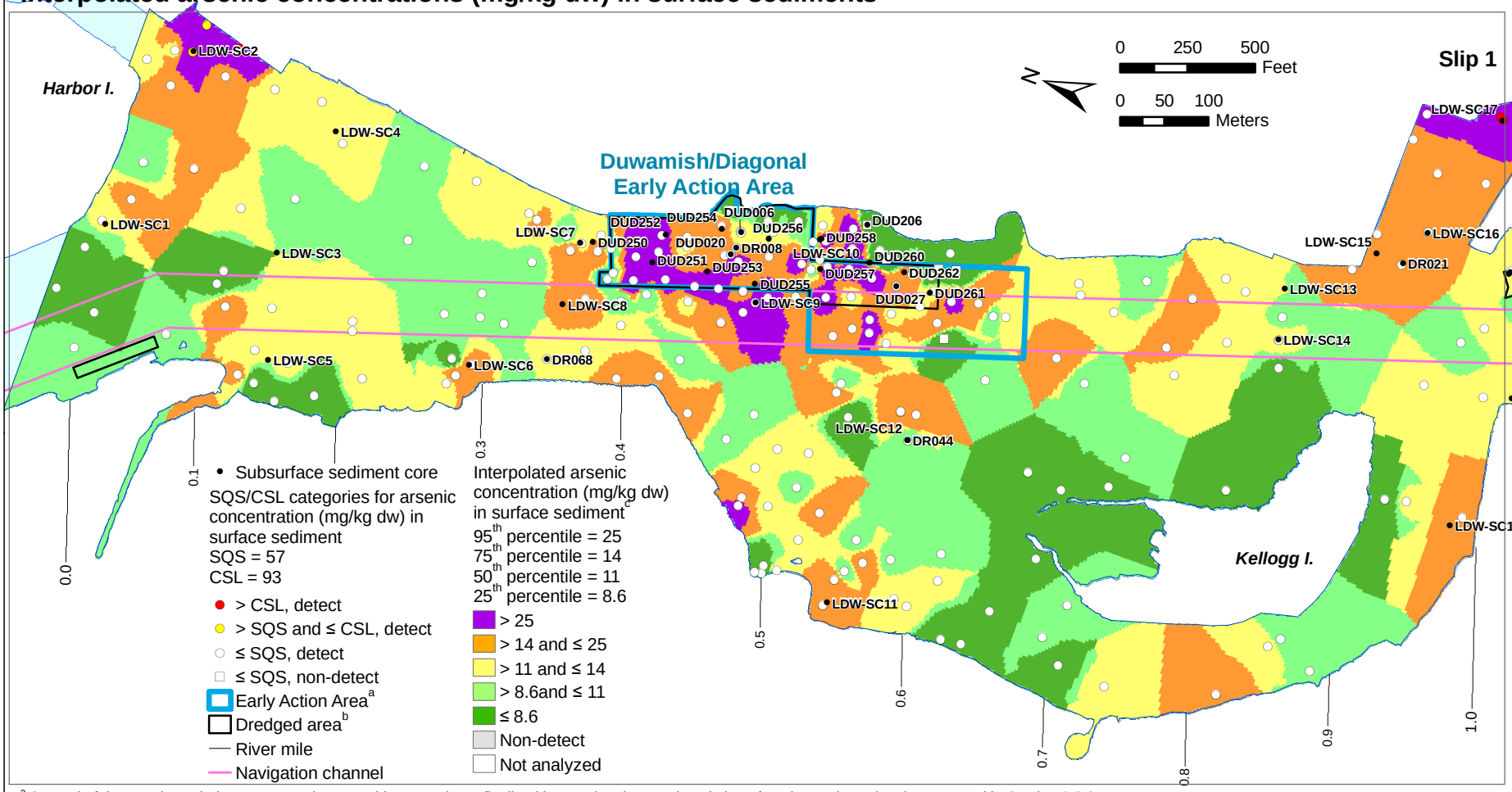
Map 4-32c. Arsenic concentrations in subsurface sediment within the 0-to-2-ft, 2-to-4-ft, and 4-to-6-ft sampling intervals, RM 3.7 to RM 6.0

Windward environmental LLC

Prepared by CEH, 07/15/2010, MAP 2813, W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Depth Intervals\Arsenic

Dredging information provided by AECOM.

Interpolated arsenic concentrations (mg/kg dw) in surface sediments



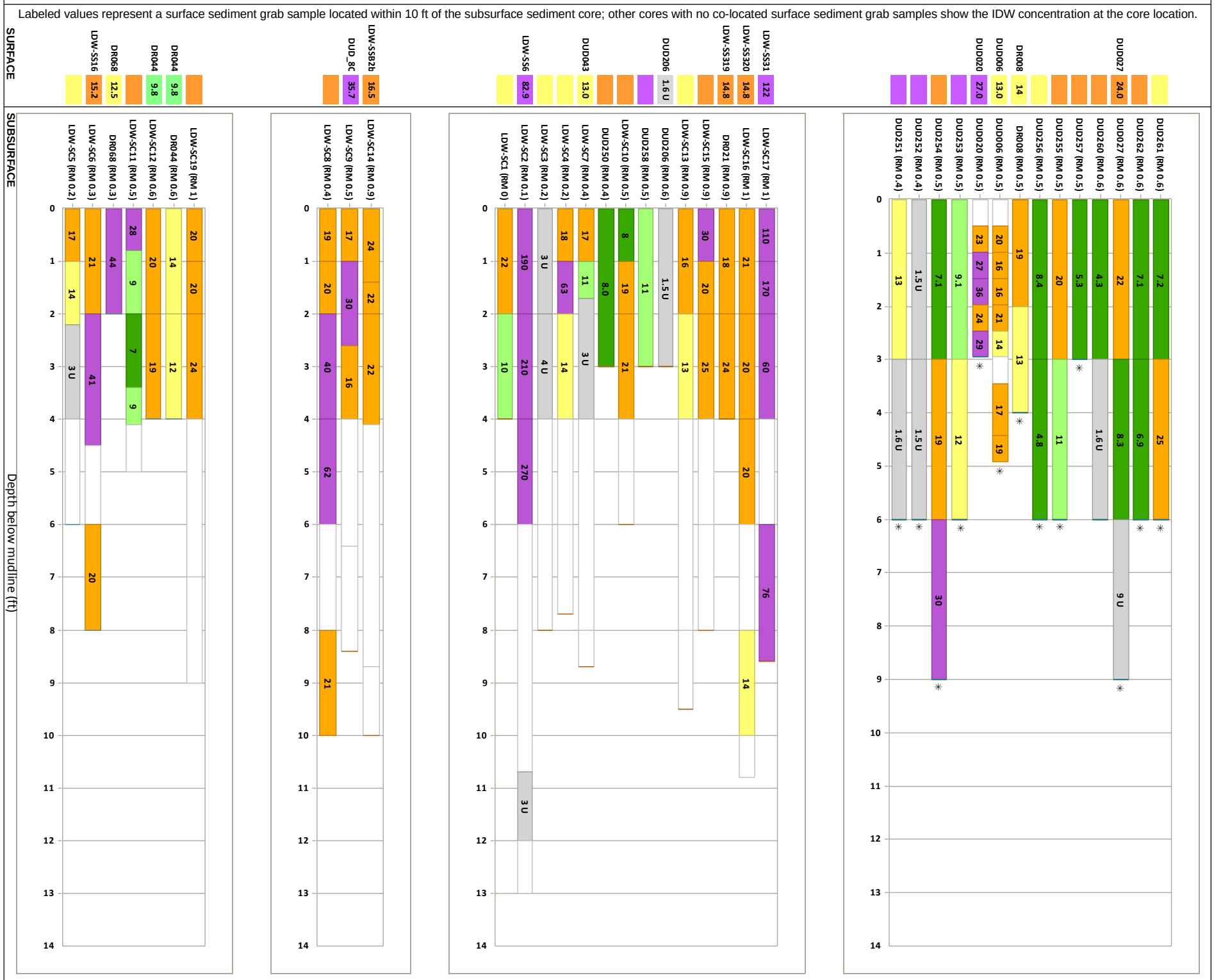
[a] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[b] For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, and thin-layer placement in 2003 to 2005. Subsurface sediment data in dredged areas were collected prior to dredging.

[c] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 25 mg/kg dw). Interpolated concentrations were calculated including locations with non-detected values. For locations with non-detects, a value of one-half the RL at that location was used. Interpolated surface does not show non-detects.

Arsenic concentrations (mg/kg dw) in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment grab sample located within 10 ft of the subsurface sediment core; other cores with no co-located surface sediment grab samples show the IDW concentration at the core location.



✳ This core was collected prior to dredging at that location.

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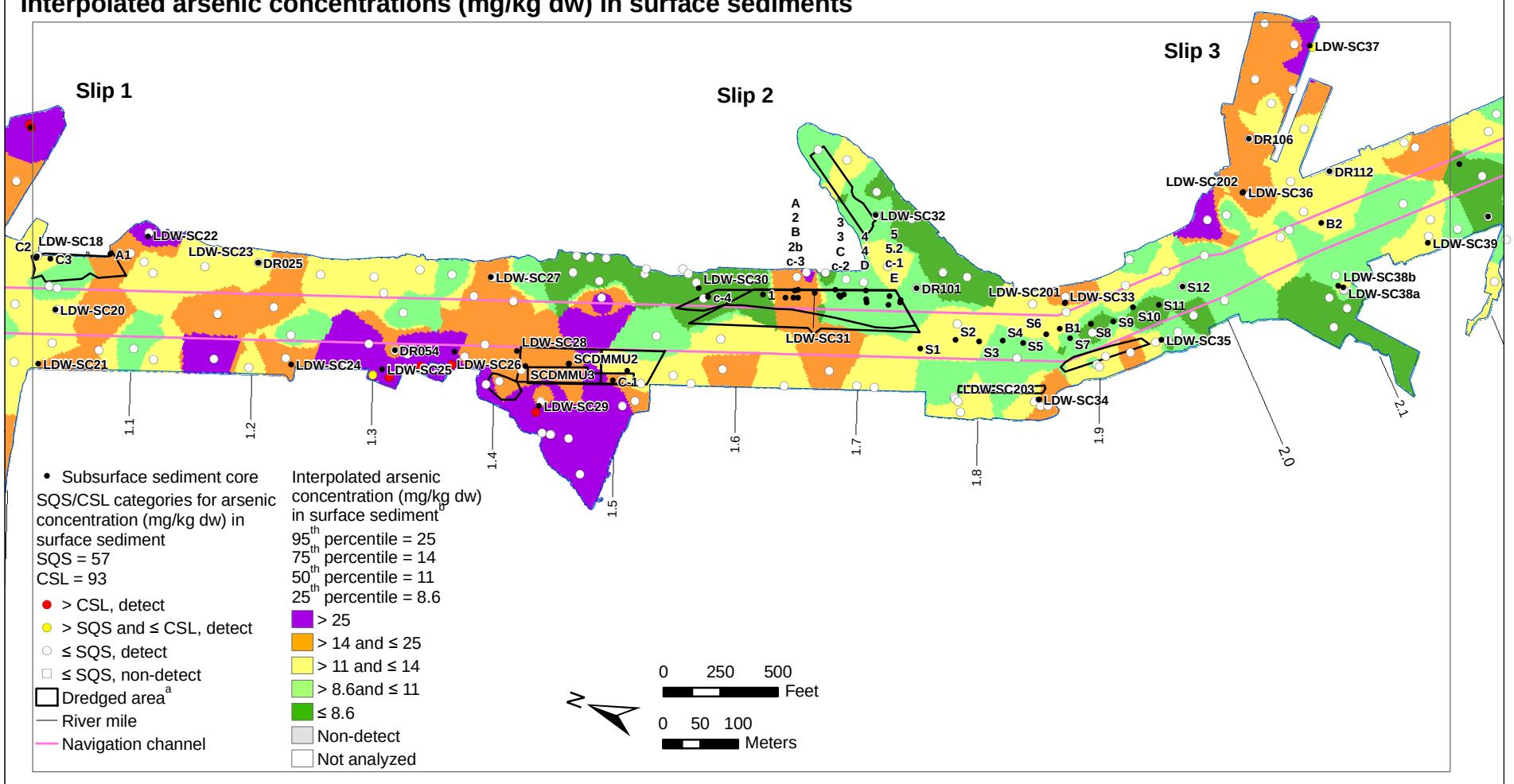
Map 4-33a. Arsenic concentrations in surface sediment and subsurface sediment cores, RM 0.0 to RM 1.0

Prepared by CEH, 07/15/2010, MAP 2988, W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.

Interpolated arsenic concentrations (mg/kg dw) in surface sediments

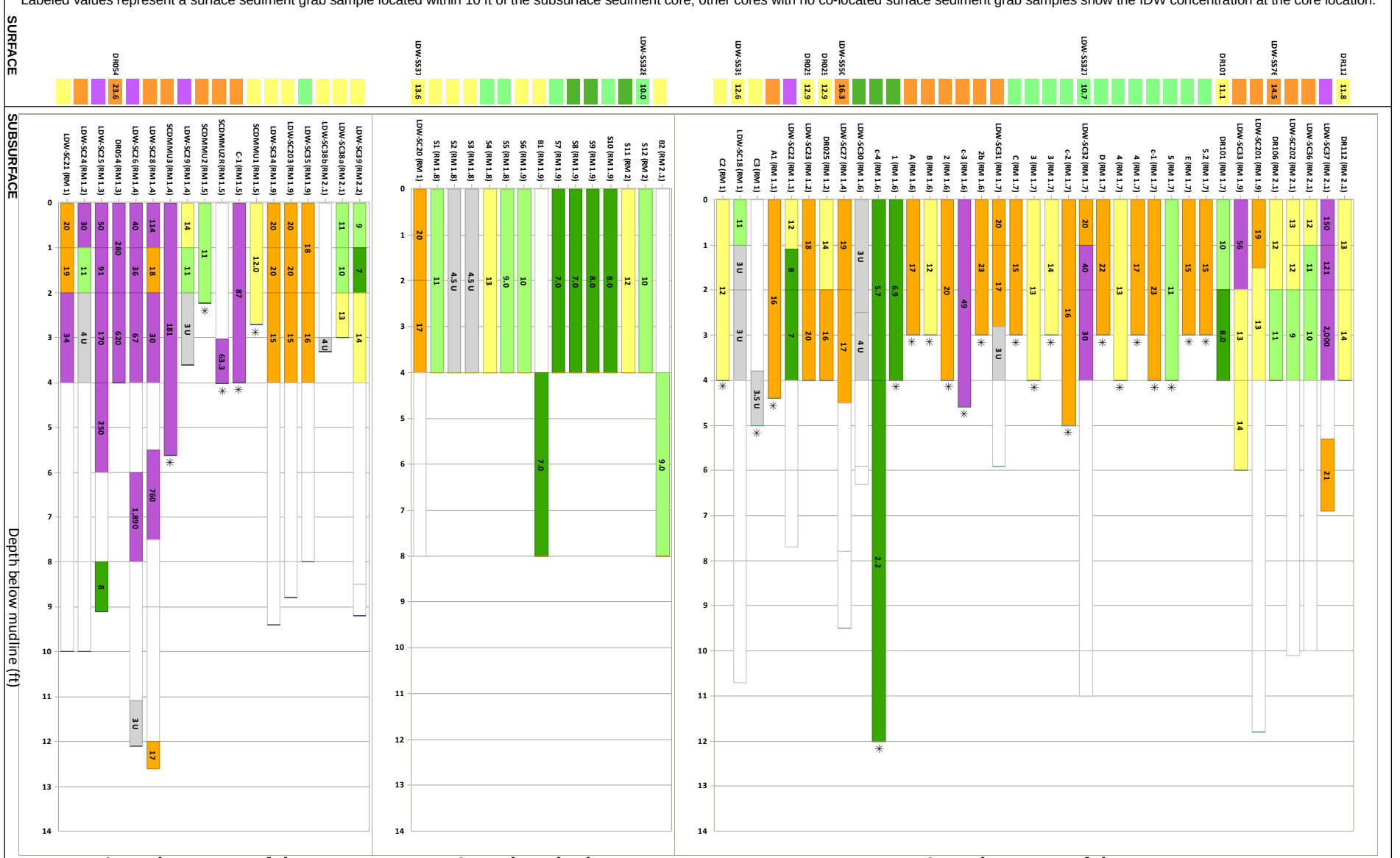


[a] Subsurface sediment data at locations in dredged areas were collected prior to dredging; surface sediment data were collected after dredging.

[b] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 25 mg/kg dw). Interpolated concentrations were calculated including locations with non-detected values. For locations with non-detects, a value of one-half the RL at that location was used. Interpolated surface does not show non-detects.

Arsenic concentrations (mg/kg dw) in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment grab sample located within 10 ft of the subsurface sediment core; other cores with no co-located surface sediment grab samples show the IDW concentration at the core location.



✳ This core was collected prior to dredging at that location.

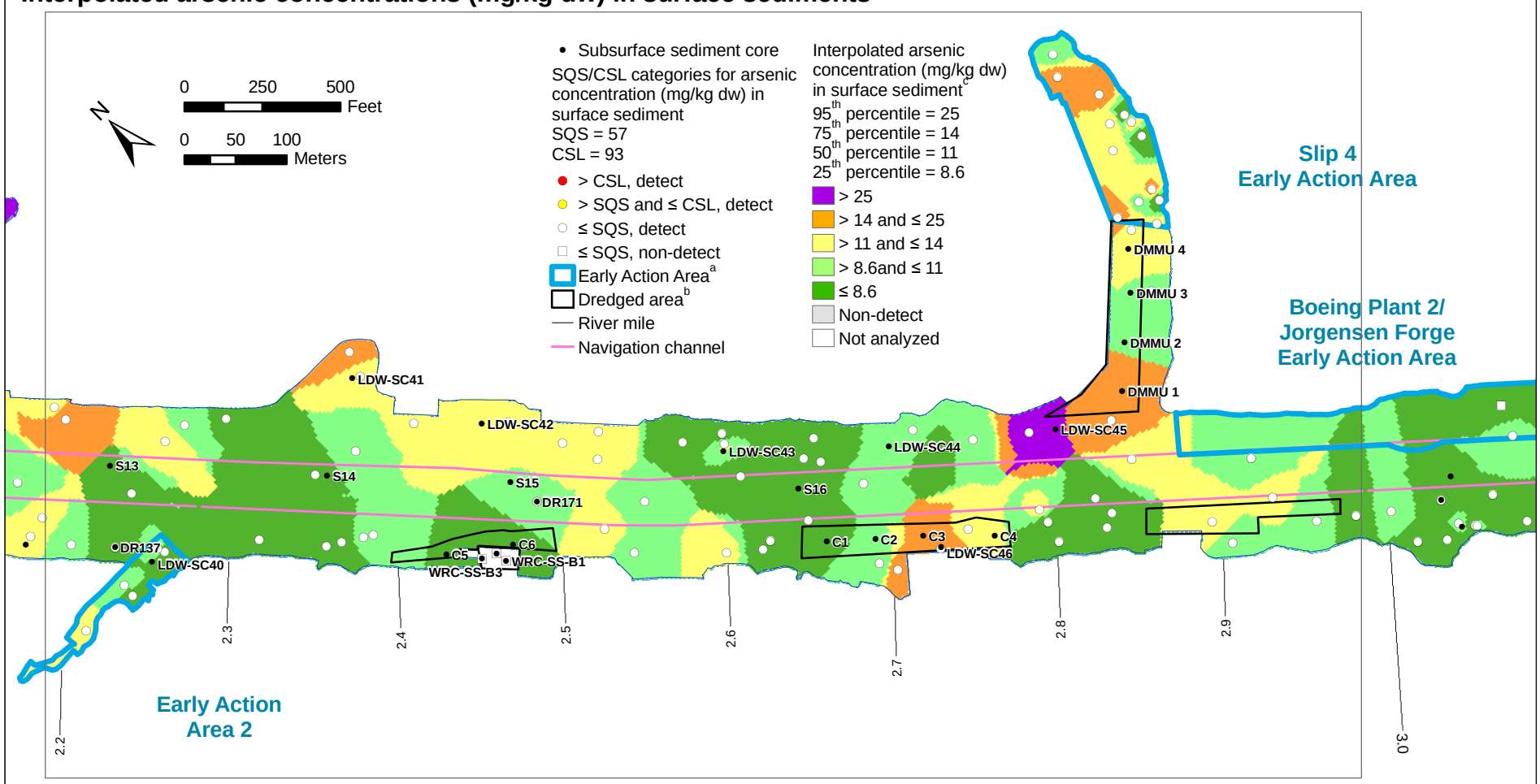
Map 4-33b. Arsenic concentrations in surface sediment and subsurface sediment cores, RM 1.0 to RM 2.2

Wind Ward environmental LLC

Prepared by CEH, 07/15/2010; MAP 2988; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.

Interpolated arsenic concentrations (mg/kg dw) in surface sediments



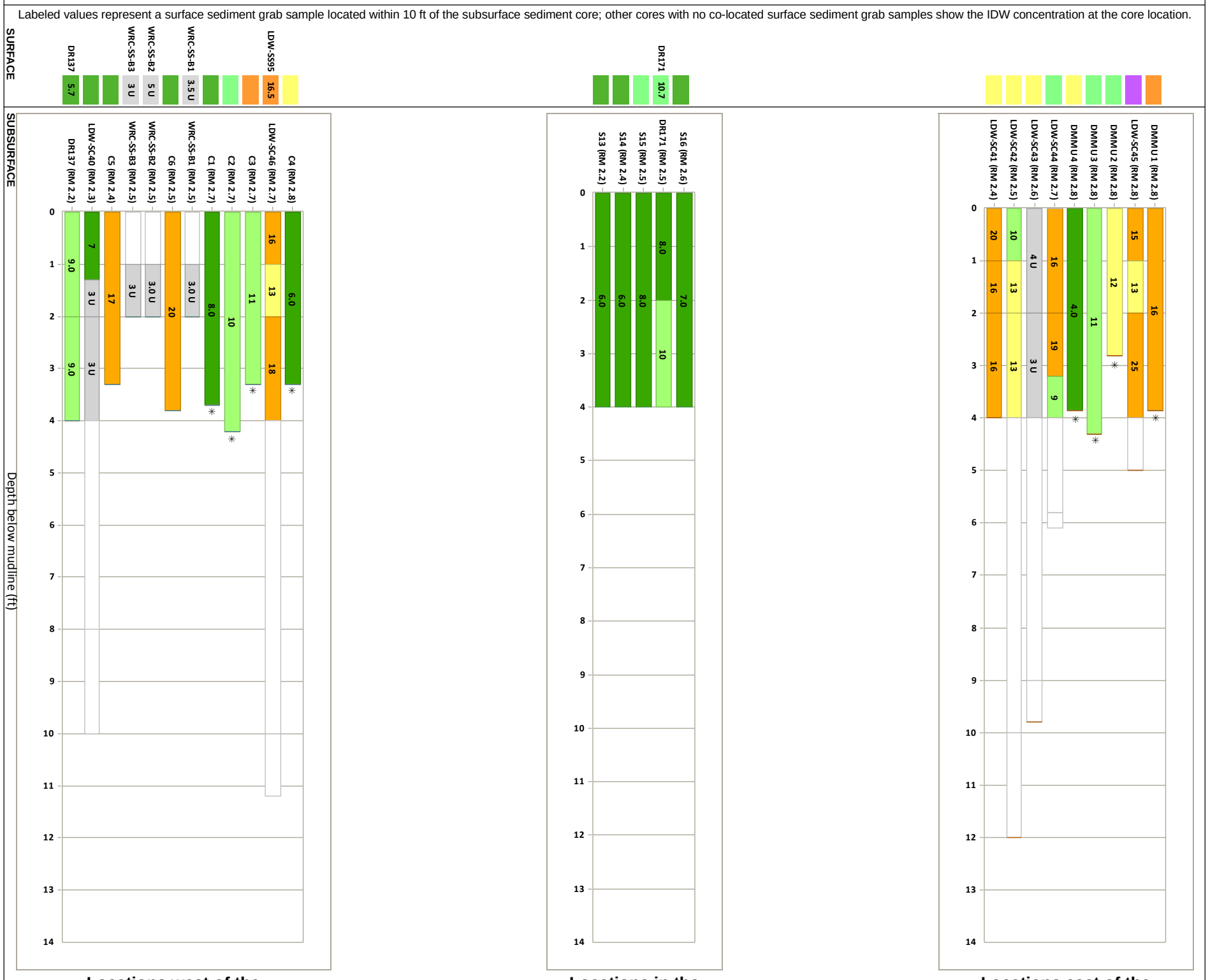
[a] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[b] Subsurface sediment data at locations in dredged areas were collected prior to dredging; surface sediment data were collected after dredging.

[c] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 25 mg/kg dw). Interpolated concentrations were calculated including locations with non-detected values. For locations with non-detects, a value of one-half the RL at that location was used. Interpolated surface does not show non-detects.

Arsenic concentrations (mg/kg dw) in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment grab sample located within 10 ft of the subsurface sediment core; other cores with no co-located surface sediment grab samples show the IDW concentration at the core location.



Locations west of the navigation channel | **Locations in the navigation channel** | **Locations east of the navigation channel**

✳ This core was collected prior to dredging at that location.

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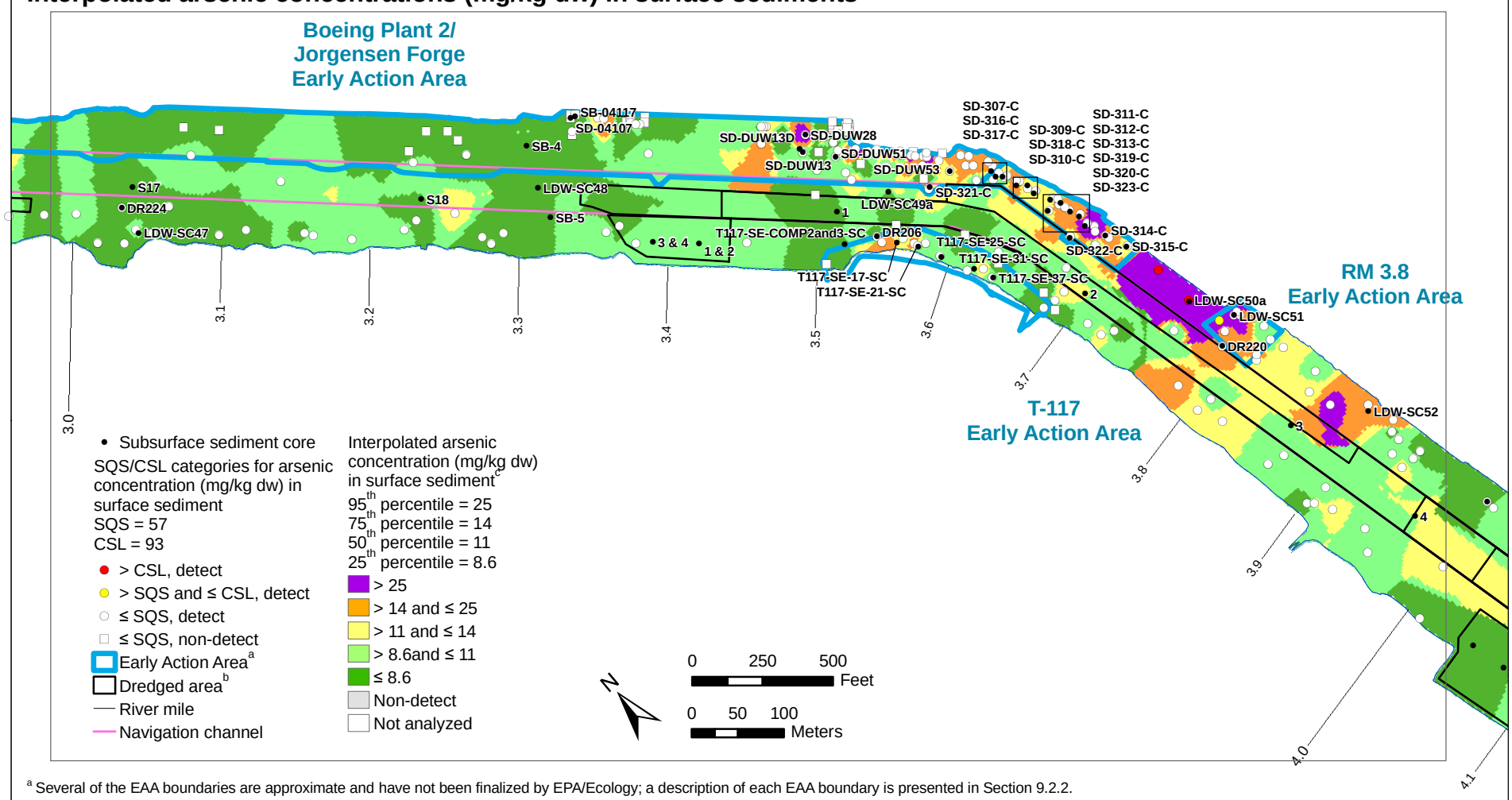
Map 4-33c. Arsenic concentrations in surface sediment and subsurface sediment cores, RM 2.2 to RM 3.0

Prepared by CEH, 07/15/2010; MAP 2988; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.

Interpolated arsenic concentrations (mg/kg dw) in surface sediments



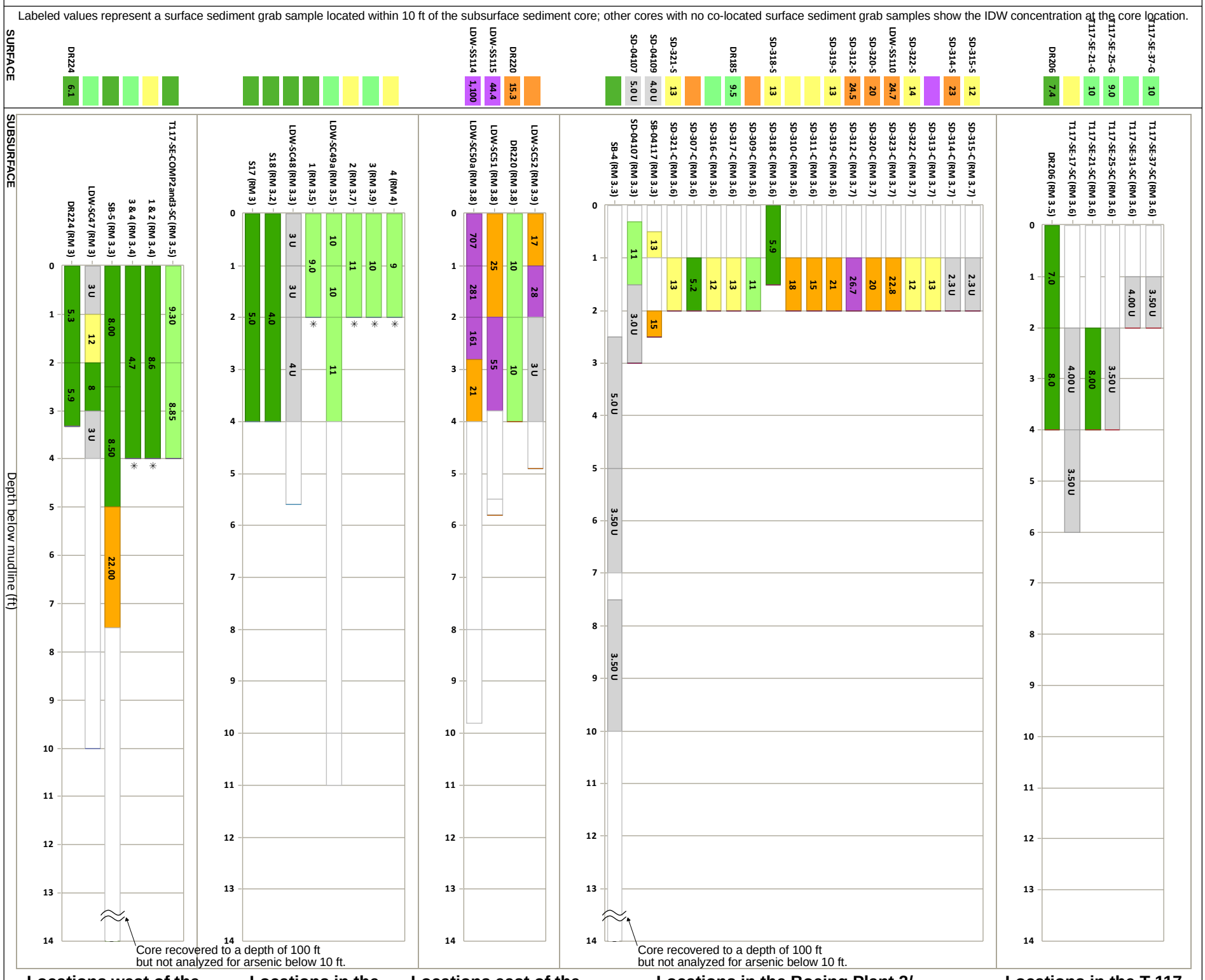
[a] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[b] Subsurface sediment data at locations in dredged areas were collected prior to dredging; surface sediment data were collected after dredging.

[c] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 25 mg/kg dw). Interpolated concentrations were calculated including locations with non-detected values. For locations with non-detects, a value of one-half the RL at that location was used. Interpolated surface does not show non-detects.

Arsenic concentrations (mg/kg dw) in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment grab sample located within 10 ft of the subsurface sediment core; other cores with no co-located surface sediment grab samples show the IDW concentration at the core location.



✳ This core was collected prior to dredging at that location.

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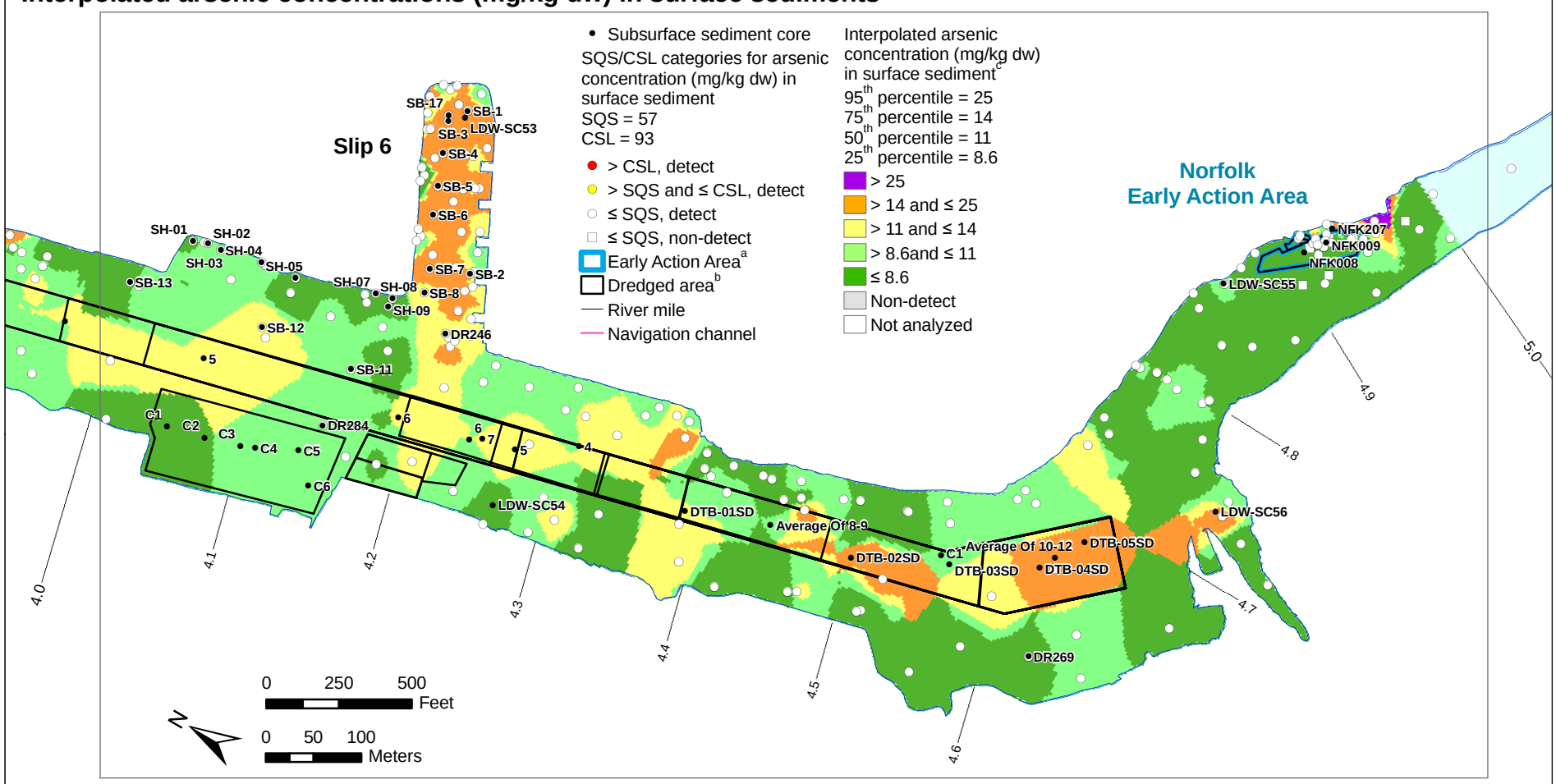
Map 4-33d. Arsenic concentrations in surface sediment and subsurface sediment cores, RM 3.0 to RM 4.0

Prepared by CEH, 07/15/2010; MAP 2988; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.

Interpolated arsenic concentrations (mg/kg dw) in surface sediments



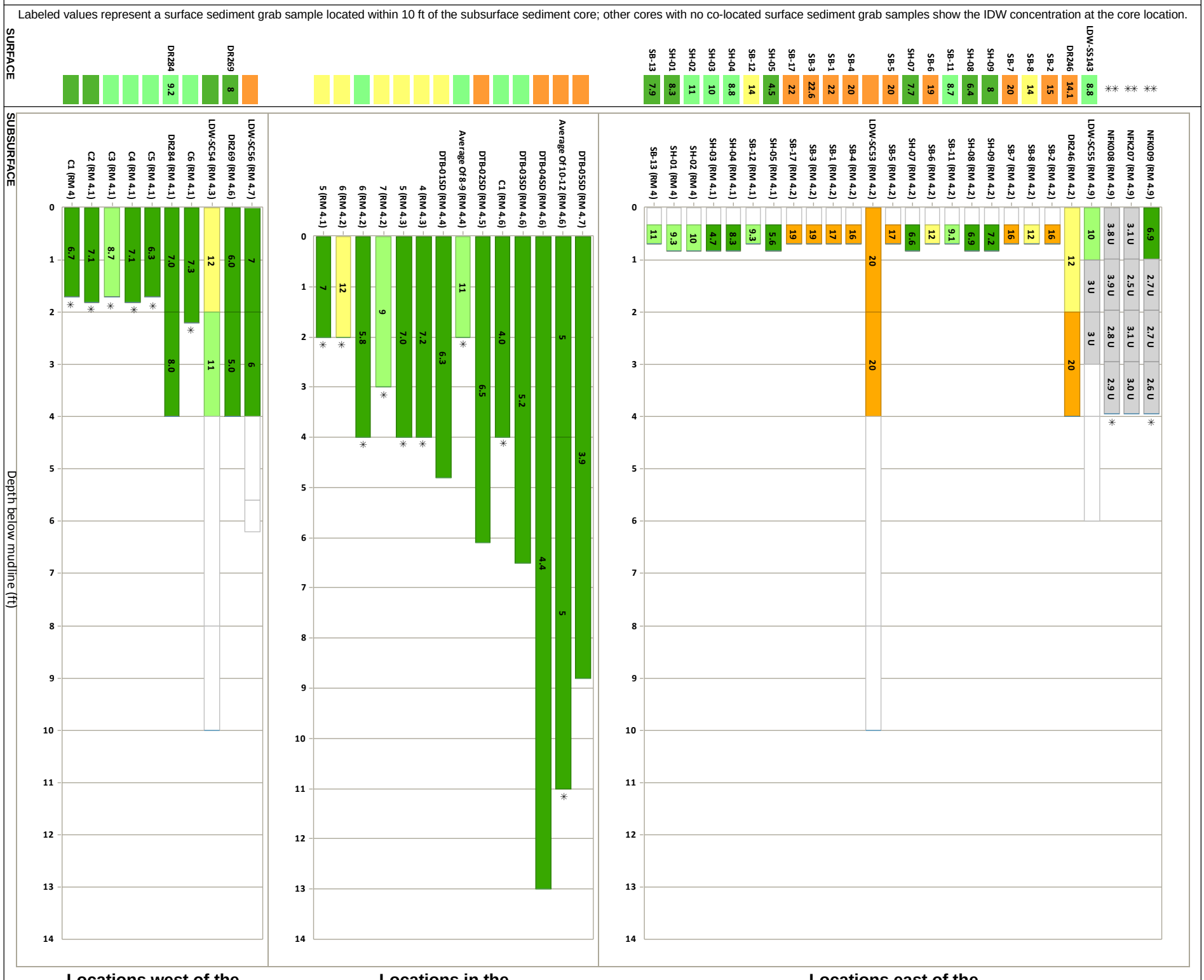
[a] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[b] For the Norfolk Early Action Area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO/SD removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003. Subsurface sediment data at locations in dredged areas were collected prior to dredging.

[c] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 25 mg/kg dw). Interpolated concentrations were calculated including locations with non-detected values. For locations with non-detects, a value of one-half the RL at that location was used. Interpolated surface does not show non-detects.

Arsenic concentrations (mg/kg dw) in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment grab sample located within 10 ft of the subsurface sediment core; other cores with no co-located surface sediment grab samples show the IDW concentration at the core location.



✳ This core was collected prior to dredging at that location.

✳✳ At the Norfolk EAA, surface sediment data, which were collected after the removal action at the Norfolk CSO area in 1999 but before the removal action at the BDC south storm drain outfall area in 2003, do not reflect conditions at the time subsurface cores were collected in 1995.

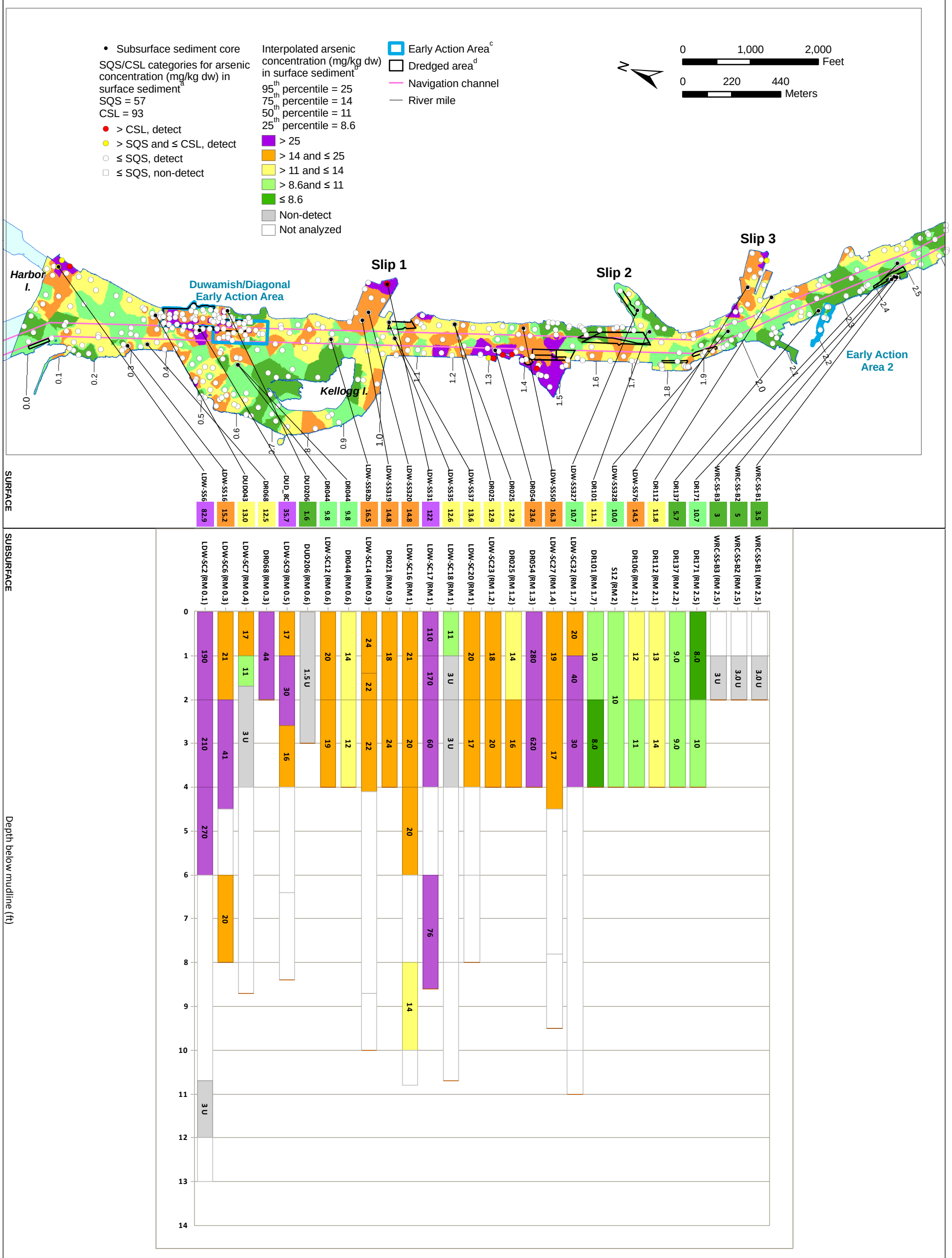
Map 4-33e. Arsenic concentrations in surface sediment and subsurface sediment cores, RM 4.0 to RM 5.0

Wind Ward environmental LLC

Prepared by CEH, 07/15/2010; MAP 2988; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.

Arsenic concentrations (mg/kg dw) in surface sediments, subsurface core data, and co-located (within 10 ft) surface sediment data



[a] When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations were compared instead to the LAET and 2LAET.

[b] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 25 mg/kg dw). Interpolated concentrations were calculated including locations with non-detected values. For locations with non-detects, a value of one-half the RL at that location was used.

[c] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[d] For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, and thin-layer placement in 2003 to 2005. Subsurface sediment data in dredged areas were collected prior to dredging.

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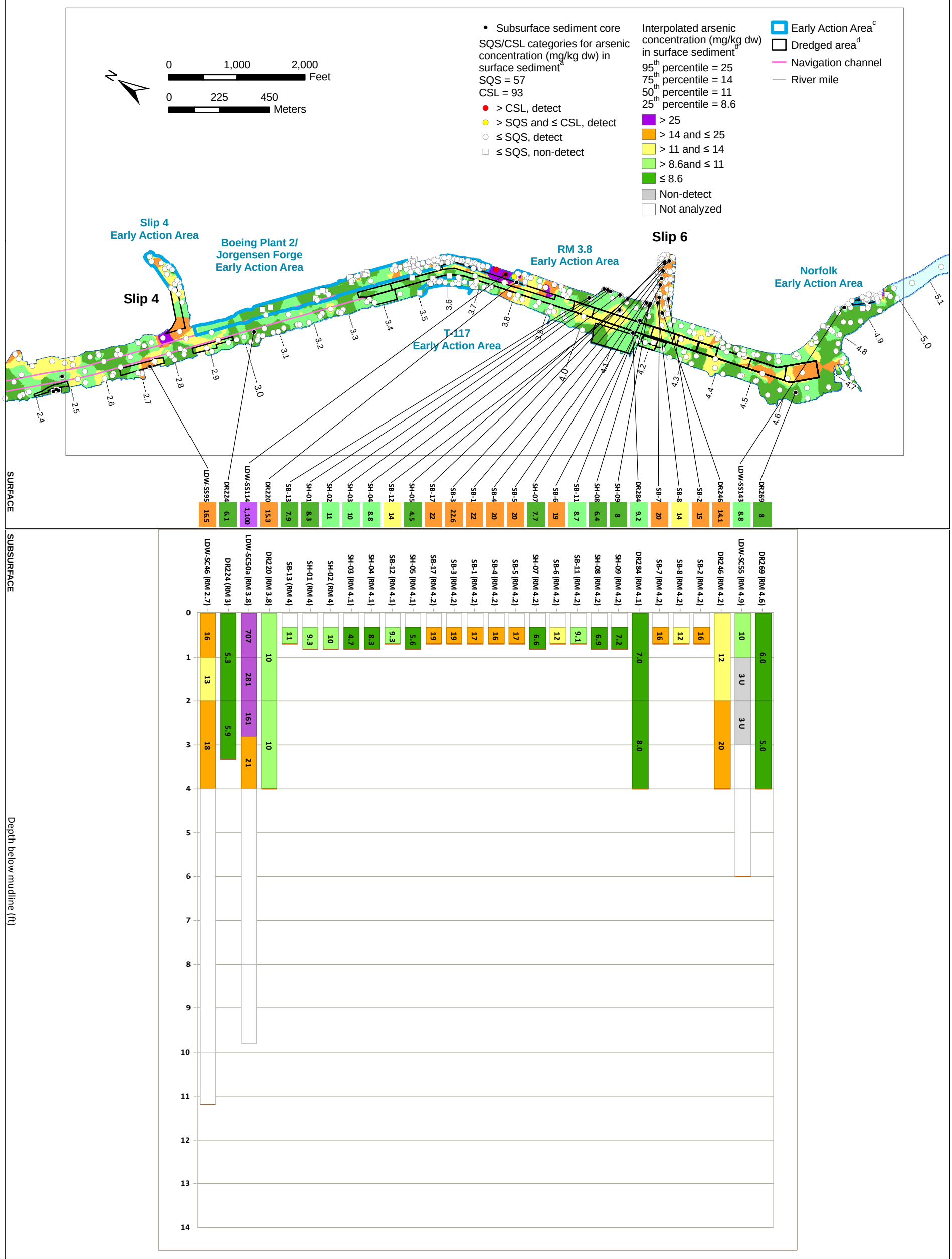
Map 4-34a. Comparison of arsenic concentrations in subsurface cores to co-located surface sediment locations, RM 0.0 to RM 2.5

Prepared by CEH, 07/15/2010; MAP 3795; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Nature and Extent\Subsurface\Colocation

Dredging information provided by AECOM.

Arsenic concentrations (mg/kg dw) in surface sediments, subsurface core data, and co-located (within 10 ft) surface sediment data



[a] When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations were compared instead to the LAET and 2LAET.

[b] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 25 mg/kg dw). Interpolated concentrations were calculated including locations with non-detected values. For locations with non-detects, a value of one-half the RL at that location was used.

[c] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[d] For the Norfolk Early Action Area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003. Subsurface sediment data in dredged areas were collected prior to dredging.

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Map 4-34b. Comparison of arsenic concentrations in subsurface cores to co-located surface sediment locations, RM 2.5 to RM 5.0

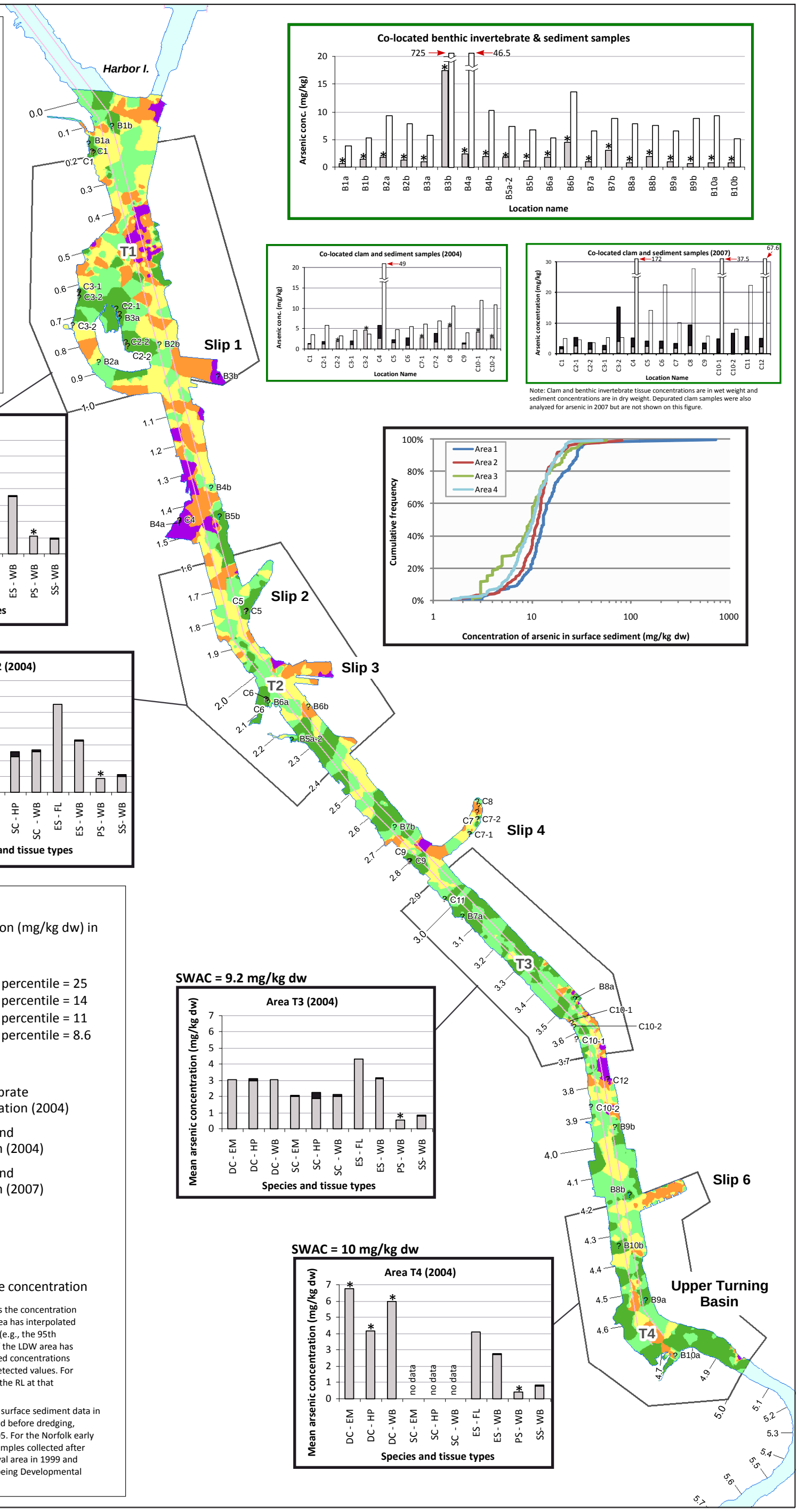
Prepared by CEH, 07/15/2010; MAP 3795; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Nature and Extent\Subsurface\Colocation
Dredging information provided by AECOM.

Graph Legend

- Total arsenic concentration in co-located sediment
- Total arsenic concentration in tissue (inorganic arsenic concentration is shown in black)
- * Sample not analyzed for inorganic arsenic

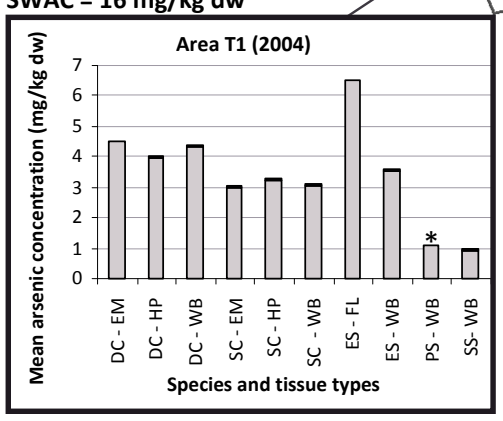
Acronyms for species and tissue type

- DC - Dungeness crab
- SC - Slender crab
- ES - English sole
- PS - Pacific staghorn sculpin
- SS - Shiner surfperch
- EM - Edible meat
- FL - Fillet with skin
- HP - Hepatopancreas
- WB - Whole body

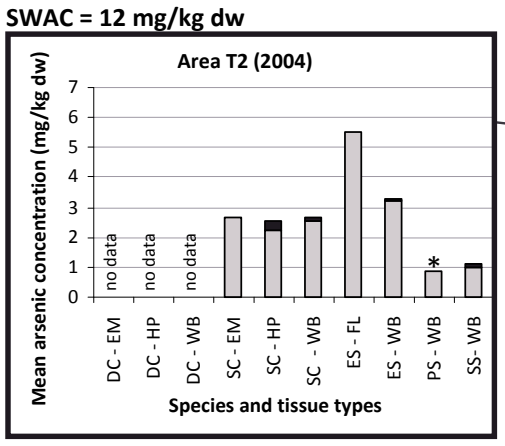


Note: Clam and benthic invertebrate tissue concentrations are in wet weight and sediment concentrations are in dry weight. Depurated clam samples were also analyzed for arsenic in 2007 but are not shown on this figure.

SWAC = 16 mg/kg dw



SWAC = 12 mg/kg dw



SWAC = 9.2 mg/kg dw

SWAC = 10 mg/kg dw

Map Legend

Interpolated arsenic concentration (mg/kg dw) in surface sediment[a,b]

- > 25
- > 14 and ≤ 25
- > 11 and ≤ 14
- > 8.6 and ≤ 11
- ≤ 8.6

95th percentile = 25
75th percentile = 14
50th percentile = 11
25th percentile = 8.6

- Co-located benthic invertebrate and sediment sampling location (2004)
- Co-located softshell clam and sediment sampling location (2004)
- Co-located softshell clam and sediment sampling location (2007)
- Tissue sampling area
- Navigation channel
- River mile

SWAC - spatially weighted average concentration

[a] Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated values ≤ 25 mg/kg dw). Interpolated concentrations were calculated including locations with non-detected values. For locations with non-detects, a value of one-half the RL at that location was used.

[b] For the Duwamish/Diagonal early action area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005. For the Norfolk early action area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

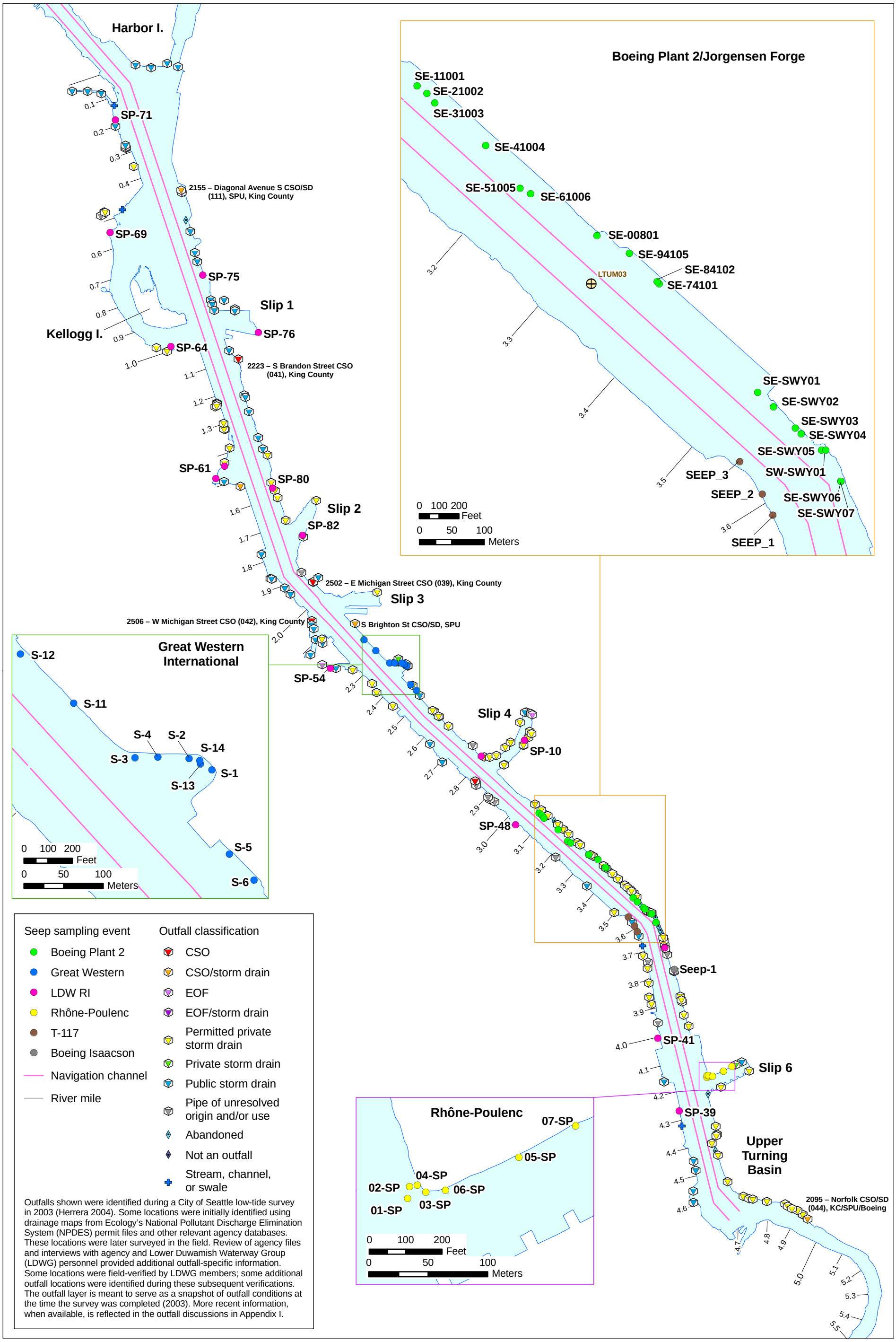
Wind Ward environmental LLC

0 0.25 0.5 Miles

0 0.25 0.5 Kilometers

Map 4-35. Total and inorganic arsenic concentrations in composite tissue samples and the IDW interpolation of total arsenic concentrations in surface sediment

Modified by Zachariah from GIS Map 2748 | June 30, 2009 | Map 4-35 (2748).xar



Wind Ward environmental LLC

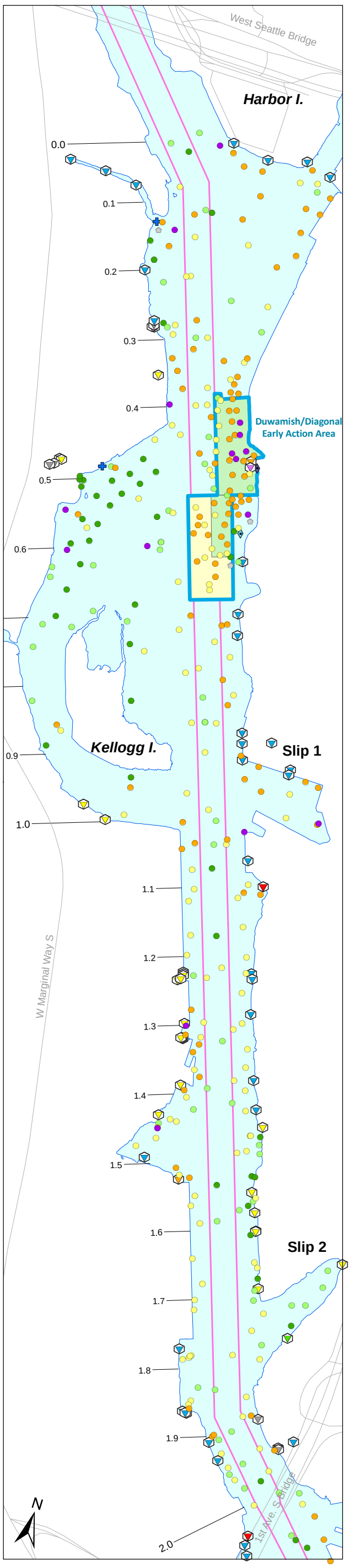
N

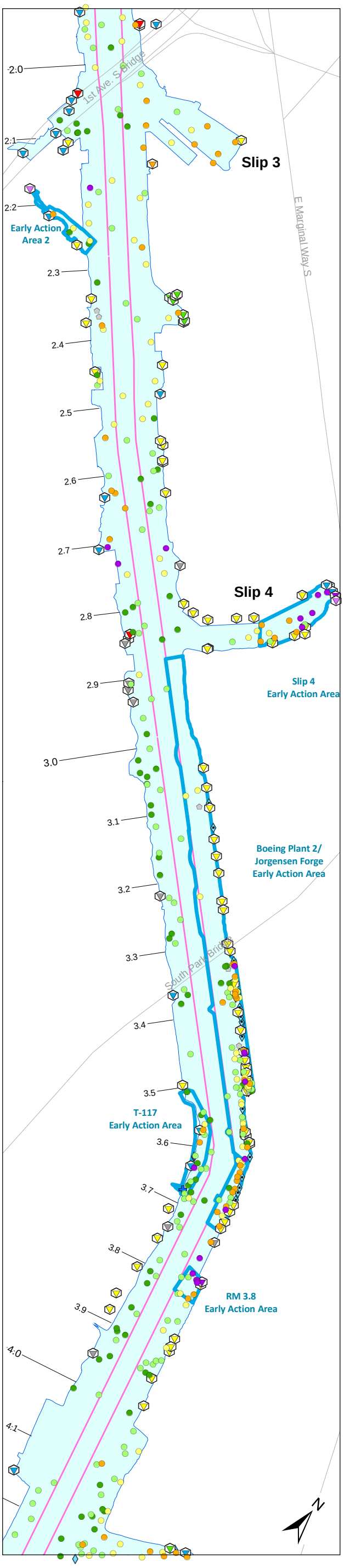
0 0.2 0.4 Miles

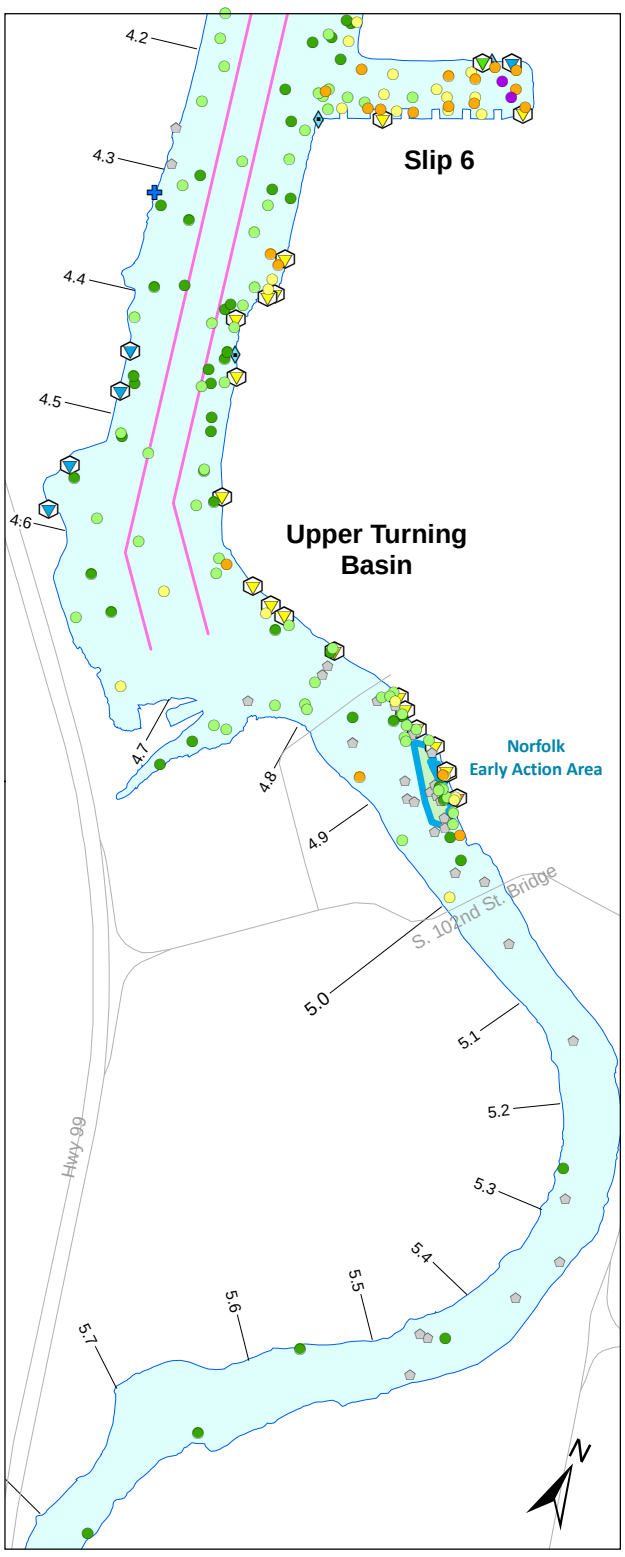
0 0.2 0.4 Kilometers

Map 4-36. Seep sampling locations with dissolved metals concentrations that were greater than acute water quality standards

Prepared by CEH, 07/15/2010; Map 2809, W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Nature and Extent\Seeps and porewater







Carcinogenic PAH concentration (µg/kg dw)[a]

- > 1,500
- > 540 and ≤ 1,500
- > 260 and ≤ 540
- > 100 and ≤ 260
- ≤ 100
- Non-detect
- Early Action Area[b]
- Dredged and capped area[c]
- Thin-layer placement[c]
- Navigation channel
- River mile

95th percentile = 1,500
75th percentile = 540
50th percentile = 260
25th percentile = 100

Outfall classification[d]

- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. cPAH concentrations are based on benzo(a)pyrene equivalents. TEQs were calculated with mammalian PEFs for seven individual PAH compounds (California EPA 1994), using one-half the RL for undetected compounds.

[a] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer capping in 2003 to 2005. For the Norfolk Early Action Area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

[d] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

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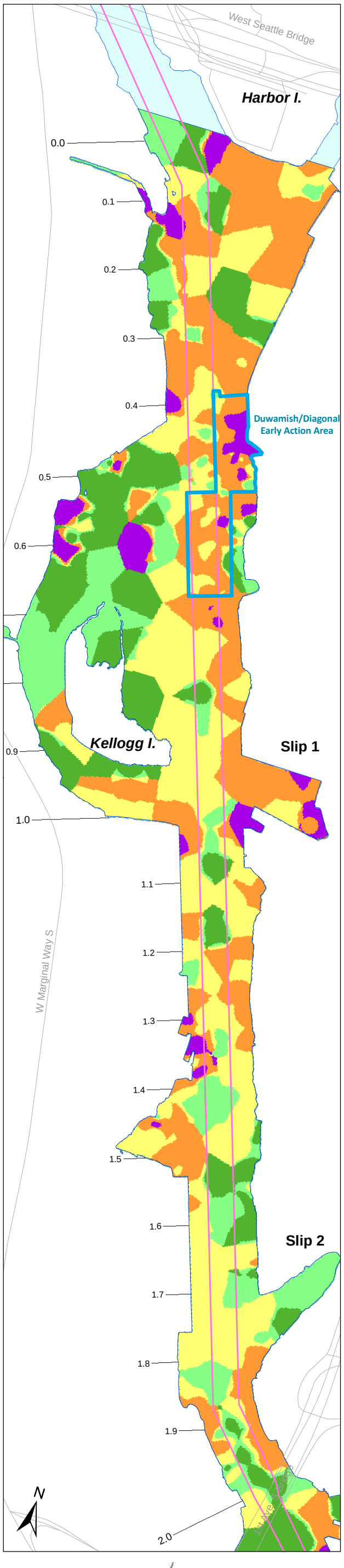
0 0.1 0.2 Miles

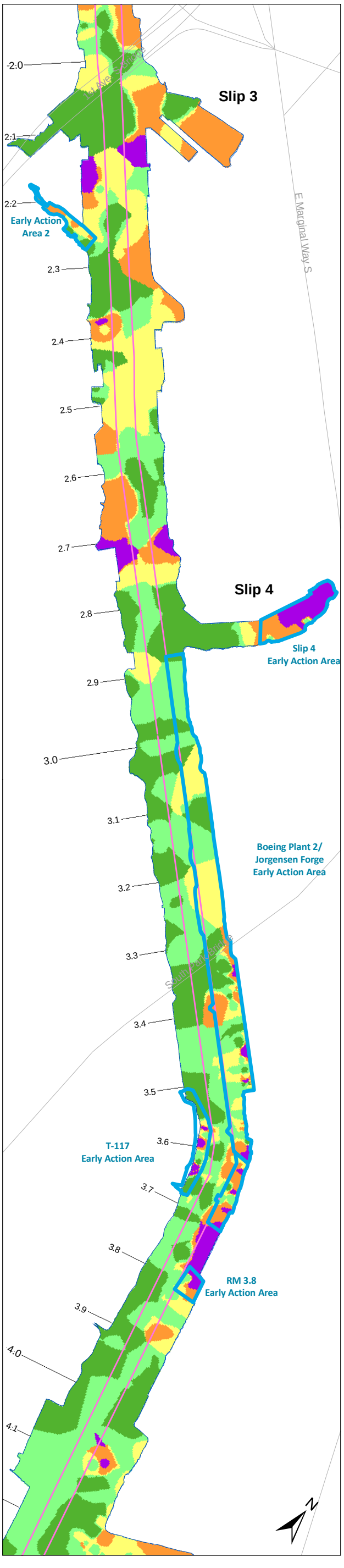
0 0.1 0.2 Kilometers

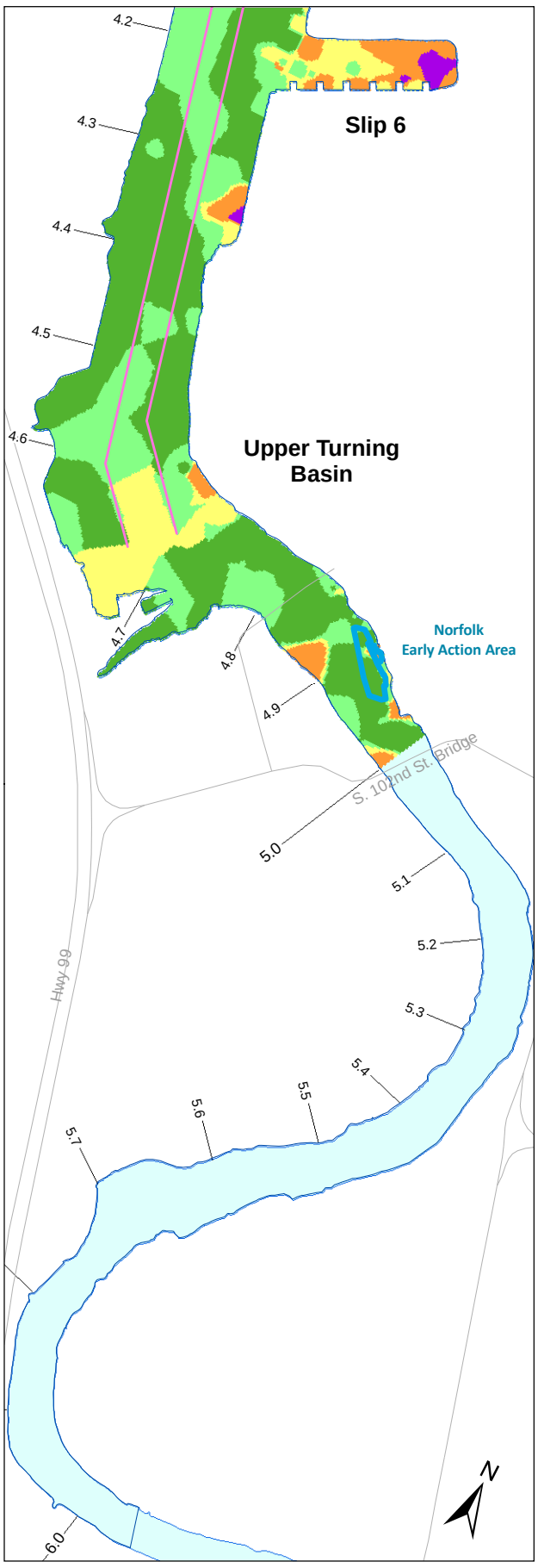
Scale is the same for each inset map

Map 4-37. cPAH concentrations in surface sediment

Prepared by CEH, 07/15/2010; MAP 2662; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\cPAHs







Carcinogenic PAH concentration (µg/kg dw)[a]

- > 1,100
- > 460 and ≤ 1,100
- > 260 and ≤ 460
- > 130 and ≤ 260
- ≤ 130
- Early Action Area[b]
- Navigation channel
- River mile

95th percentile = 1,100
75th percentile = 460
50th percentile = 260
25th percentile = 130

[a] Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 1,100 µg/kg dw). Interpolated concentrations were calculated including locations with non-detected values. cPAH concentrations are based on benzo(a)pyrene equivalents. TEQs were calculated with mammalian PEFs for seven individual PAH compounds (California EPA 1994), using one-half the RL for undetected compounds.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2. For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer capping in 2003 to 2005. For the Norfolk Early Action Area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

Wind Ward LLC environmental

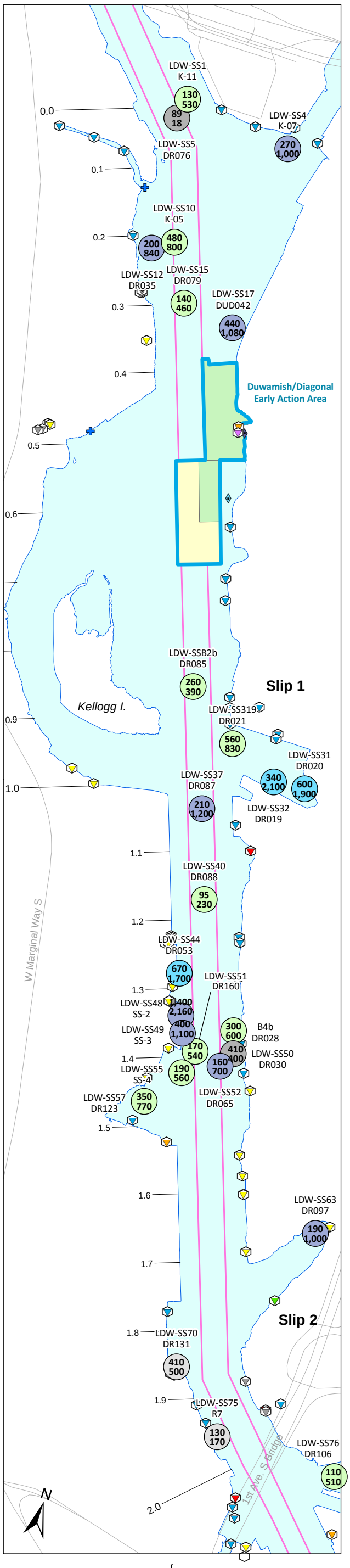
0 0.1 0.2 Miles

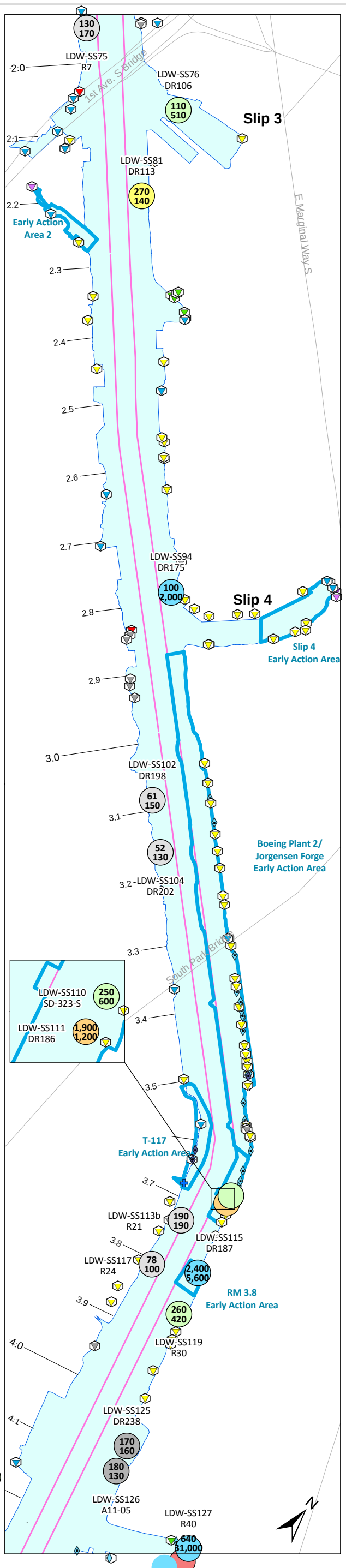
0 0.1 0.2 Kilometers

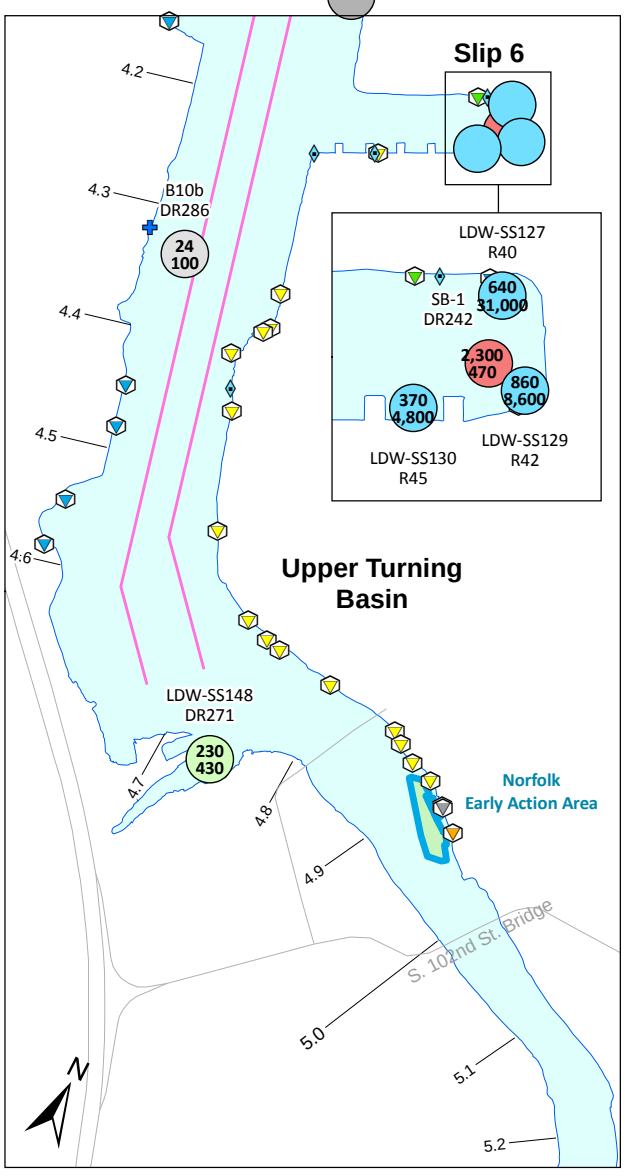
Scale is the same for each inset map

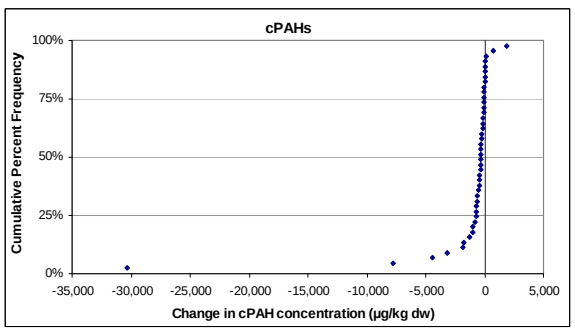
Map 4-38. IDW interpolation of cPAH concentrations in surface sediment

Prepared by CEH, 07/15/2010; MAP 2780; W:\Projects\00-08-06 Duwamish RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\cPAHs









Difference in cPAH concentrations (µg/kg dw)[a]

New value minus old value

- ≤ -1,000
- > -1,000 and ≤ -500
- > -500 and ≤ -100
- > -100 and ≤ 0
- > 0 and ≤ 100
- > 100 and ≤ 500
- > 500 and ≤ 1,000
- > 1,000
- Early Action Area[b]
- Dredged and capped area
- Thin-layer placement

New value
Old value
New location ID
Old location ID
89 18 LDW-SS5 DR076
U = non-detect

Outfall classification[c]

- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale
- Road
- Navigation channel
- River mile

[a] A location was considered to have been resampled if the new location was within 10 ft of the old location. TEQs were calculated with mammalian PEFs for seven individual PAH compounds (California EPA 1994), using one-half the RL for undetected compounds.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time of the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

Note: Samples collected in the Duwamish/Diagonal and Norfolk EAAs were not included in this evaluation.

0 0.1 0.2 Miles

0 0.1 0.2 Kilometers

Scale is the same for each inset map

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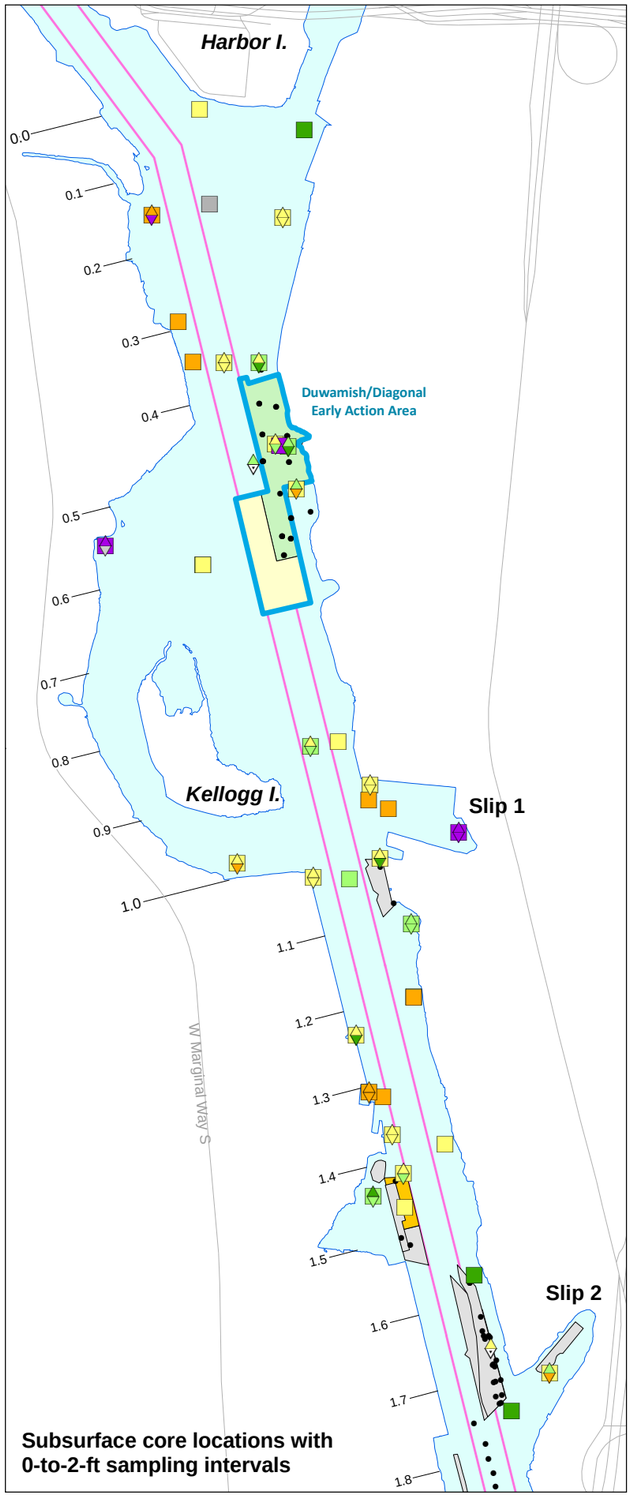
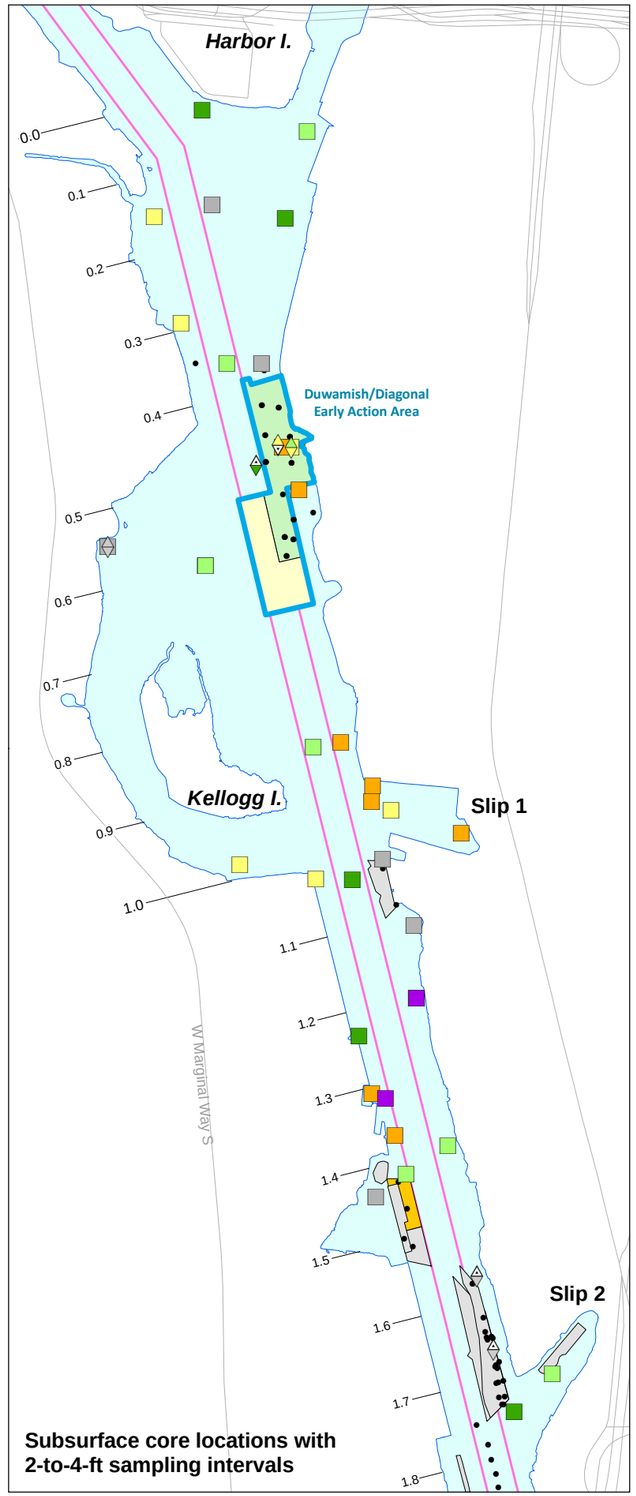
Map 4-39. Differences in cPAH concentrations in surface sediment at locations that have been resampled

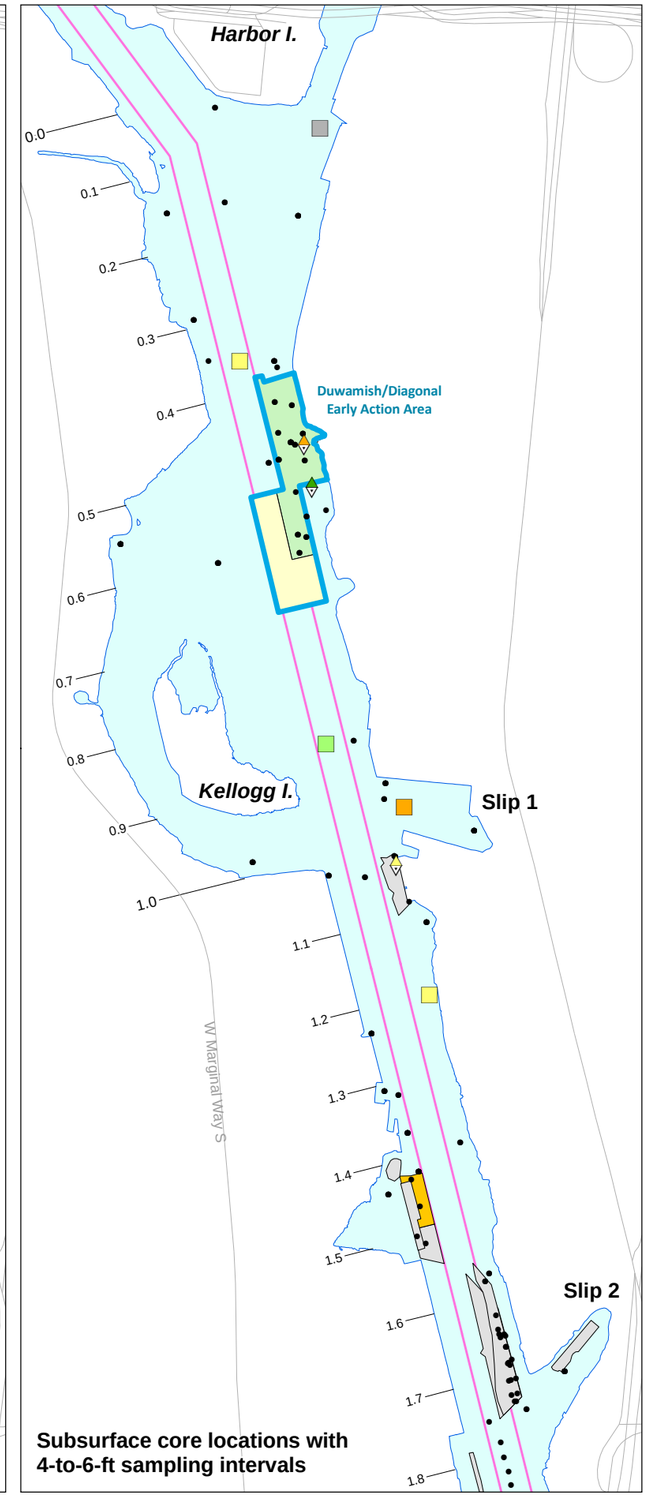
Prepared by CEH, 07/15/2010; MAP 2746; W:\Projects\00-08-06 Duwamish RI\data\gis\Phase2 RI\Nature and Extent\Round3 Trumping



Subsurface core locations with 0-to-2-ft sampling intervals



Subsurface core locations with 2-to-4-ft sampling intervals



Subsurface core locations with 4-to-6-ft sampling intervals

cPAH concentration (µg/kg dw)[a]

> 1,500	95th percentile = 1,500
> 540 and ≤ 1,500	75th percentile = 540
> 260 and ≤ 540	50th percentile = 260
> 100 and ≤ 260	25th percentile = 100
≤ 100	
Non-detect	

Sampling interval

	Left panel	Middle panel	Right panel
	0-to-2-ft[b]	2-to-4-ft[b]	4-to-6-ft[b]
	0-to-1-ft[c]	2-to-3-ft[c]	4-to-5-ft[c]
	1-to-2-ft[c]	3-to-4-ft[c]	5-to-6-ft[c]

Not analyzed in that sampling interval

Other subsurface sampling location analyzed for cPAH, but not in the illustrated sampling intervals

Early Action Area[d]

Dredged area[e]

Dredged and capped area[e]

Dredged and thin-layer placement[e]

Thin-layer placement

Navigation channel

River mile

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. cPAH concentrations are based on benzo(a)-pyrene equivalents. TEQs were calculated with mammalian PEFs for seven individual PAH compounds (California EPA 1994), using one-half the RL for undetected compounds.

[b] Data from 2-foot sampling intervals; some locations show an average of data from both 1-foot intervals within that 2-foot interval at a given location.

[c] Data from 1-foot sampling intervals are shown if available. If both 1-foot intervals within the 2-foot interval were collected, the average of the two intervals is also shown.

[d] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[e] Subsurface sediment data at locations in dredged areas were collected prior to dredging.

N

0 0.1 0.2 Kilometers

0 0.1 0.2 Miles

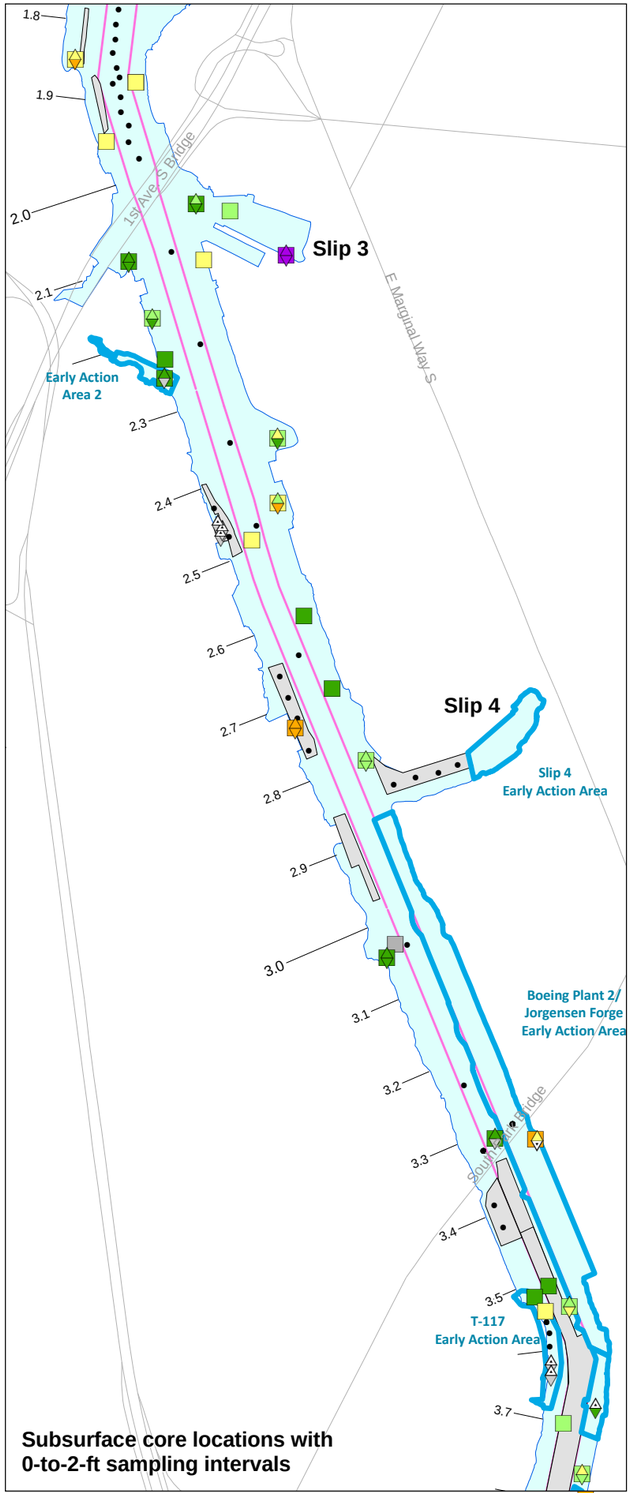
Scale is the same for each map frame

Map 4-40a. cPAH concentrations in subsurface sediment within the 0-to-2-ft, 2-to-4-ft, and 4-to-6-ft sampling intervals, RM 0.0 to RM 1.8

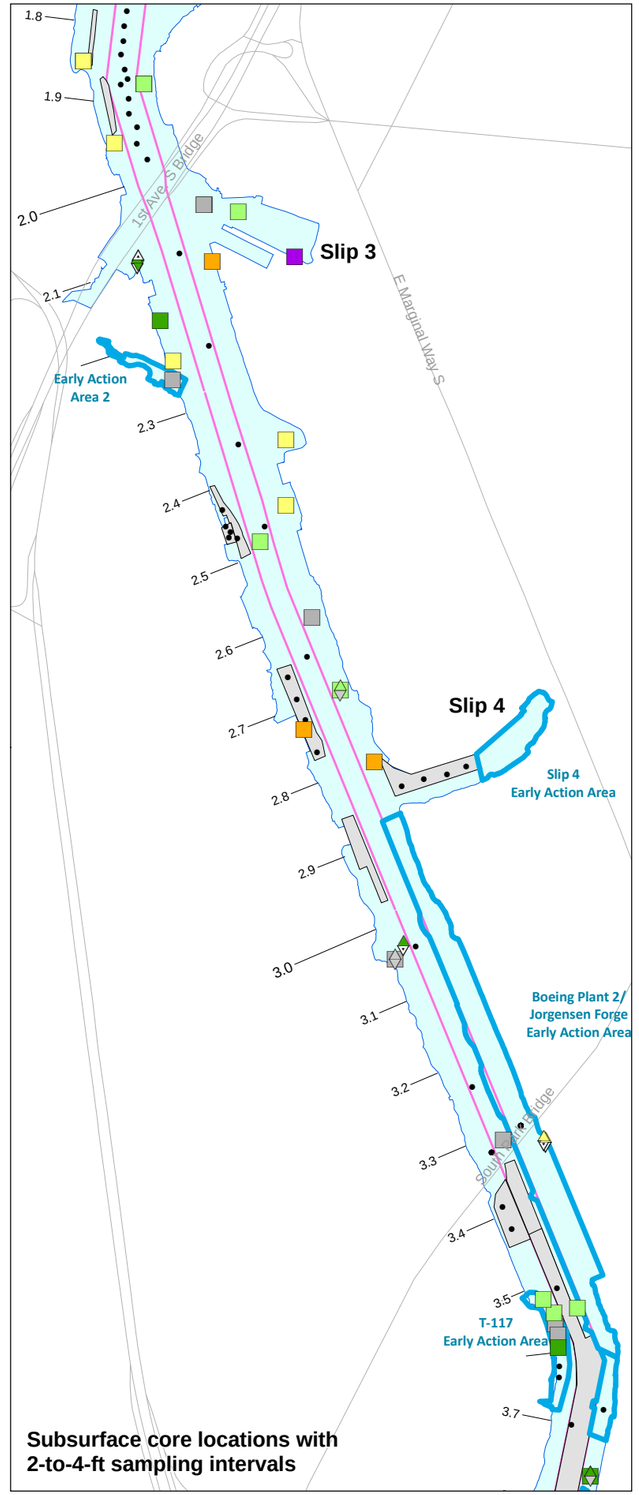
Windward environmental LLC

Prepared by: CEH, 07/15/2010. MAP 2812: W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Depth Intervals\Other COCs

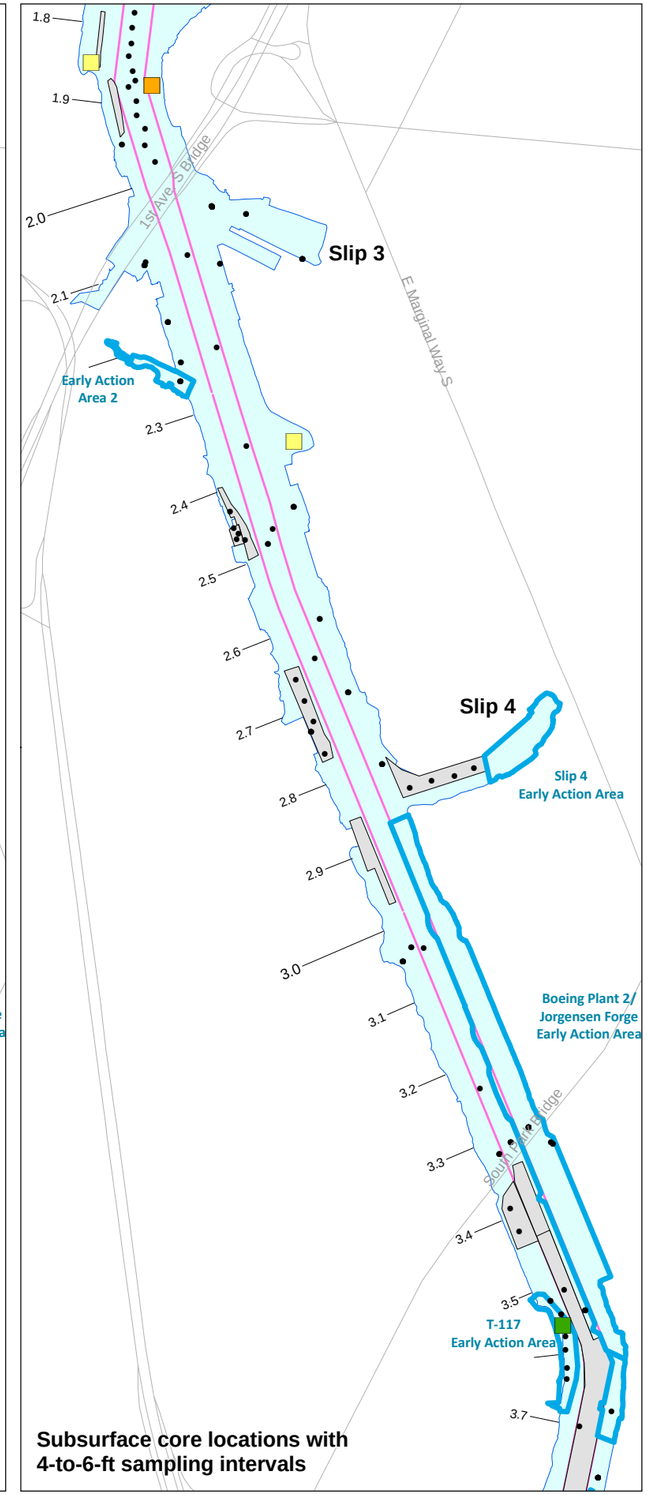
Dredging information provided by AECOM.



Subsurface core locations with 0-to-2-ft sampling intervals



Subsurface core locations with 2-to-4-ft sampling intervals



Subsurface core locations with 4-to-6-ft sampling intervals

cPAH concentration (µg/kg dw)[a]

- > 1,500 — 95th percentile = 1,500
- > 540 and ≤ 1,500 — 75th percentile = 540
- > 260 and ≤ 540 — 50th percentile = 260
- > 100 and ≤ 260 — 25th percentile = 100
- ≤ 100
- Non-detect

Sampling interval

0-to-2-ft[b]	2-to-4-ft[b]	4-to-6-ft[b]
0-to-1-ft[c]	2-to-3-ft[c]	4-to-5-ft[c]
1-to-2-ft[c]	3-to-4-ft[c]	5-to-6-ft[c]

- Not analyzed in that sampling interval
- Other subsurface sampling location analyzed for cPAH, but not in the illustrated sampling intervals
- Early Action Area[d]
- Dredged area[e]
- Navigation channel
- River mile

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. cPAH concentrations are based on benzo(a)-pyrene equivalents. TEQs were calculated with mammalian PEFs for seven individual PAH compounds (California EPA 1994), using one-half the RL for undetected compounds.

[b] Data from 2-foot sampling intervals; some locations show an average of data from both 1-foot intervals within that 2-foot interval at a given location.

[c] Data from 1-foot sampling intervals are shown if available. If both 1-foot intervals within the 2-foot interval were collected, the average of the two intervals is also shown.

[d] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[e] Subsurface sediment data at locations in dredged areas were collected prior to dredging.

0 0.1 0.2 Kilometers

0 0.1 0.2 Miles

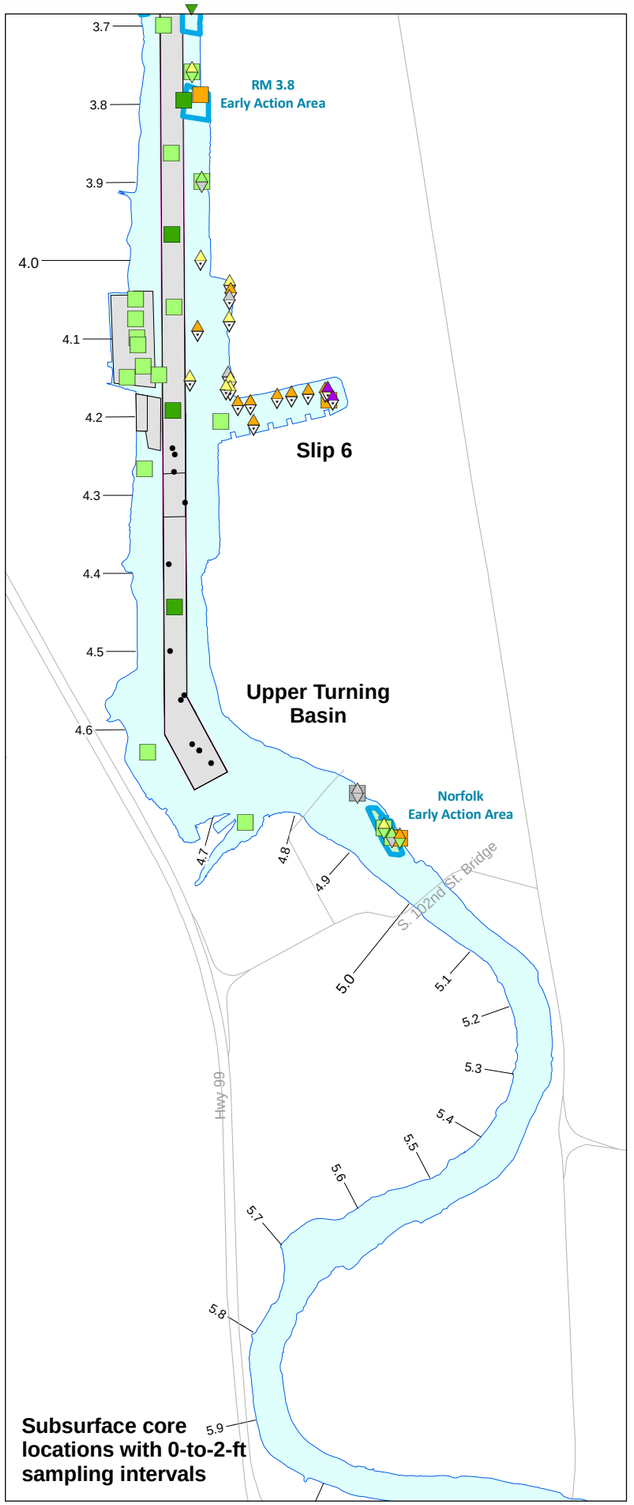
Scale is the same for each map frame

Map 4-40b. cPAH concentrations in subsurface sediment within the 0-to-2-ft, 2-to-4-ft, and 4-to-6-ft sampling intervals, RM 1.8 to RM 3.7

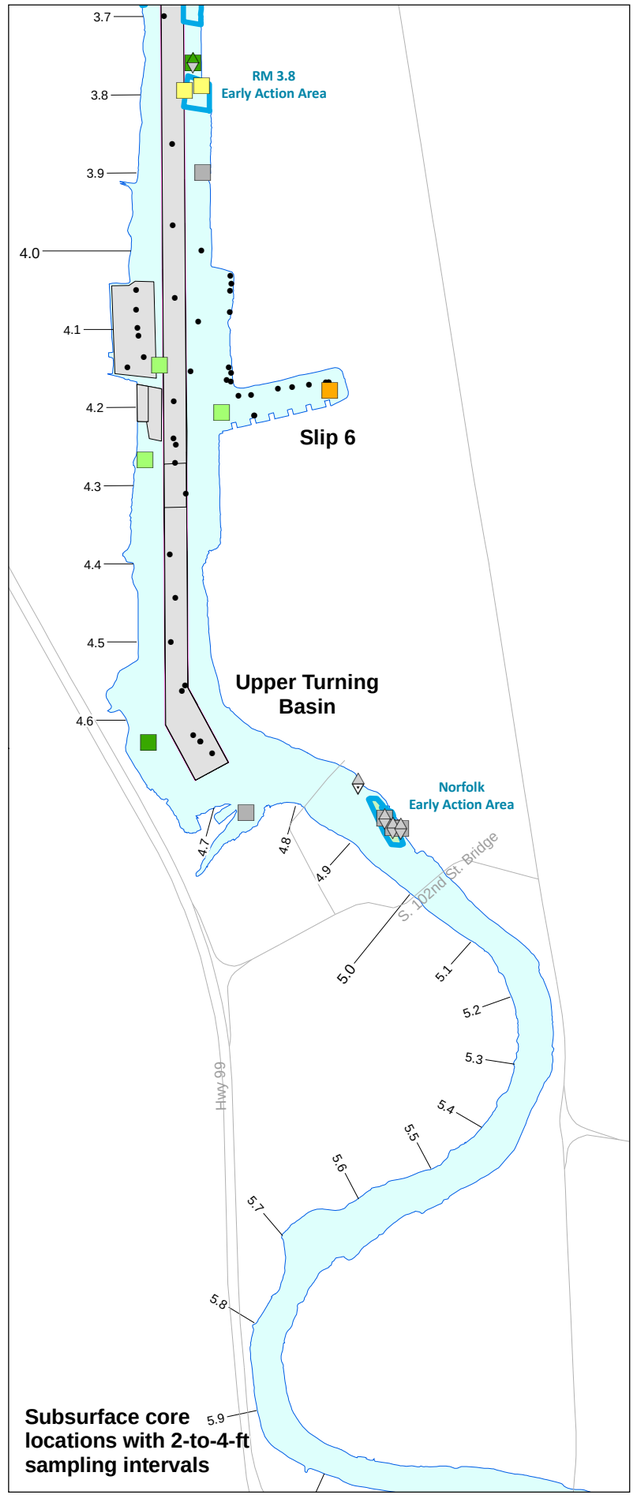
Windward environmental LLC

Prepared by: CEH, 07/15/2010, MAP 2812, W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Depth Interval\Other COCs

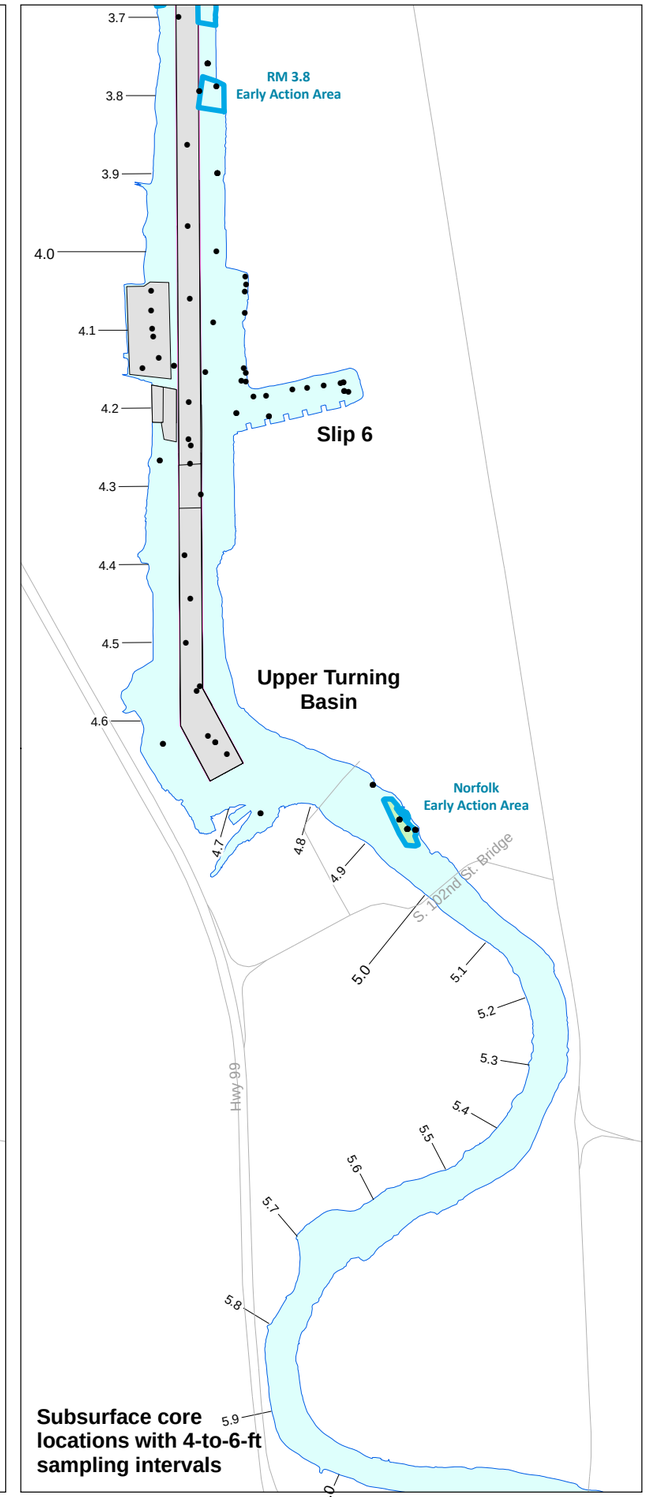
Dredging information provided by AECOM.



Subsurface core locations with 0-to-2-ft sampling intervals



Subsurface core locations with 2-to-4-ft sampling intervals



Subsurface core locations with 4-to-6-ft sampling intervals

cPAH concentration (µg/kg dw)[a]

- > 1,500
- > 540 and ≤ 1,500
- > 260 and ≤ 540
- > 100 and ≤ 260
- ≤ 100
- Non-detect

95th percentile = 1,500
75th percentile = 540
50th percentile = 260
25th percentile = 100

Sampling interval

	Left panel	Middle panel	Right panel
	0-to-2-ft[b]	2-to-4-ft[b]	4-to-6-ft[b]
	0-to-1-ft[c]	2-to-3-ft[c]	4-to-5-ft[c]
	1-to-2-ft[c]	3-to-4-ft[c]	5-to-6-ft[c]

Not analyzed in that sampling interval

Other subsurface sampling location analyzed for cPAH, but not in the illustrated sampling intervals

Early Action Area[d]

Dredged area[e]

Dredged and capped area[e]

Navigation channel

River mile

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. cPAH concentrations are based on benzo(a)-pyrene equivalents. TEQs were calculated with mammalian PEFs for seven individual PAH compounds (California EPA 1994), using one-half the RL for undetected compounds.

[b] Data from 2-foot sampling intervals; some locations show an average of data from both 1-foot intervals within that 2-foot interval at a given location.

[c] Data from 1-foot sampling intervals are shown if available. If both 1-foot intervals within the 2-foot interval were collected, the average of the two intervals is also shown.

[d] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[e] Subsurface sediment data at locations in dredged areas were collected prior to dredging.

N

0 0.1 0.2 Kilometers

0 0.1 0.2 Miles

Scale is the same for each map frame

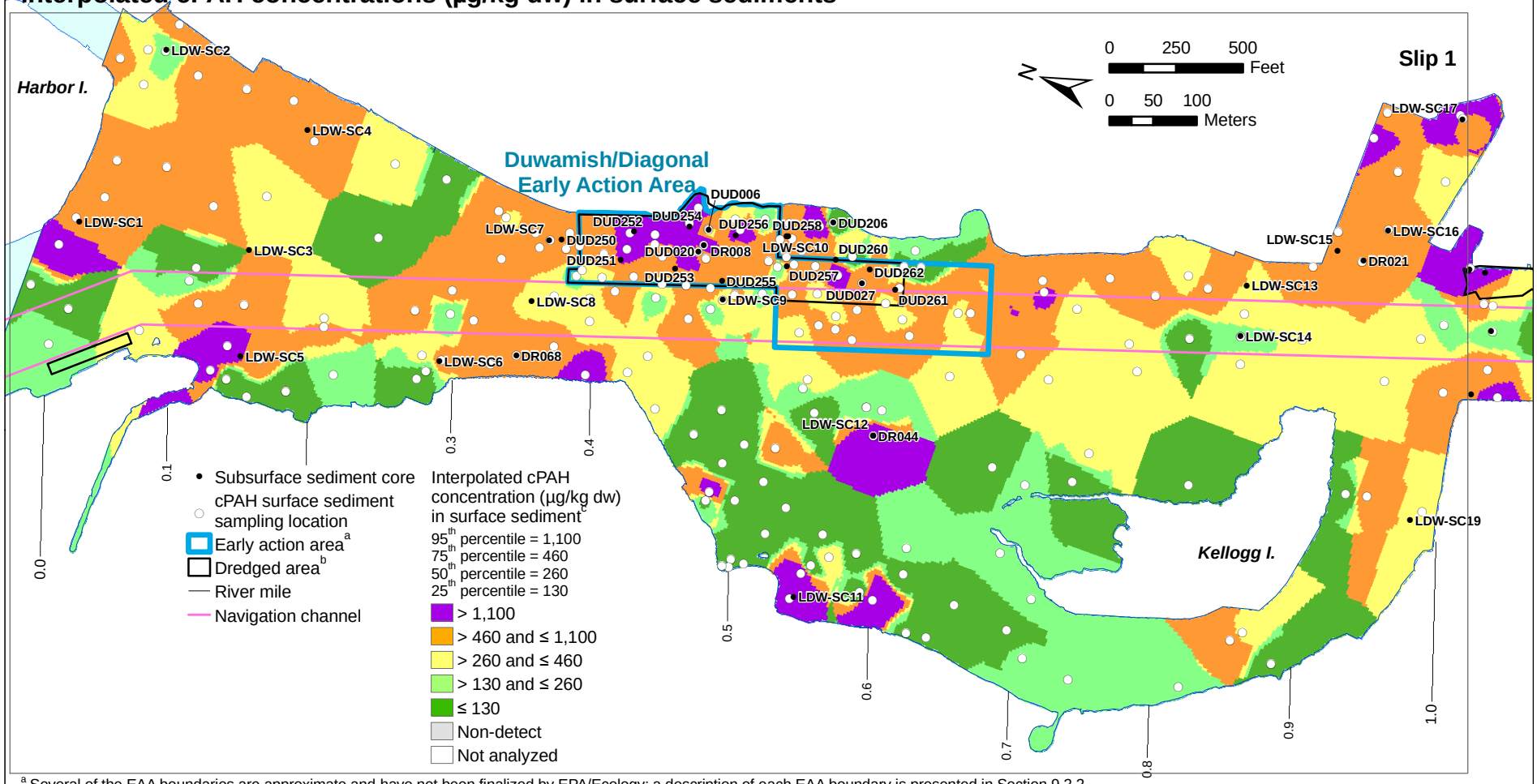
Map 4-40c. cPAH concentrations in subsurface sediment within the 0-to-2-ft, 2-to-4-ft, and 4-to-6-ft sampling intervals, RM 3.7 to RM 6.0

Wind Ward environmental LLC

Prepared by CEH, 07/15/2010. MAP 2812. W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Depth Interval\Other COCs

Dredging information provided by AECOM.

Interpolated cPAH concentrations (µg/kg dw) in surface sediments



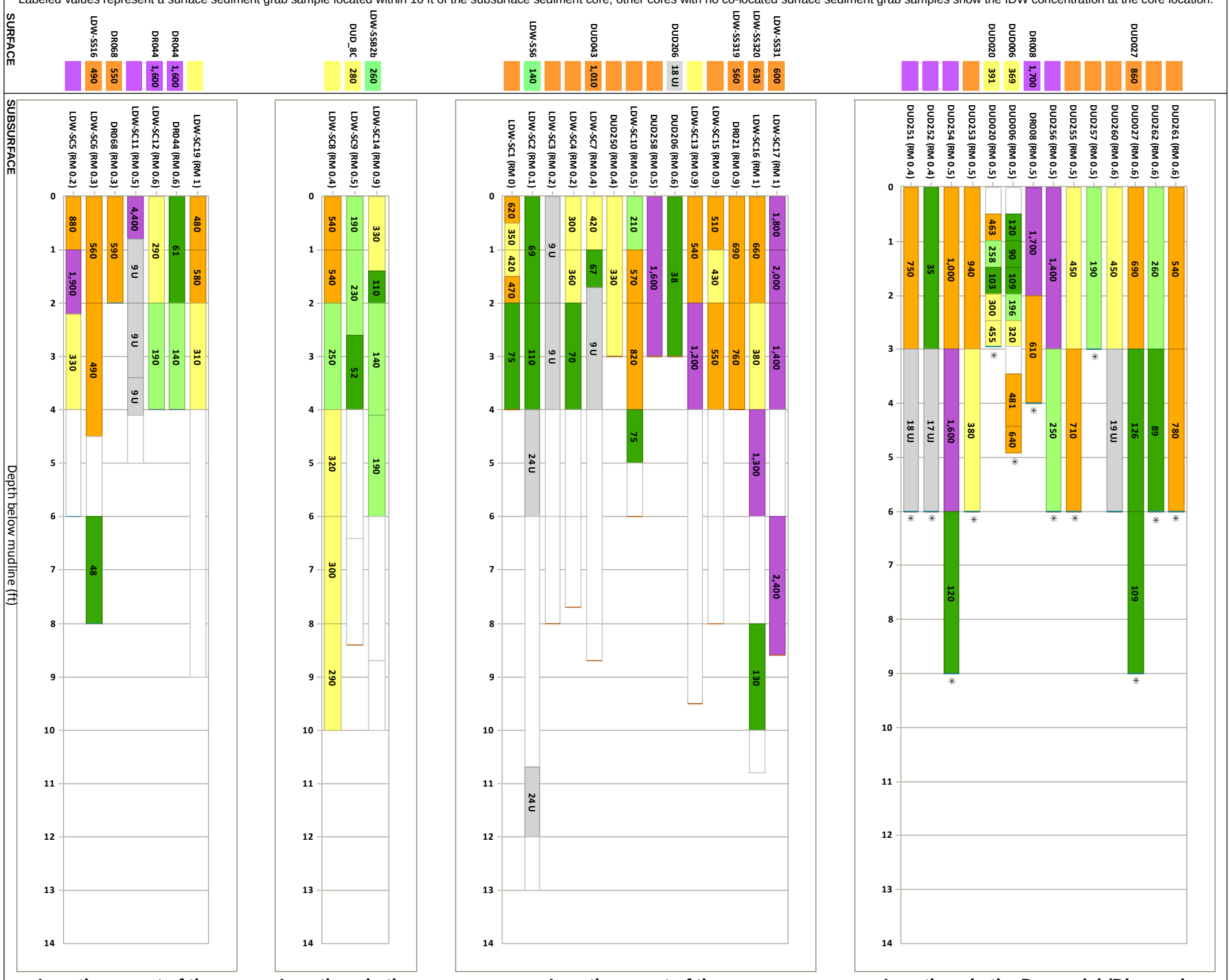
[a] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[b] For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, and thin-layer placement in 2003 to 2005. Subsurface sediment data in dredged areas were collected prior to dredging.

[c] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 1,100 µg/kg dw). Interpolated concentrations were calculated including locations with non-detected values. TEQs were calculated with mammalian PEFs for seven individual PAH compounds (California EPA 1994), using one-half the RL for undetected compounds. Interpolated surface does not show non-detects.

cPAH concentrations (µg/kg dw) in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment grab sample located within 10 ft of the subsurface sediment core; other cores with no co-located surface sediment grab samples show the IDW concentration at the core location.



✳ This core was collected prior to dredging at that location.

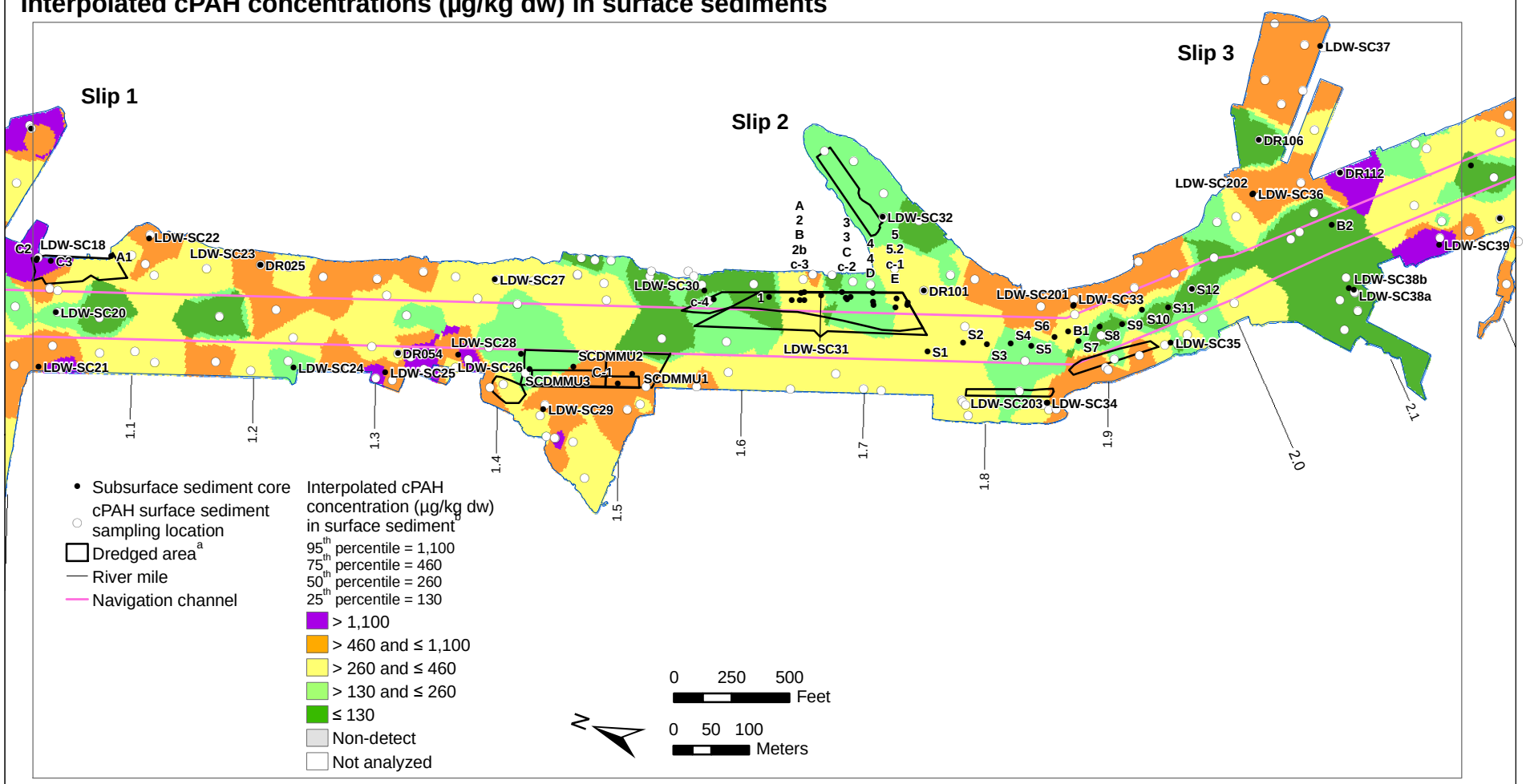
Wind Ward environmental LLC

Map 4-41a. cPAH concentrations in surface sediment and subsurface sediment cores, RM 0.0 to RM 1.0

Prepared by CEH, 07/15/2010; MAP 2994; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.

Interpolated cPAH concentrations (µg/kg dw) in surface sediments

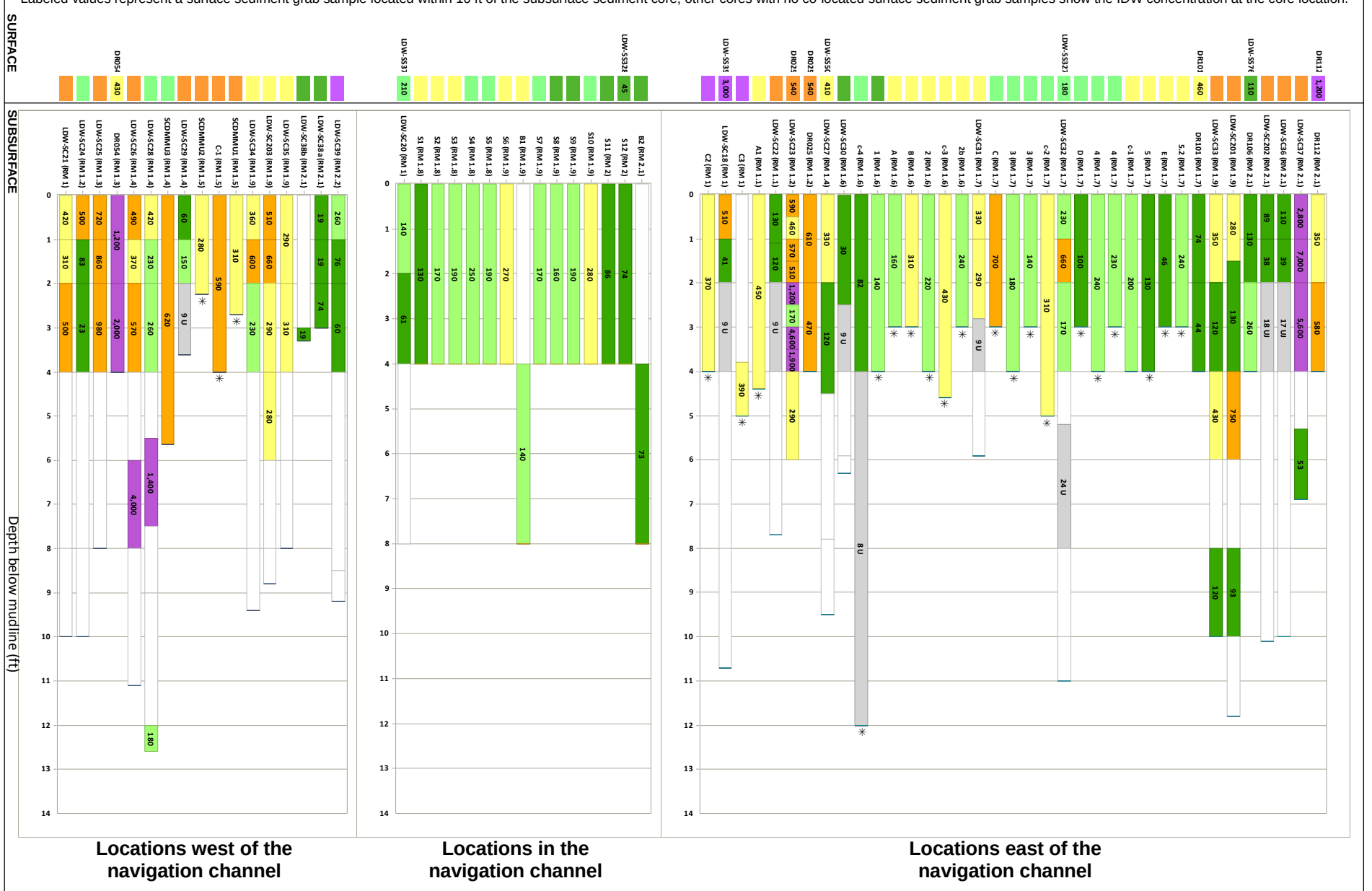


[a] Subsurface sediment data at locations in dredged areas were collected prior to dredging; surface sediment data were collected after dredging.

[b] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 1,100 µg/kg dw). Interpolated concentrations were calculated including locations with non-detected values. TEQs were calculated with mammalian PEFs for seven individual PAH compounds (California EPA 1994), using one-half the RL for undetected compounds. Interpolated surface does not show non-detects.

cPAH concentrations (µg/kg dw) in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment grab sample located within 10 ft of the subsurface sediment core; other cores with no co-located surface sediment grab samples show the IDW concentration at the core location.



✳ This core was collected prior to dredging at that location.

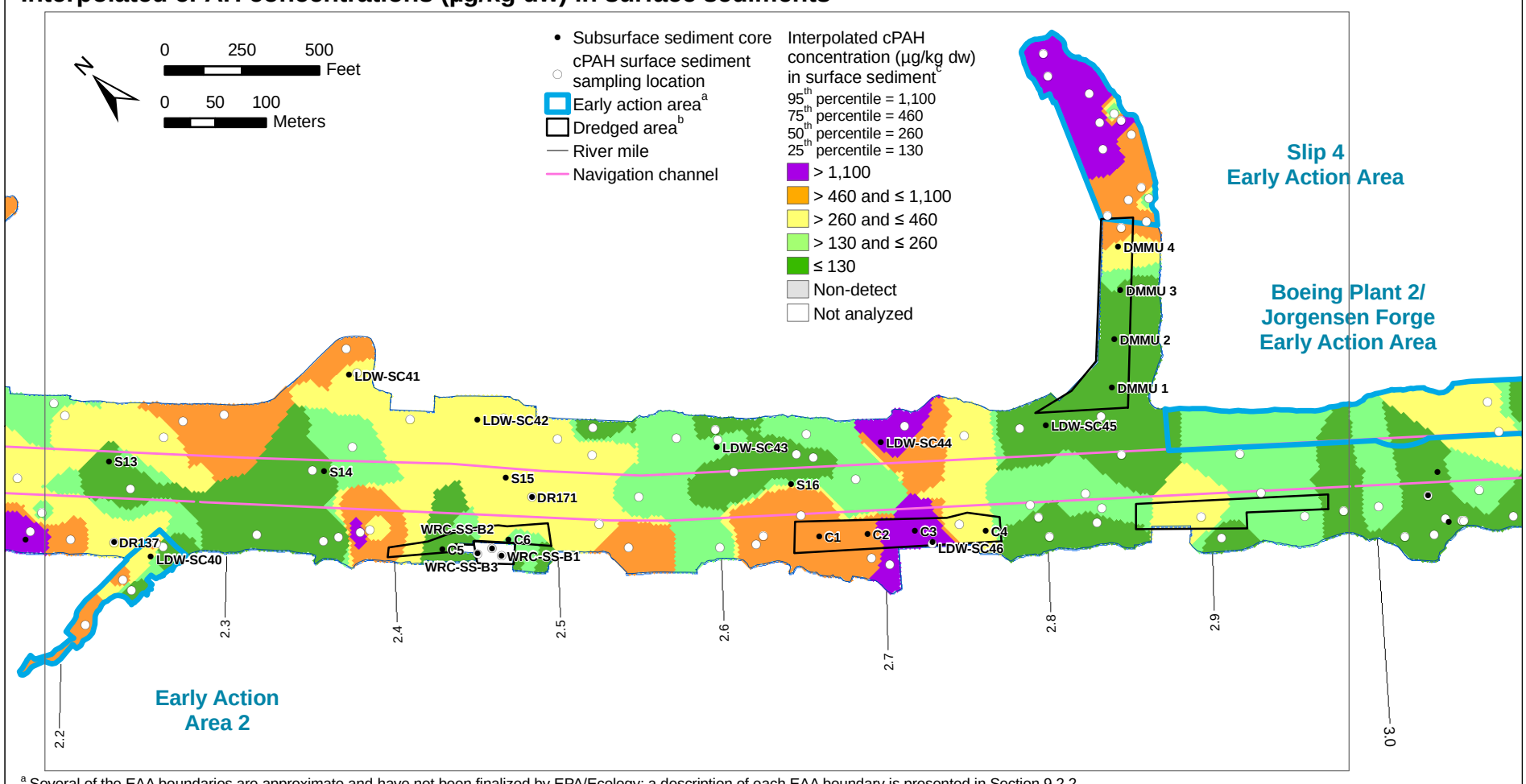
Map 4-41b. cPAH concentrations in surface sediment and subsurface sediment cores, RM 1.0 to RM 2.2

Wind Ward environmental LLC

Prepared by CEH, 07/15/2010; MAP 2994; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.

Interpolated cPAH concentrations (µg/kg dw) in surface sediments



[a] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[b] Subsurface sediment data at locations in dredged areas were collected prior to dredging; surface sediment data were collected after dredging.

[c] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 1,100 µg/kg dw). Interpolated concentrations were calculated including locations with non-detected values. TEQs were calculated with mammalian PEFs for seven individual PAH compounds (California EPA 1994), using one-half the RL for undetected compounds. Interpolated surface does not show non-detects.

cPAH concentrations (µg/kg dw) in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment grab sample located within 10 ft of the subsurface sediment core; other cores with no co-located surface sediment grab samples show the IDW concentration at the core location.

✳ This core was collected prior to dredging at that location.

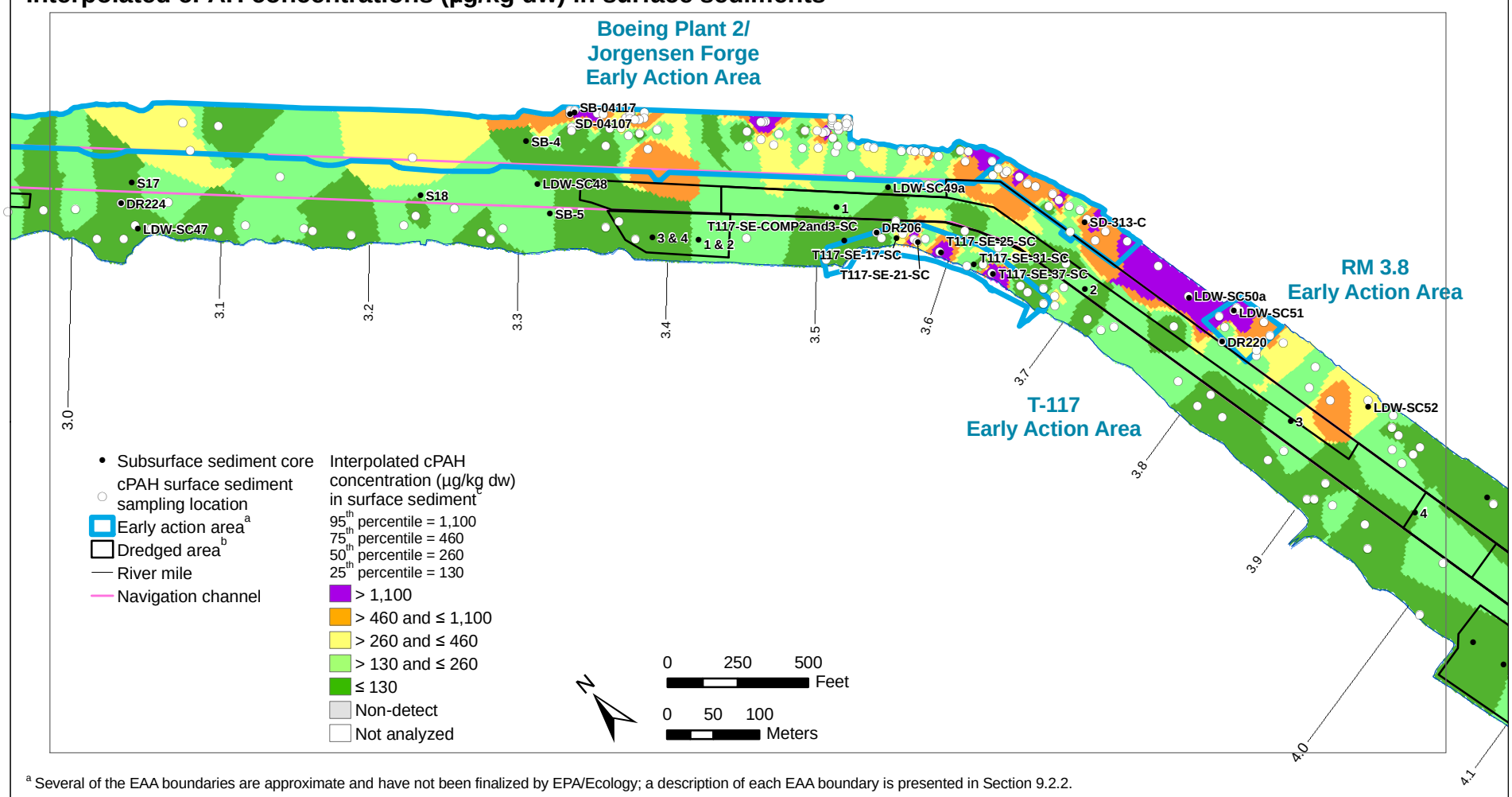
Wind Ward environmental LLC

Map 4-41c. cPAH concentrations in surface sediment and subsurface sediment cores, RM 2.2 to RM 3.0

Prepared by CEH, 07/15/2010; MAP 2994; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.

Interpolated cPAH concentrations (µg/kg dw) in surface sediments



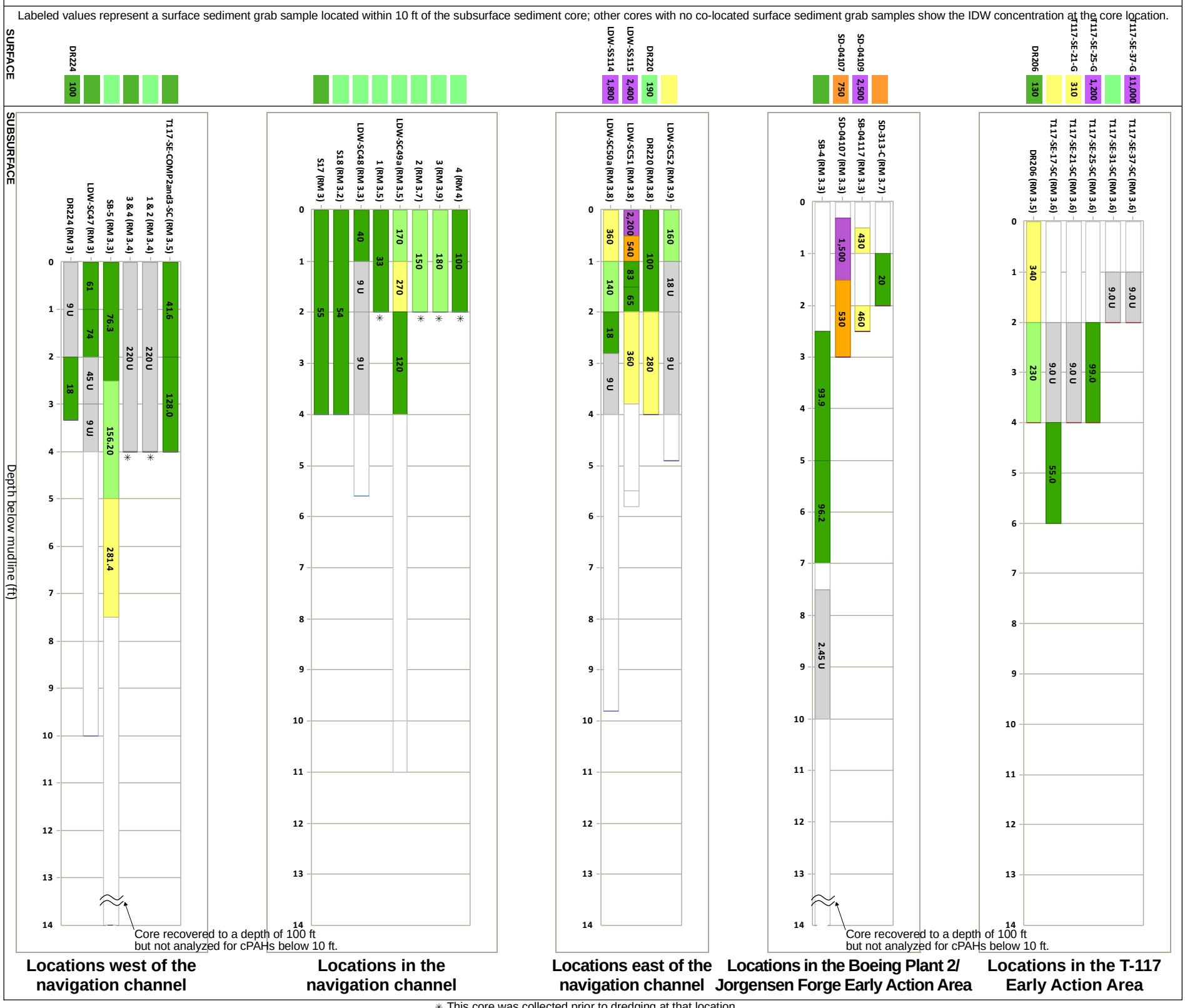
[a] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[b] Subsurface sediment data at locations in dredged areas were collected prior to dredging; surface sediment data were collected after dredging.

[c] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 1,100 µg/kg dw). Interpolated concentrations were calculated including locations with non-detected values. TEQs were calculated with mammalian PEFs for seven individual PAH compounds (California EPA 1994), using one-half the RL for undetected compounds. Interpolated surface does not show non-detects.

cPAH concentrations (µg/kg dw) in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment grab sample located within 10 ft of the subsurface sediment core; other cores with no co-located surface sediment grab samples show the IDW concentration at the core location.



✳ This core was collected prior to dredging at that location.

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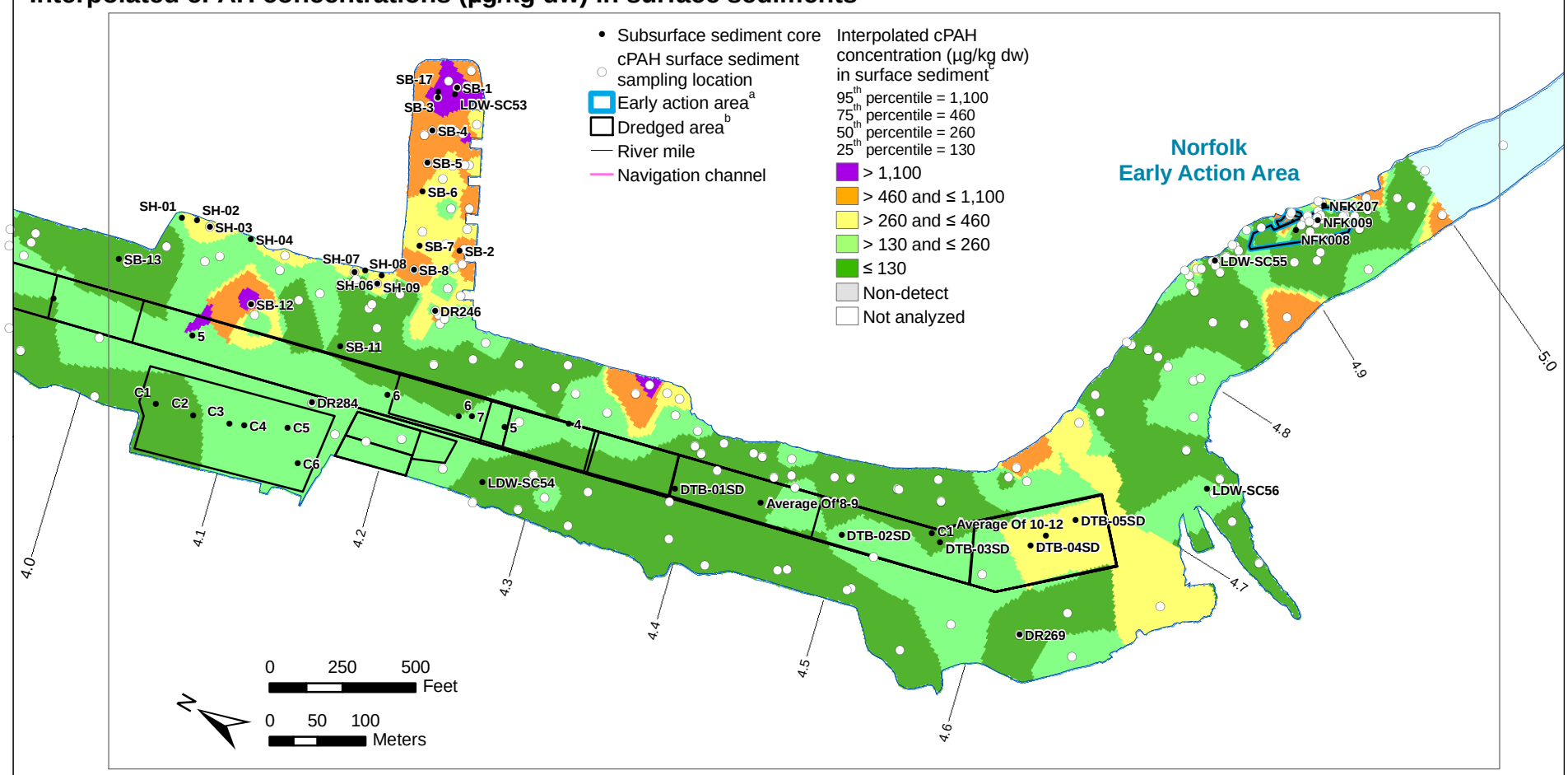
Map 4-41d. cPAH concentrations in surface sediment and subsurface sediment cores, RM 3.0 to RM 4.0

Prepared by CEH, 07/15/2010; MAP 2994; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.

Interpolated cPAH concentrations (µg/kg dw) in surface sediments



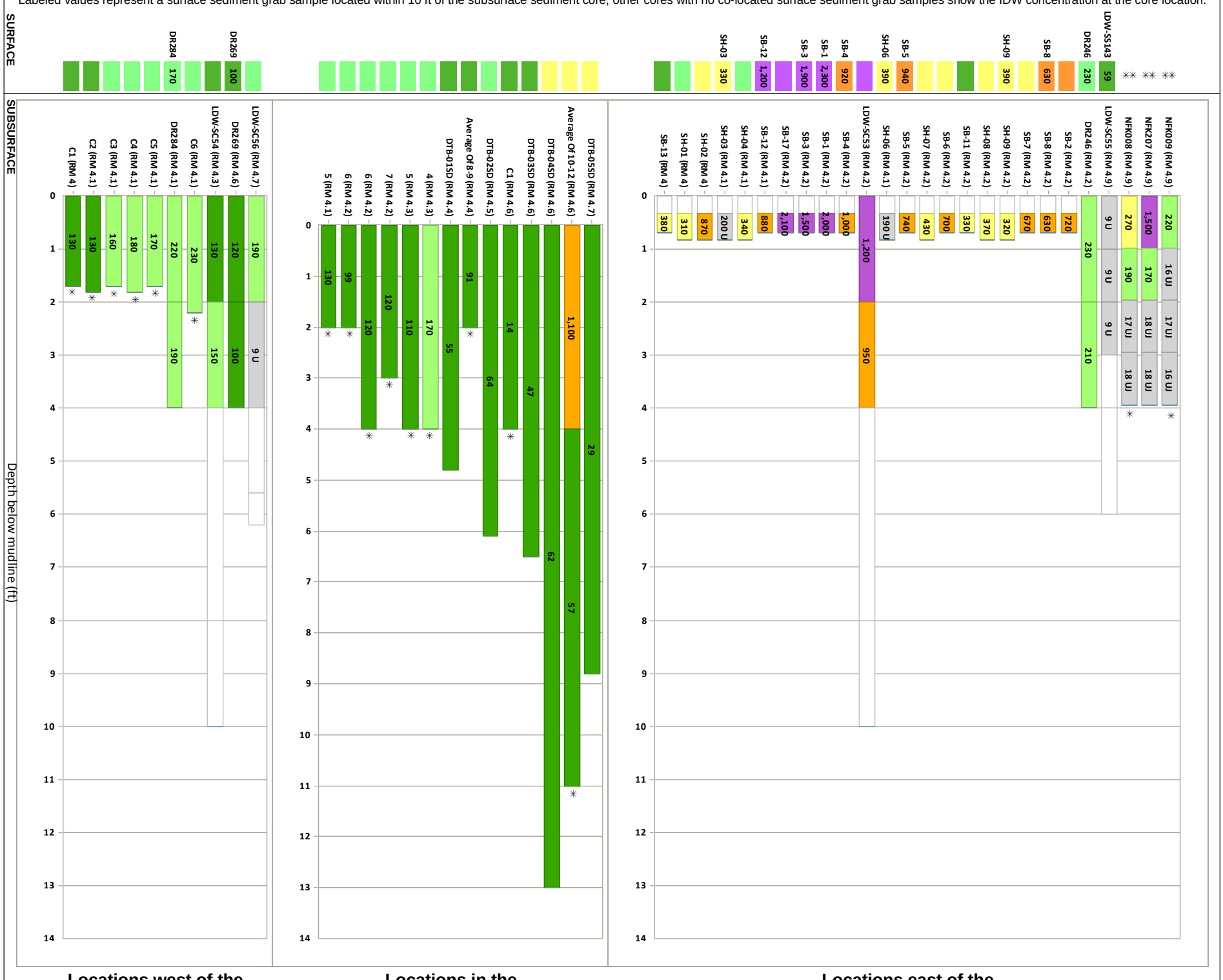
[a] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[b] For the Norfolk Early Action Area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO/SD removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003. Subsurface sediment data at locations in dredged areas were collected prior to dredging.

[c] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 1,100 µg/kg dw). Interpolated concentrations were calculated including locations with non-detected values. TEQs were calculated with mammalian PEFs for seven individual PAH compounds (California EPA 1994), using one-half the RL for undetected compounds. Interpolated surface does not show non-detects.

cPAH concentrations (µg/kg dw) in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment grab sample located within 10 ft of the subsurface sediment core; other cores with no co-located surface sediment grab samples show the IDW concentration at the core location.



✳ This core was collected prior to dredging at that location.

✳✳ At the Norfolk EAA, surface sediment data, which were collected after the removal action at the Norfolk CSO area in 1999 but before the removal action at the BDC south storm drain outfall area in 2003, do not reflect conditions at the time subsurface cores were collected in 1995.

Map 4-41e. cPAH concentrations in surface sediment and subsurface sediment cores, RM 4.0 to RM 5.0

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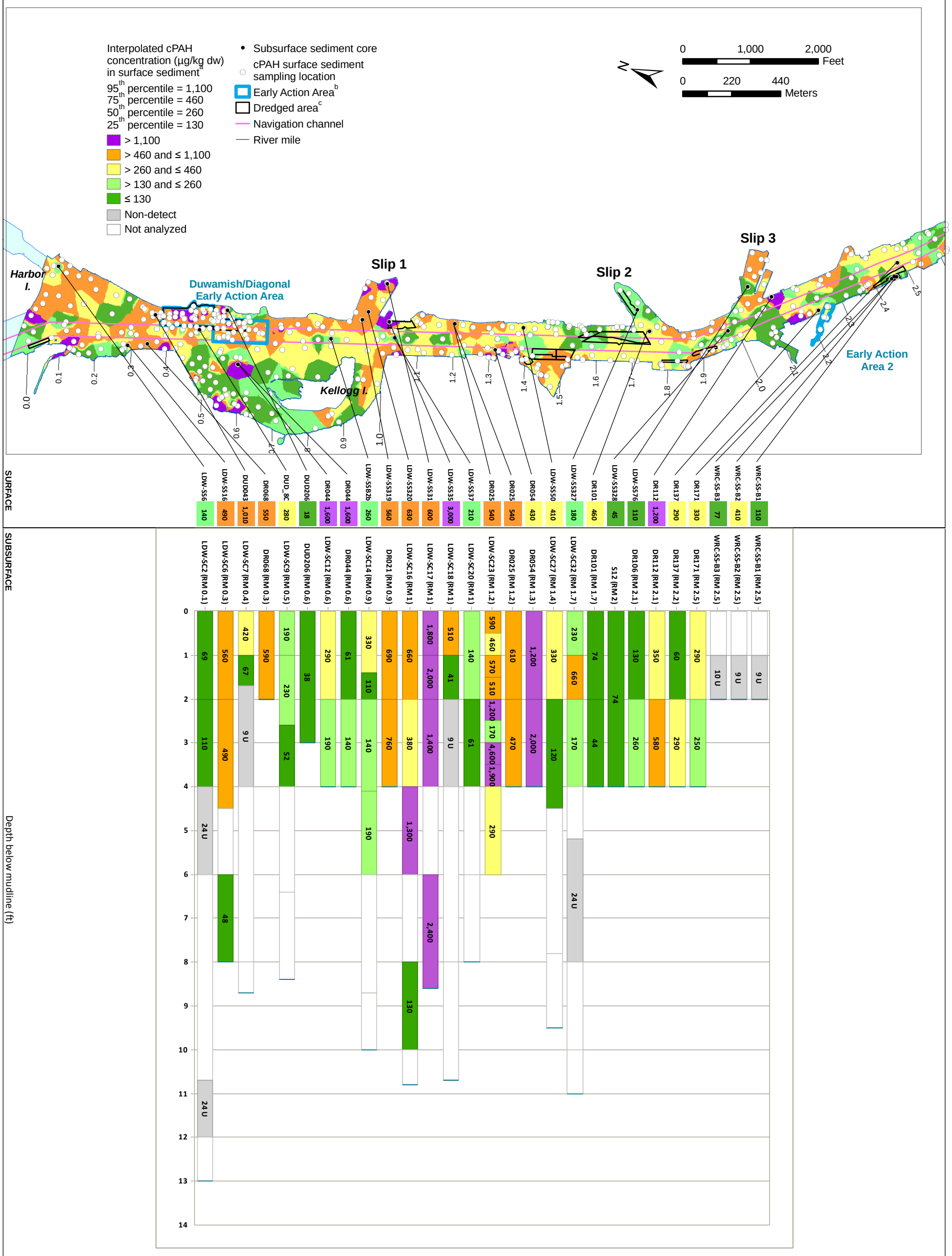
Prepared by CEH, 07/15/2010; MAP 2994; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.

cPAH concentrations (µg/kg dw) in surface sediments, subsurface core data, and co-located (within 10 ft) surface sediment data



[a] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 1,100 µg/kg dw). Interpolated concentrations were calculated including locations with non-detected values. TEQs were calculated with mammalian PEFs for seven individual PAH compounds (California EPA 1994), using one-half the RL for undetected compounds. Interpolated surface does not show non-detects.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, and thin-layer placement in 2003 to 2005. Subsurface sediment data in dredged areas were collected prior to dredging.

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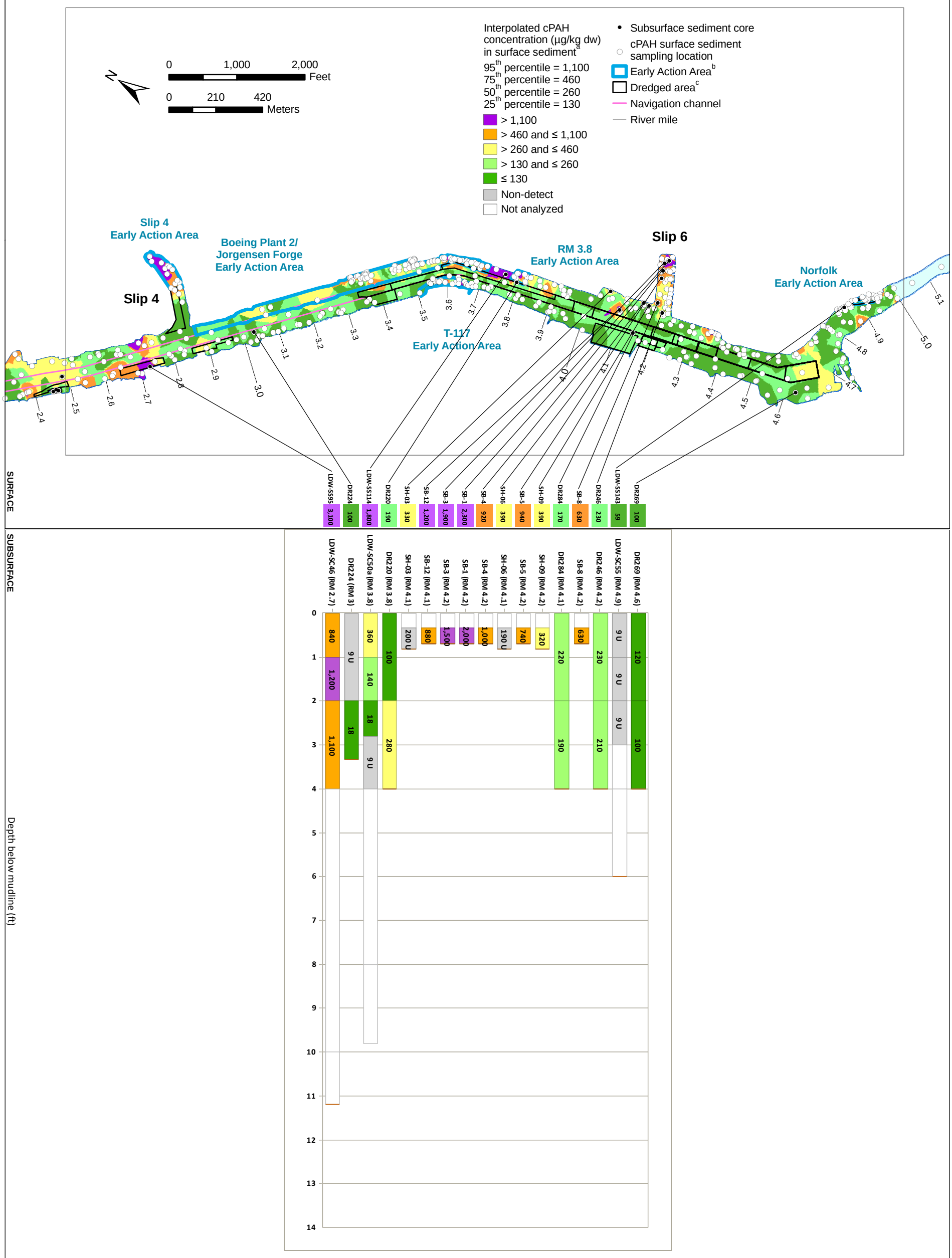
Map 4-42a. Comparison of cPAH concentrations in subsurface cores to co-located surface sediment locations, RM 0.0 to RM 2.5

Prepared by CEH, 07/16/2010; MAP 3796; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Nature and Extent\Subsurface\Colocation

Dredging information provided by AECOM.

cPAH concentrations (µg/kg dw) in surface sediments, subsurface core data, and co-located (within 10 ft) surface sediment data



[a] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 1,100 µg/kg dw). Interpolated concentrations were calculated including locations with non-detected values. TEQs were calculated with mammalian PEFs for seven individual PAH compounds (California EPA 1994), using one-half the RL for undetected compounds. Interpolated surface does not show non-detects.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Norfolk Early Action Area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003. Subsurface sediment data in dredged areas were collected prior to dredging.

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Map 4-42b. Comparison of cPAH concentrations in subsurface cores to co-located surface sediment locations, RM 2.5 to RM 5.0

Prepared by CEH, 07/16/2010; MAP 3796; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Nature and Extent\Subsurface\Colocation

Dredging information provided by ENSR.

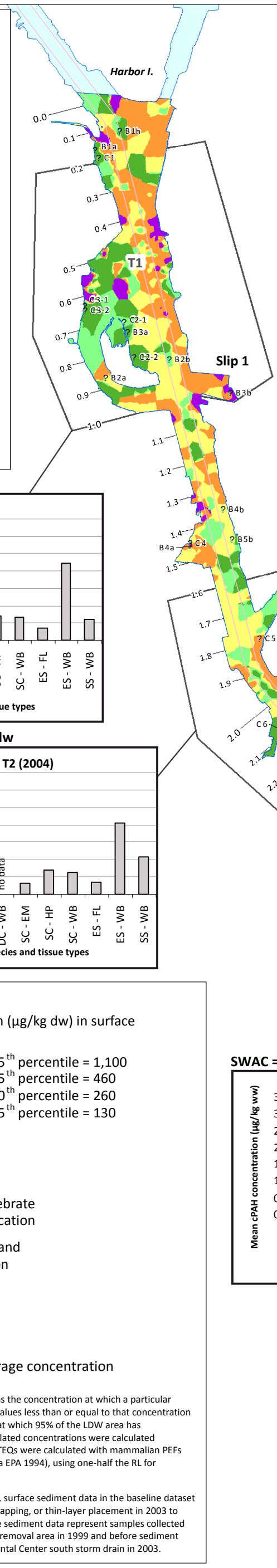
Graph Legend

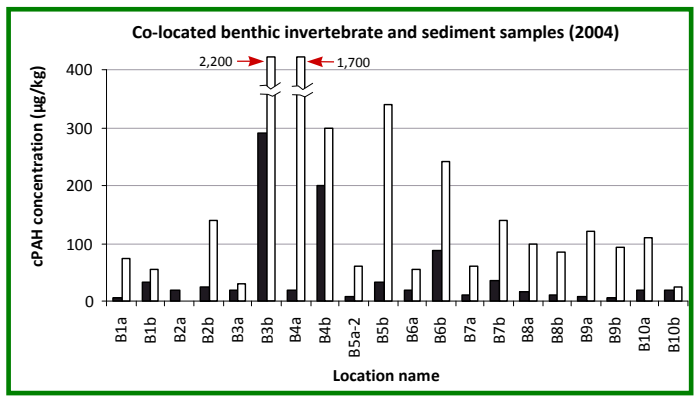
- Co-located cPAH concentration in sediment
- Co-located cPAH concentration in benthic invertebrate or clam tissue
- Mean cPAH concentration in tissue
- * cPAHs were not detected for this tissue type in this area; half the RL was used

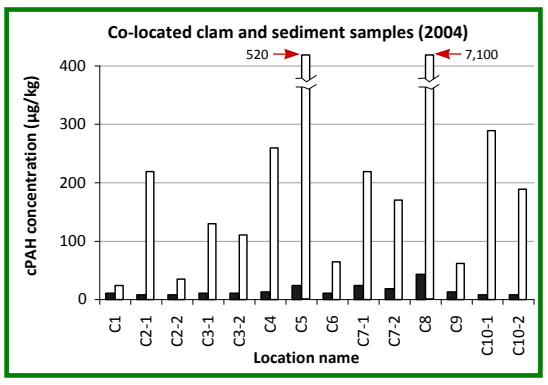
Acronyms for species and tissue type

DC - Dungeness crab
SC - Slender crab
ES - English sole
SS - Shiner surfperch
EM - Edible meat
FL - Fillet with skin
HP - Hepatopancreas
WB - Whole body

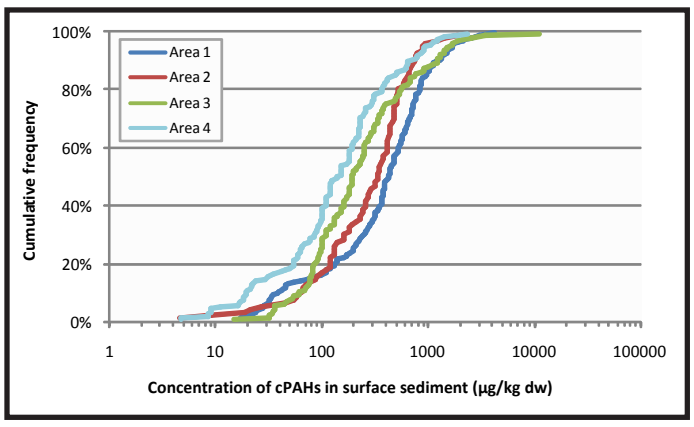
Note: Results for Pacific staghorn sculpin and English sole fillet without skin are not presented because of the low detection frequency and high reporting limits (see Section 4.2.3.4).



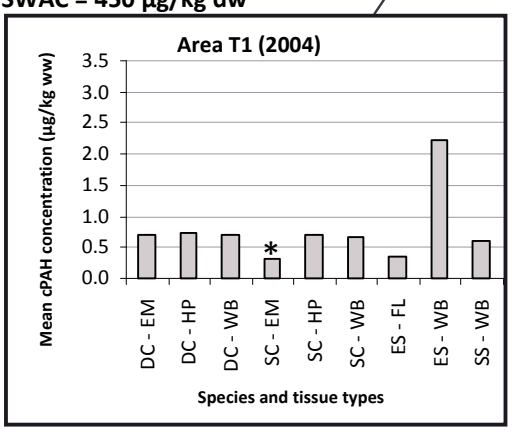




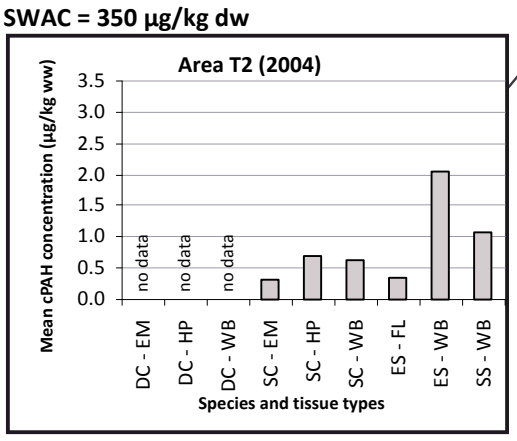
Note: Clam and benthic invertebrate tissue concentrations are in wet weight and sediment concentrations are in dry weight. Depurated clam samples were also analyzed for cPAHs in 2007 but are not shown on this figure.



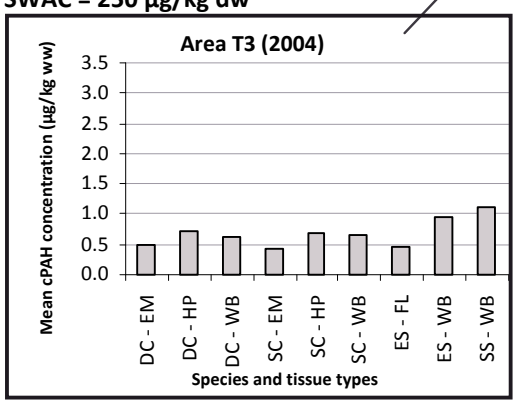
SWAC = 450 µg/kg dw



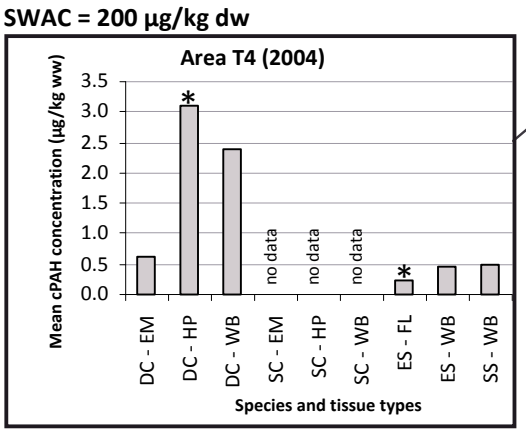
SWAC = 350 µg/kg dw



SWAC = 250 µg/kg dw



SWAC = 200 µg/kg dw



Map Legend

Interpolated cPAH concentration (µg/kg dw) in surface sediment[a,b]

- > 1,100
- > 460 and ≤ 1,100
- > 260 and ≤ 460
- > 130 and ≤ 260
- ≤ 130

95th percentile = 1,100
75th percentile = 460
50th percentile = 260
25th percentile = 130

- Co-located benthic invertebrate and sediment sampling location
- Co-located softshell clam and sediment sampling location
- Tissue sampling area
- Navigation channel
- River mile

SWAC - spatially weighted average concentration

[a] Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated values ≤ 1,100 µg/kg dw). Interpolated concentrations were calculated including locations with non-detected values. TEQs were calculated with mammalian PEFs for seven individual PAH compounds (California EPA 1994), using one-half the RL for undetected compounds.

[b] For the Duwamish/Diagonal early action area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005. For the Norfolk early action area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

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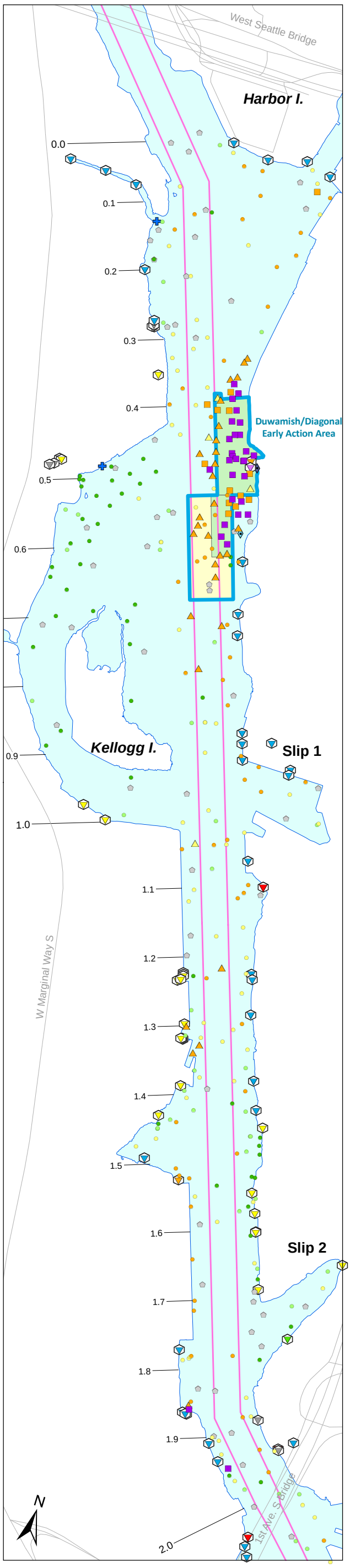
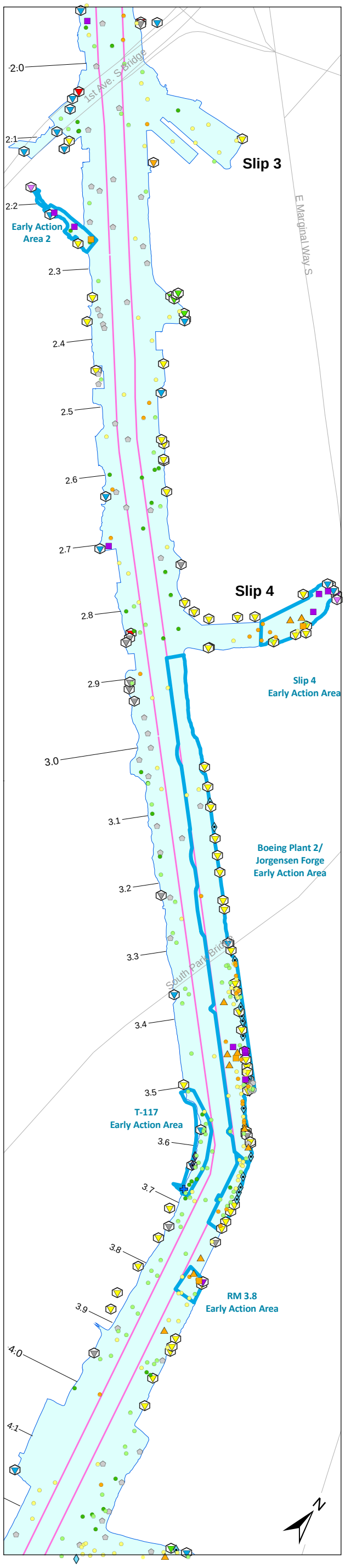
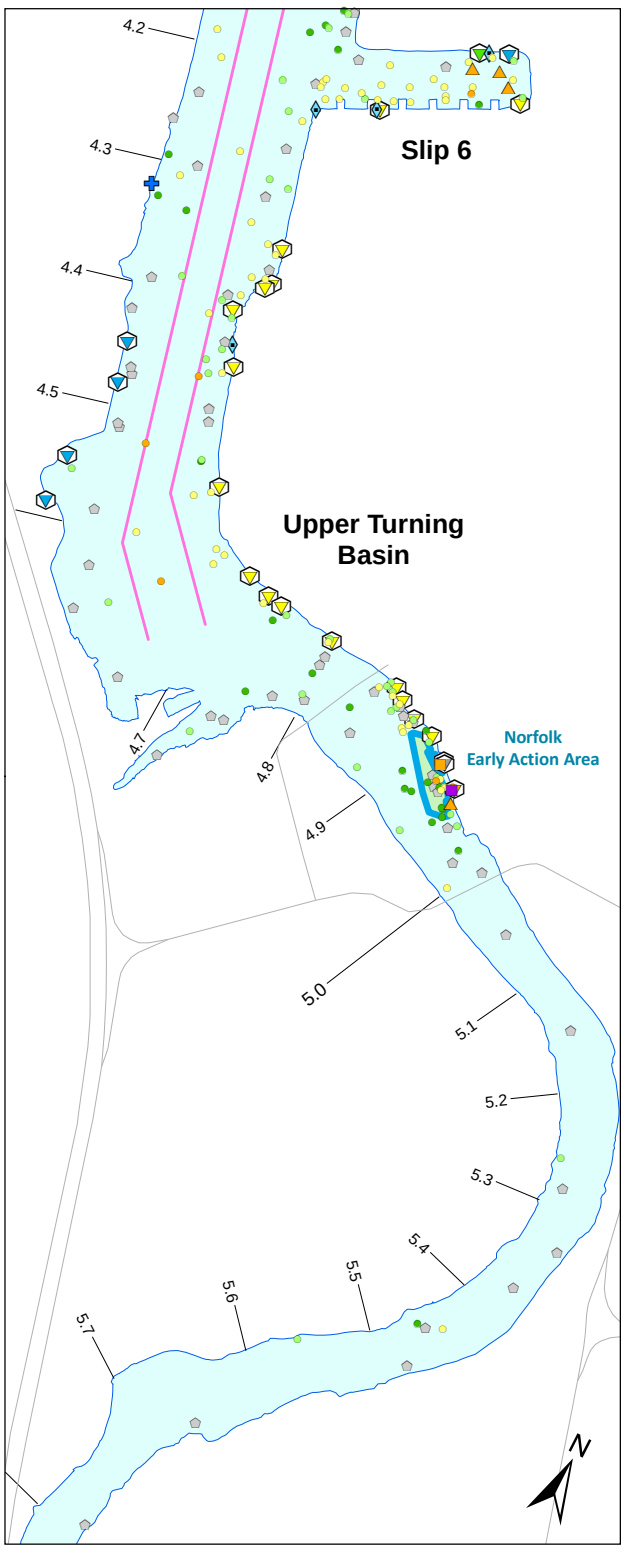
0 0.25 0.5 Miles
0 0.25 0.5 Kilometers

Map 4-43. cPAH concentrations in composite tissue samples of fish, crabs, clams, and benthic invertebrate community superimposed on the IDW interpolation of cPAH concentrations in surface sediment

Modified by Zachariah from GIS Map 2760 | July 16, 2009 | Map 4-43 (2760).xar







BEHP concentration (µg/kg dw)[a]

- > 2,400
- > 490 and ≤2,400
- > 230 and ≤ 490
- > 95 and ≤ 230
- ≤ 95
- Non-detect
- > CSL
- > SQS and ≤ CSL
- ≤ SQS
- Early Action Area[b]
- Dredged and capped area[c]
- Thin-layer placement[c]
- Road
- Navigation channel
- River mile

95th percentile = 2,400
75th percentile = 490
50th percentile = 230
25th percentile = 95

Outfall classification[d]

- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, a value of one-half the RL at that location was used. When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations are compared instead to the LAET and 2LAET.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer capping in 2003 to 2005. For the Norfolk Early Action Area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

[d] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

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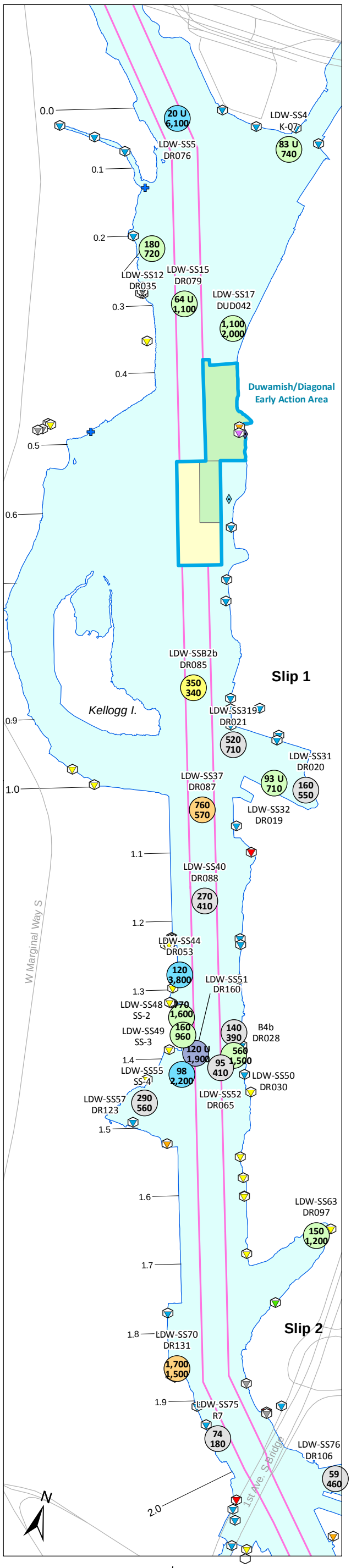
0 0.1 0.2 Miles

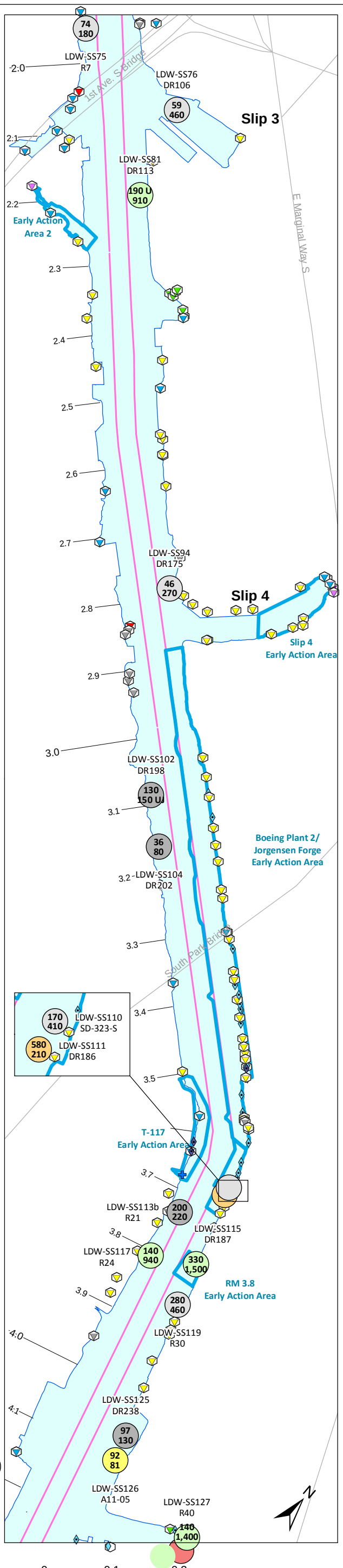
0 0.1 0.2 Kilometers

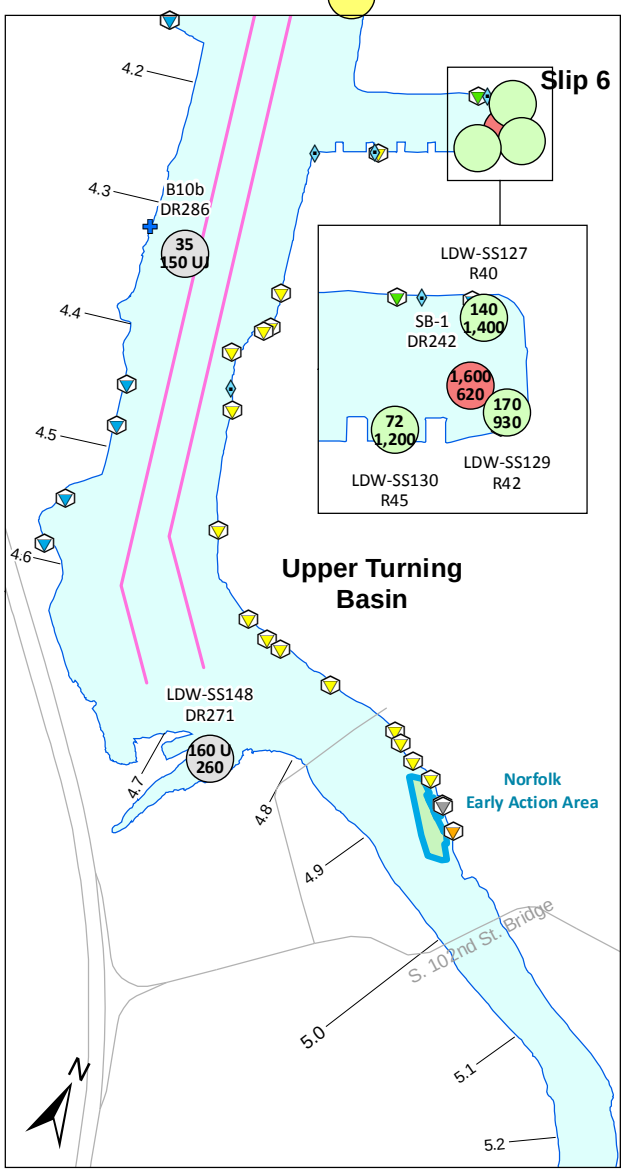
Scale is the same for each inset map

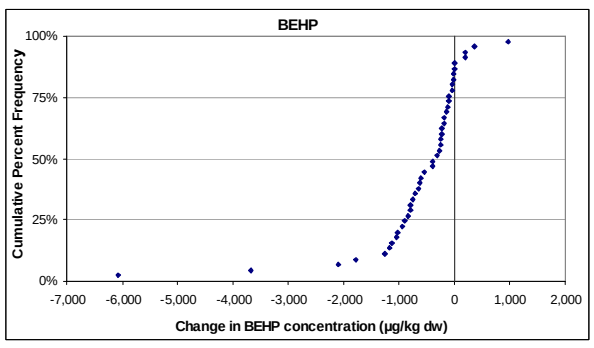
Map 4-44. BEHP concentrations in surface sediment

Prepared by CEH, 07/15/2010, MAP 2771; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\Other COCs









Difference in BEHP dry weight values (µg/kg dw)[a]
New value minus old value

- ≤ -2,000
- > -2,000 and ≤ -1,500
- > -1,500 and ≤ -500
- > -500 and ≤ -100
- > -100 and ≤ 0
- > 0 and ≤ 100
- > 100 and ≤ 500
- > 500
- Early Action Area[b]
- Dredged and capped area
- Thin-layer placement

New value
Old value
New location ID
Old location ID
20U
6,100
LDW-SS5
DR076
U = non-detect

Outfall classification[c]

- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale
- Road
- Navigation channel
- River mile

[a] A location was considered to have been resampled if the new location was within 10 ft of the old location.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time of the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

Note: Samples collected in the Duwamish/Diagonal and Norfolk EAAs were not included in this evaluation.

0 0.1 0.2 Miles

0 0.1 0.2 Kilometers

Scale is the same for each inset map

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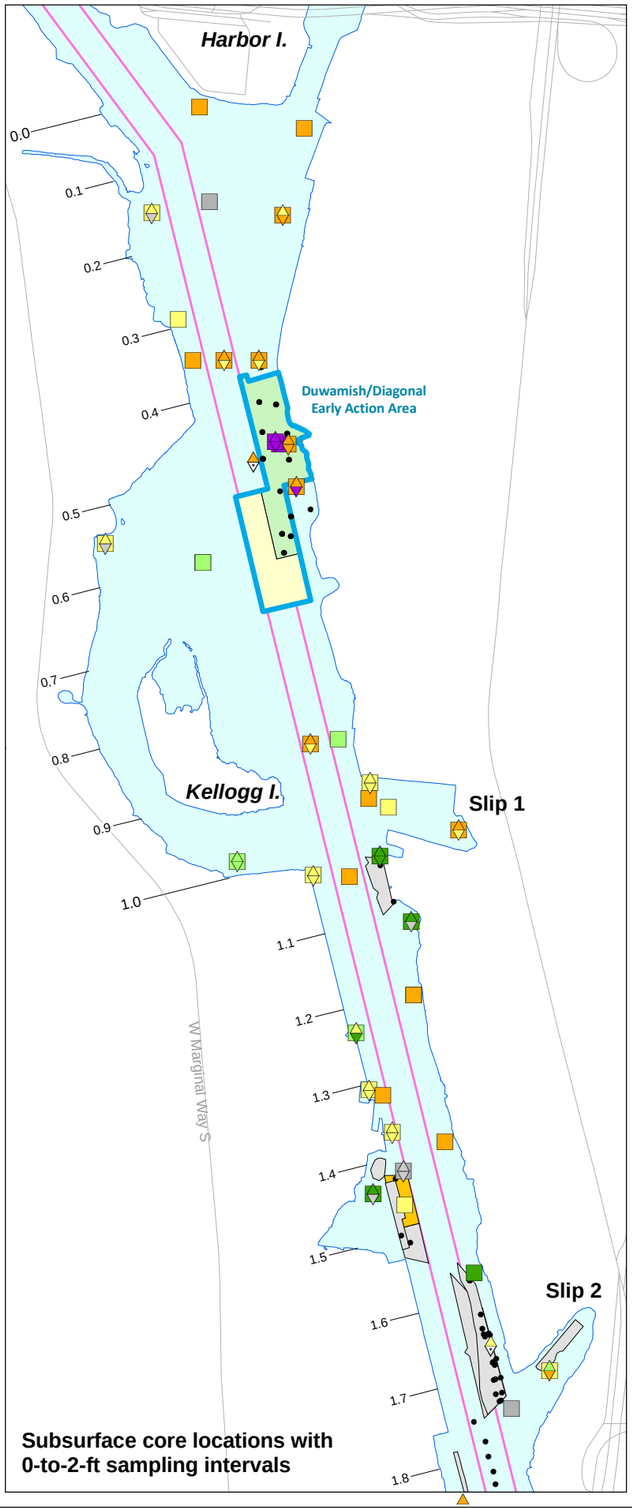
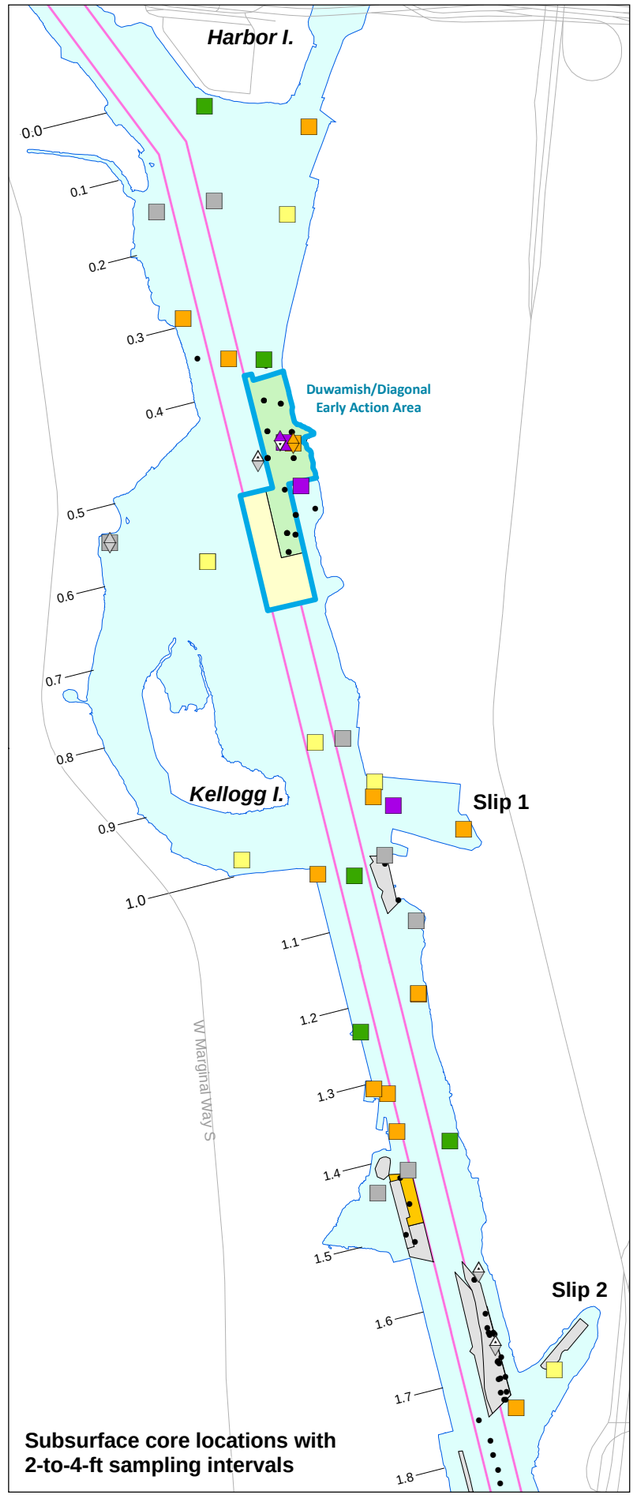
Map 4-45. Differences in BEHP concentrations in surface sediment at locations that have been resampled

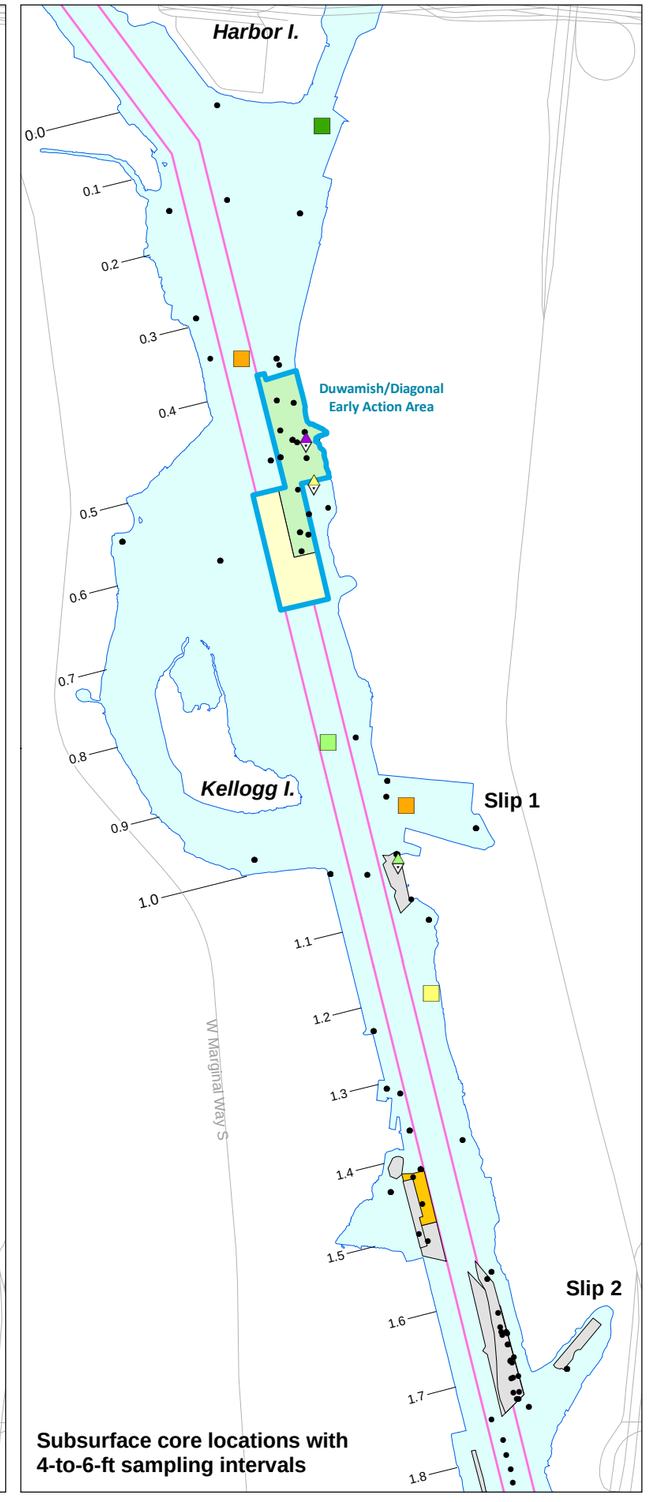
Prepared by CEH, 07/15/2010; MAP 2734; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Round3 Trumping



Subsurface core locations with 0-to-2-ft sampling intervals



Subsurface core locations with 2-to-4-ft sampling intervals



Subsurface core locations with 4-to-6-ft sampling intervals

BEHP concentration (µg/kg dw)[a]

> 2,400	95th percentile = 2,400
> 490 and ≤ 2,400	75th percentile = 490
> 230 and ≤ 490	50th percentile = 230
> 95 and ≤ 230	25th percentile = 95
≤ 95	
Non-detect	

Sampling interval

Left panel	Middle panel	Right panel
0-to-2-ft[b]	2-to-4-ft[b]	4-to-6-ft[b]
0-to-1-ft[c]	2-to-3-ft[c]	4-to-5-ft[c]
1-to-2-ft[c]	3-to-4-ft[c]	5-to-6-ft[c]

Not analyzed in that sampling interval

Other subsurface sampling locations analyzed for BEHP but not in the illustrated sampling intervals

Early Action Area[d]

Dredged area[e]

Dredged and capped area[e]

Dredged and thin-layer placement[e]

Thin-layer placement

Navigation channel

River mile

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, a value of one-half the RL at that location was used.

[b] Data from 2-foot sampling intervals; some locations show an average of data from both 1-foot intervals within that 2-foot interval at a given location.

[c] Data from 1-foot sampling intervals are shown if available. If both 1-foot intervals within the 2-foot interval were collected, the average of the two intervals is also shown.

[d] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[e] Subsurface sediment data at locations in dredged areas were collected prior to dredging.

N

0 0.1 0.2 Kilometers

0 0.1 0.2 Miles

Scale is the same for each map frame

Map 4-46a. BEHP concentrations in subsurface sediment within the 0-to-2-ft, 2-to-4-ft, and 4-to-6-ft sampling intervals, RM 0.0 to RM 1.8

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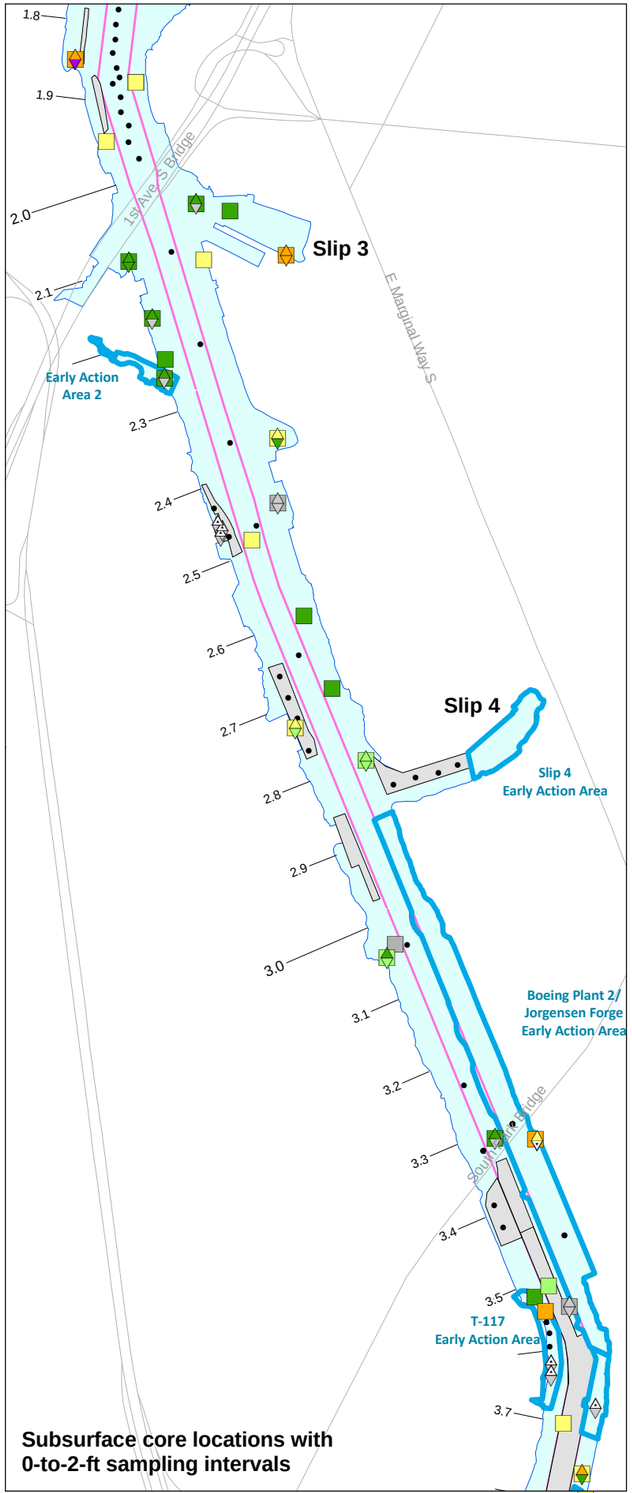
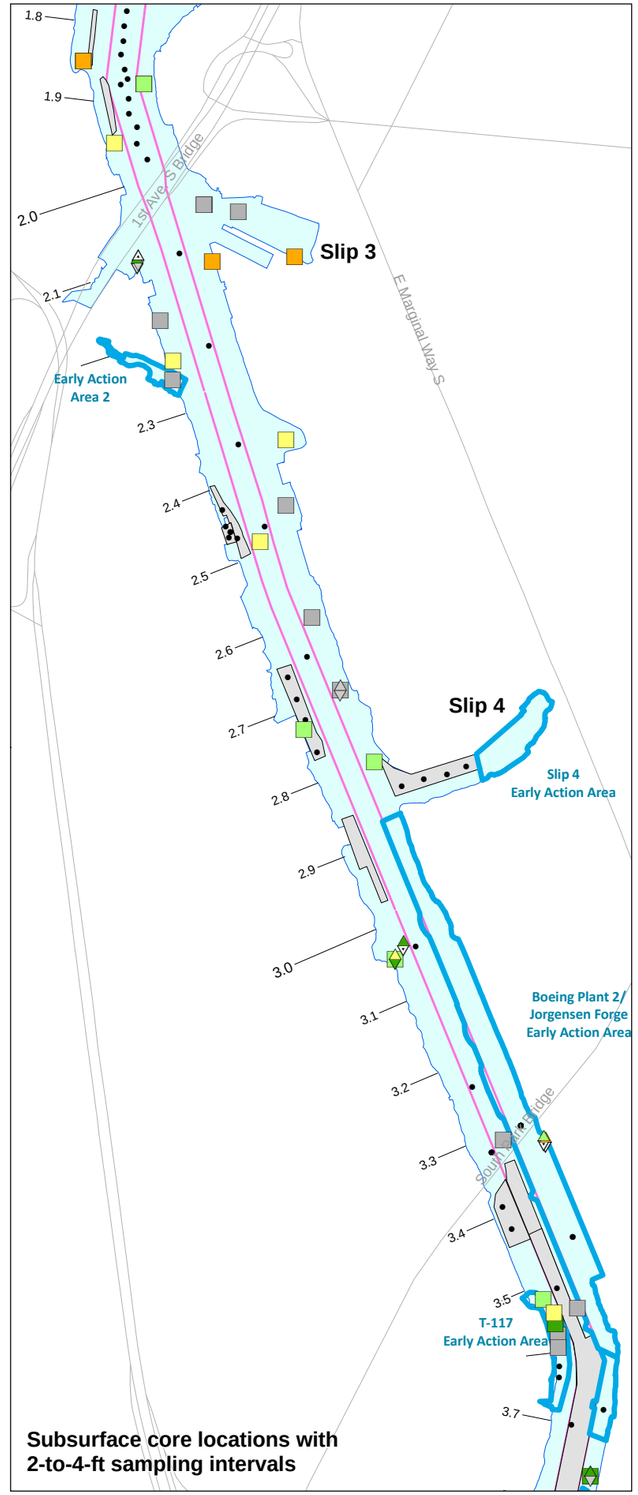
Prepared by CEH, 07/15/2010, MAP 2811, W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Depth Interval\PCBs

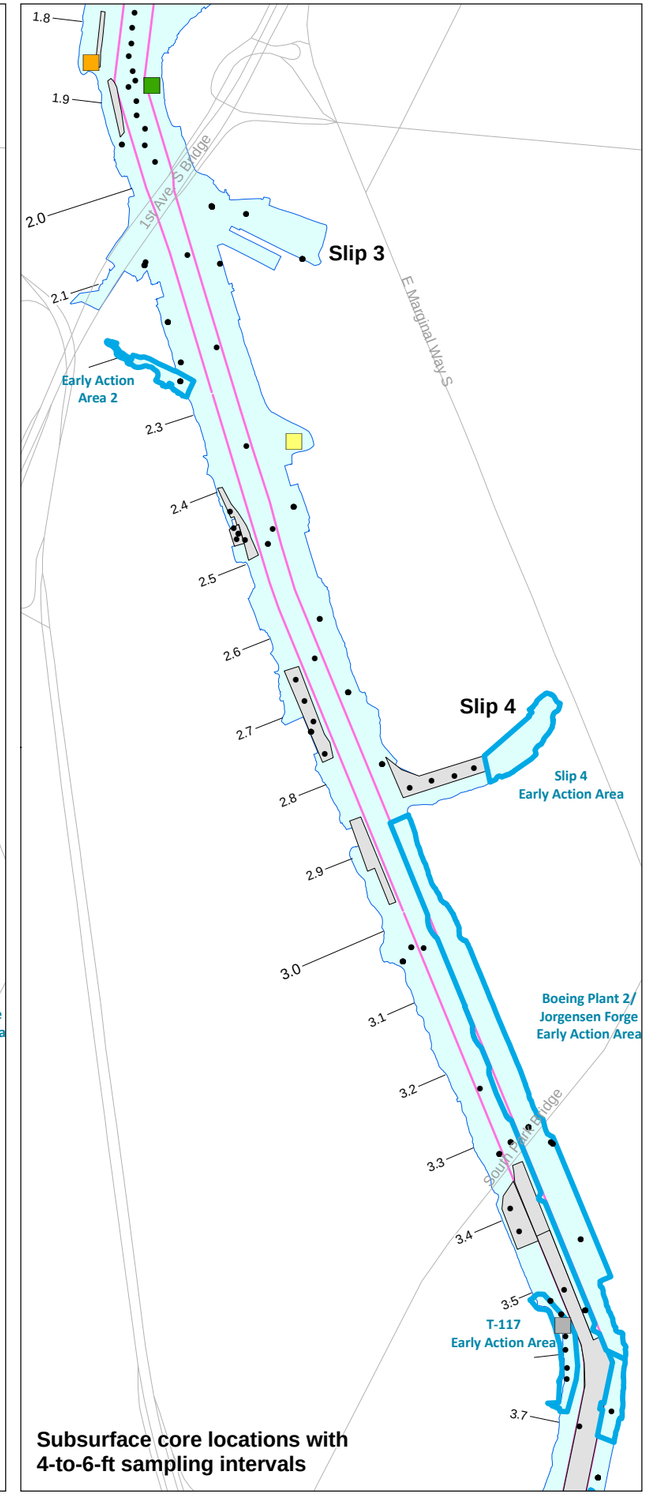
Dredging information provided by AECOM.



Subsurface core locations with 0-to-2-ft sampling intervals



Subsurface core locations with 2-to-4-ft sampling intervals



Subsurface core locations with 4-to-6-ft sampling intervals

BEHP concentration (µg/kg dw)[a]

- > 2,400 — 95th percentile = 2,400
- > 490 and ≤ 2,400 — 75th percentile = 490
- > 230 and ≤ 490 — 50th percentile = 230
- > 95 and ≤ 230 — 25th percentile = 95
- ≤ 95
- Non-detect

Sampling interval

	Left panel	Middle panel	Right panel
	0-to-2-ft[b]	2-to-4-ft[b]	4-to-6-ft[b]
	0-to-1-ft[c]	2-to-3-ft[c]	4-to-5-ft[c]
	1-to-2-ft[c]	3-to-4-ft[c]	5-to-6-ft[c]

Not analyzed in that sampling interval

Other subsurface sampling locations analyzed for BEHP but not in the illustrated sampling intervals

Early Action Area[d]

Dredged area[e]

Navigation channel

River mile

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, a value of one-half the RL at that location was used.

[b] Data from 2-foot sampling intervals; some locations show an average of data from both 1-foot intervals within that 2-foot interval at a given location.

[c] Data from 1-foot sampling intervals are shown if available. If both 1-foot intervals within the 2-foot interval were collected, the average of the two intervals is also shown.

[d] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[e] Subsurface sediment data at locations in dredged areas were collected prior to dredging.

N

0 0.1 0.2 Kilometers

0 0.1 0.2 Miles

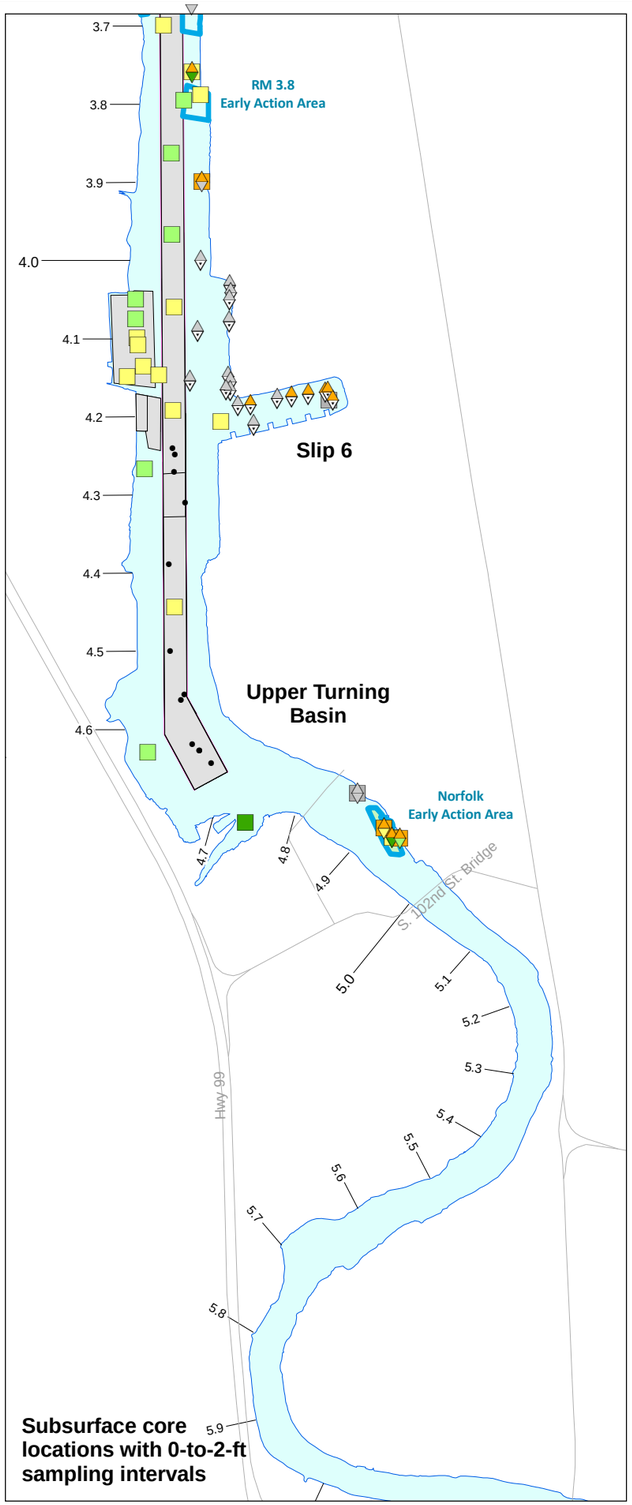
Scale is the same for each map frame

Map 4-46b. BEHP concentrations in subsurface sediment within the 0-to-2-ft, 2-to-4-ft, and 4-to-6-ft sampling intervals, RM 1.8 to RM 3.7

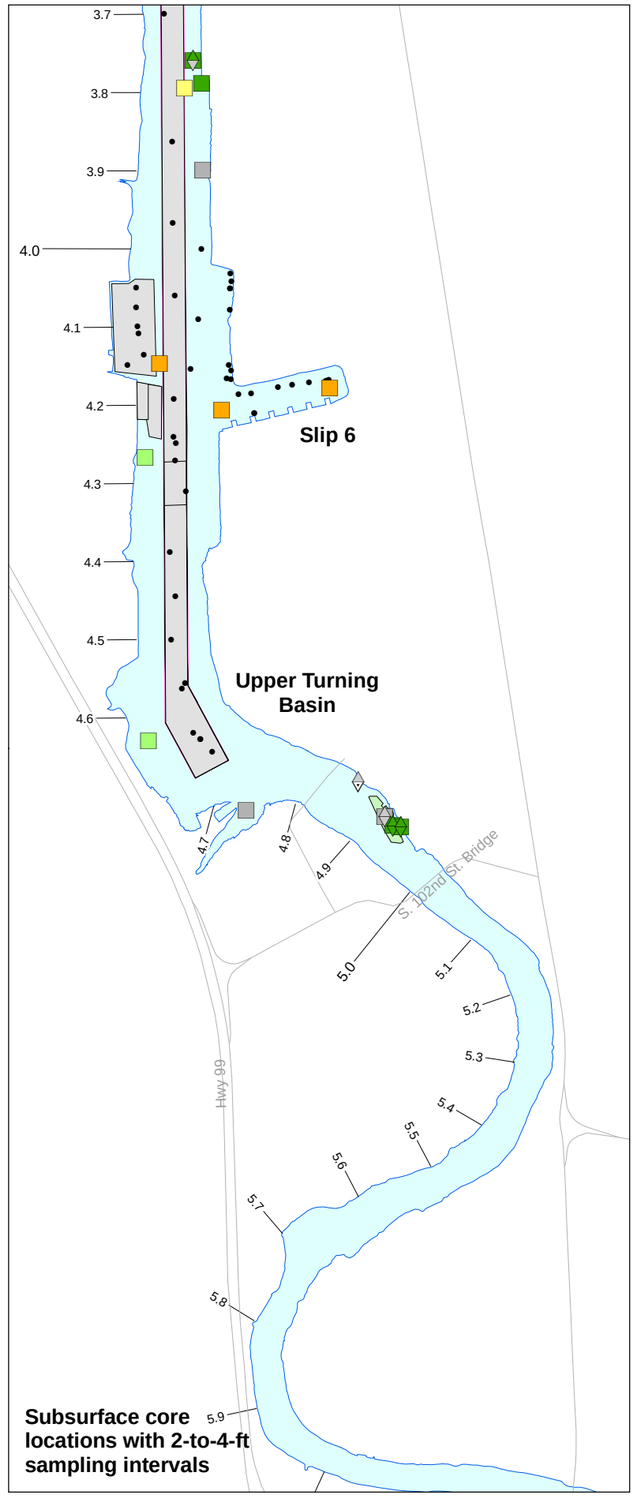
Windward environmental LLC

Prepared by: CEH, 07/15/2010, MAP 2811, W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Depth Intervals\PCBs

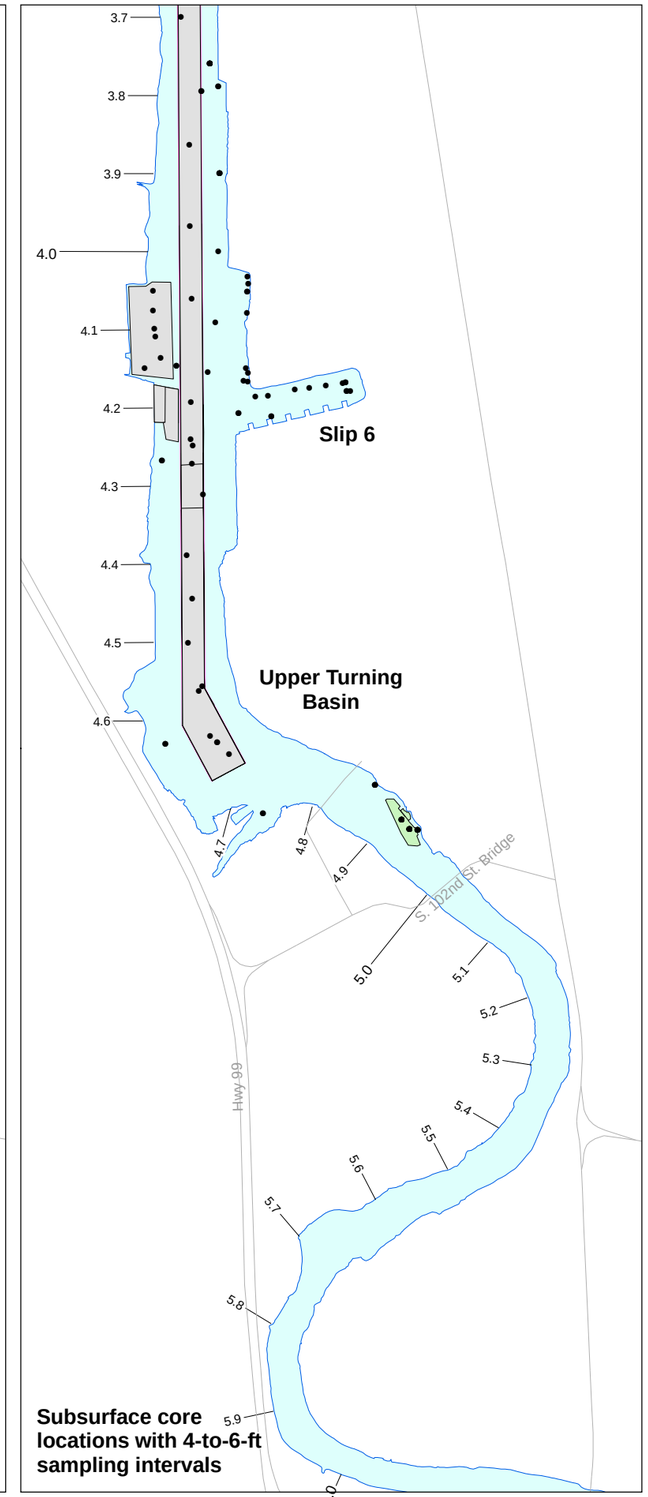
Dredging information provided by AECOM.



Subsurface core locations with 0-to-2-ft sampling intervals



Subsurface core locations with 2-to-4-ft sampling intervals



Subsurface core locations with 4-to-6-ft sampling intervals

BEHP concentration (µg/kg dw)[a]

- > 2,400 — 95th percentile = 2,400
- > 490 and ≤ 2,400 — 75th percentile = 490
- > 230 and ≤ 490 — 50th percentile = 230
- > 95 and ≤ 230 — 25th percentile = 95
- ≤ 95
- Non-detect

Sampling interval

Left panel	Middle panel	Right panel
0-to-2-ft[b]	2-to-4-ft[b]	4-to-6-ft[b]
0-to-1-ft[c]	2-to-3-ft[c]	4-to-5-ft[c]
1-to-2-ft[c]	3-to-4-ft[c]	5-to-6-ft[c]

Not analyzed in that sampling interval

Other subsurface sampling locations analyzed for BEHP but not in the illustrated sampling intervals

- Early Action Area[d]
- Dredged area[e]
- Dredged and capped area[e]
- Navigation channel
- River mile

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, a value of one-half the RL at that location was used.

[b] Data from 2-foot sampling intervals; some locations show an average of data from both 1-foot intervals within that 2-foot interval at a given location.

[c] Data from 1-foot sampling intervals are shown if available. If both 1-foot intervals within the 2-foot interval were collected, the average of the two intervals is also shown.

[d] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[e] Subsurface sediment data at locations in dredged areas were collected prior to dredging.

N

0 0.1 0.2 Kilometers

0 0.1 0.2 Miles

Scale is the same for each map frame

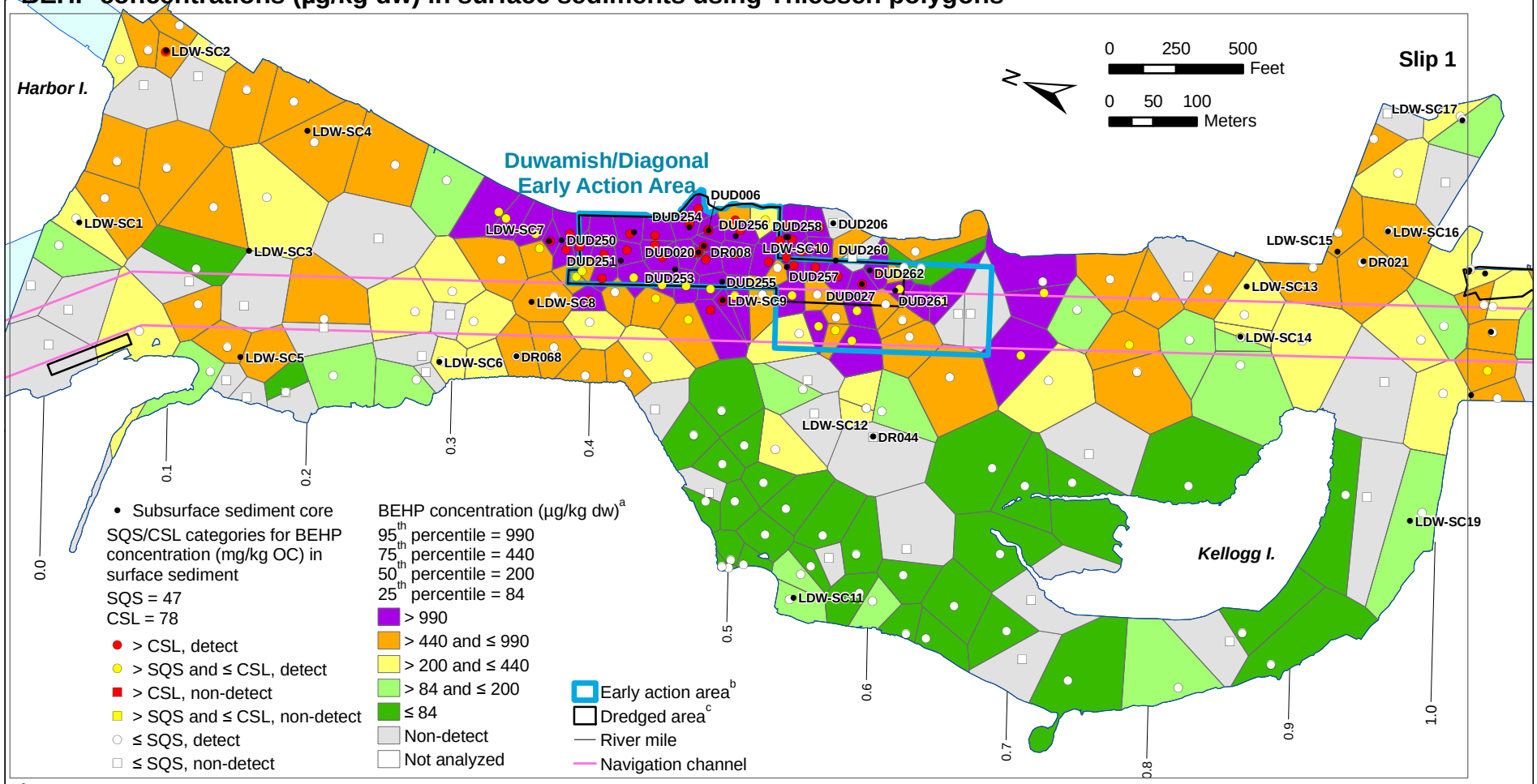
Map 4-46c. BEHP concentrations in subsurface sediment within the 0-to-2-ft, 2-to-4-ft, and 4-to-6-ft sampling intervals, RM 3.7 to RM 6.0

Wind Ward environmental LLC

Prepared by CEH, 07/15/2010. MAP 2811. W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Depth Interval

Dredging information provided by AECOM.

BEHP concentrations (µg/kg dw) in surface sediments using Thiessen polygons



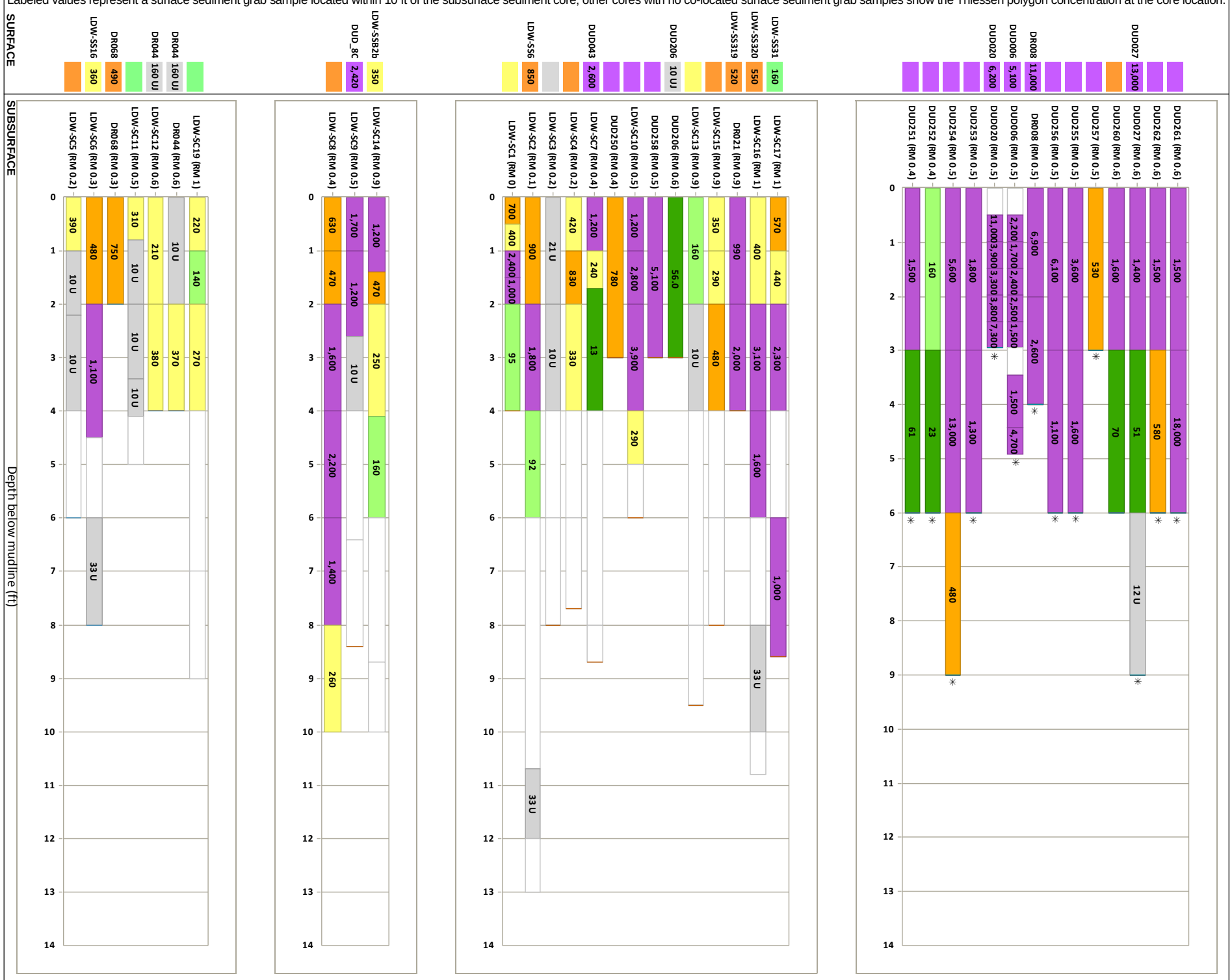
[a] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has Thiessen polygon values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has Thiessen polygon concentrations ≤ 990 µg/kg dw). Thiessen polygon concentrations were calculated including locations with non-detected values. For locations with non-detects, a value of one-half the RL at that location was used.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, and thin-layer placement in 2003 to 2005. Subsurface sediment data in dredged areas were collected prior to dredging.

BEHP concentrations (µg/kg dw) in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment grab sample located within 10 ft of the subsurface sediment core; other cores with no co-located surface sediment grab samples show the Thiessen polygon concentration at the core location.



✳ This core was collected prior to dredging at that location.

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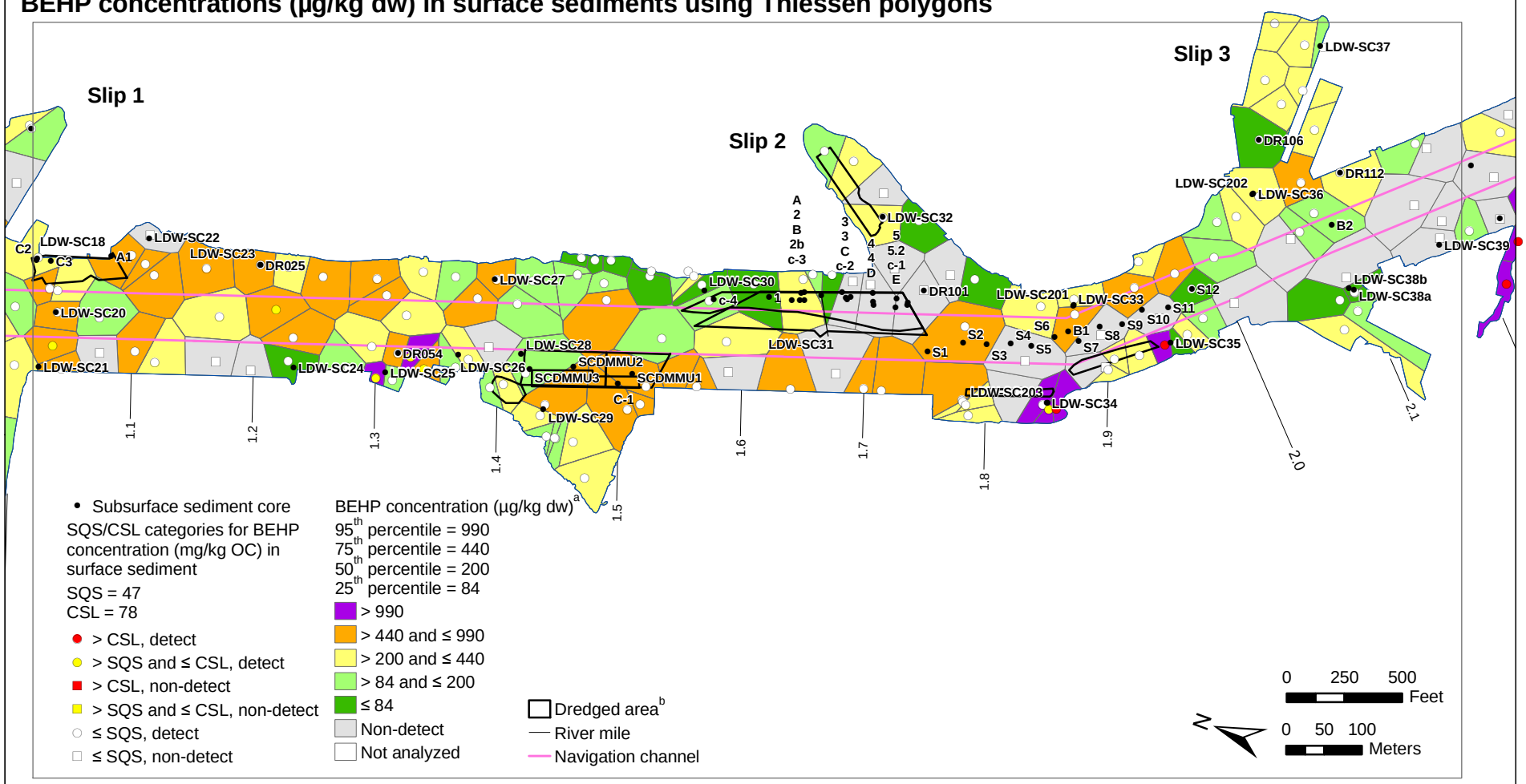
Map 4-47a. BEHP concentrations in surface sediment and subsurface sediment cores, RM 0.0 to RM 1.0

Prepared by CEH, 07/15/2010, MAP 3303, W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.

BEHP concentrations (µg/kg dw) in surface sediments using Thiessen polygons

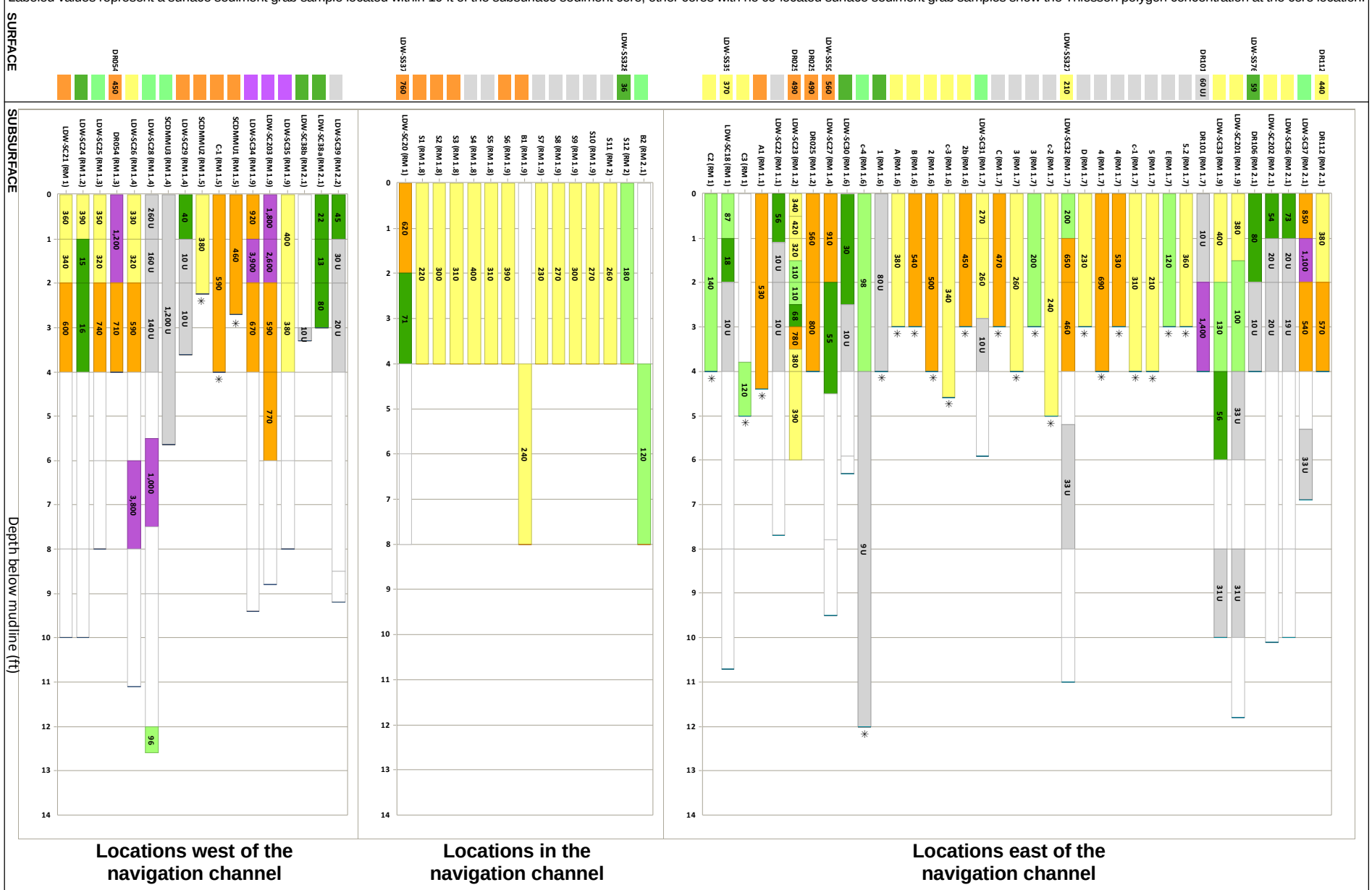


[a] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has Thiessen polygon values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has Thiessen polygon concentrations ≤ 990 µg/kg dw). Thiessen polygon concentrations were calculated including locations with non-detected values. For locations with non-detects, a value of one-half the RL at that location was used.

[b] Subsurface sediment data at locations in dredged areas were collected prior to dredging; surface sediment data were collected after dredging.

BEHP concentrations (µg/kg dw) in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment grab sample located within 10 ft of the subsurface sediment core; other cores with no co-located surface sediment grab samples show the Thiessen polygon concentration at the core location.



✳ This core was collected prior to dredging at that location.

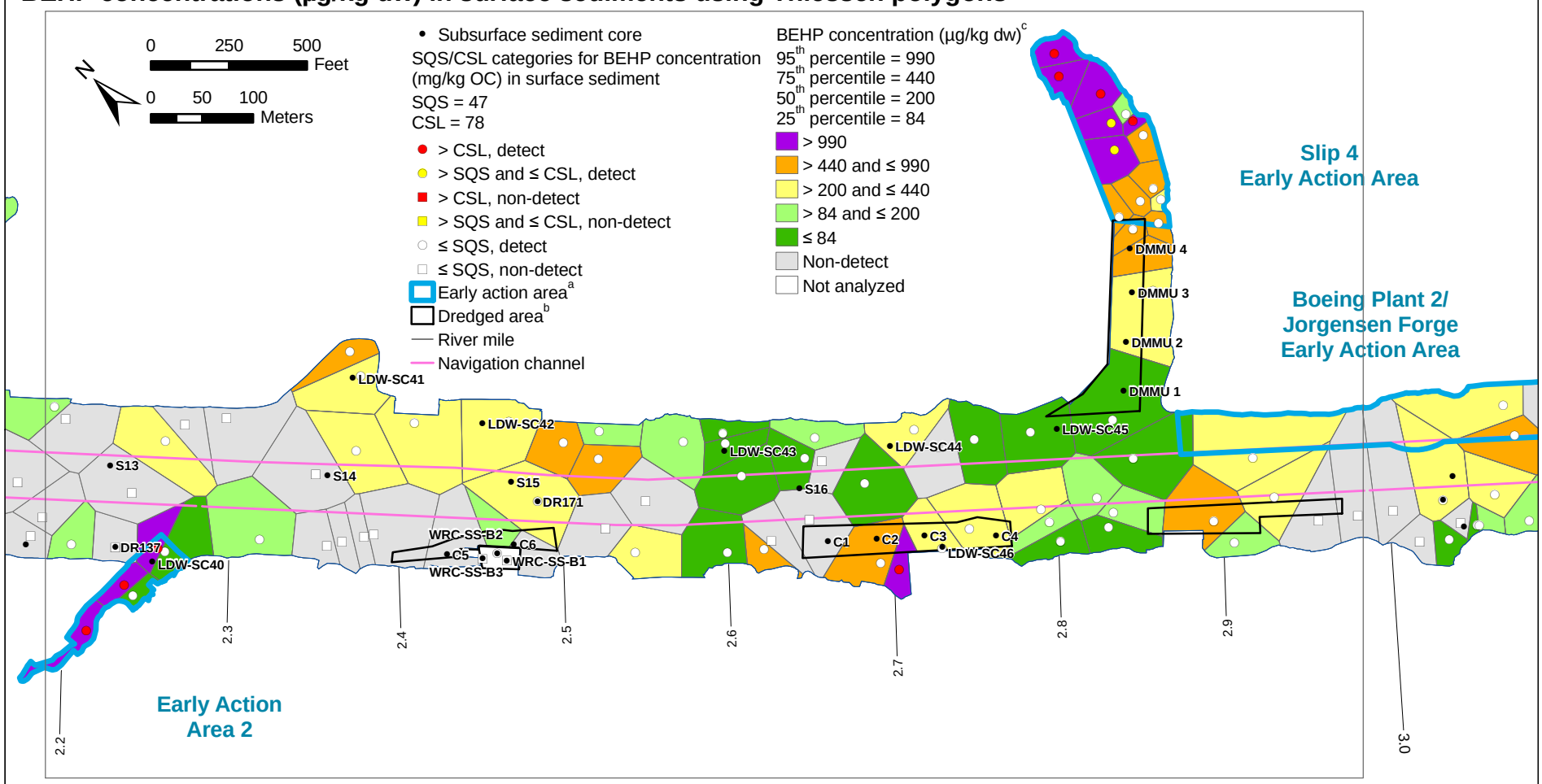
Map 4-47b. BEHP concentrations in surface sediment and subsurface sediment cores, RM 1.0 to RM 2.2

Wind Ward environmental LLC

Prepared by CEH, 07/15/2010; MAP 3303; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.

BEHP concentrations (µg/kg dw) in surface sediments using Thiessen polygons



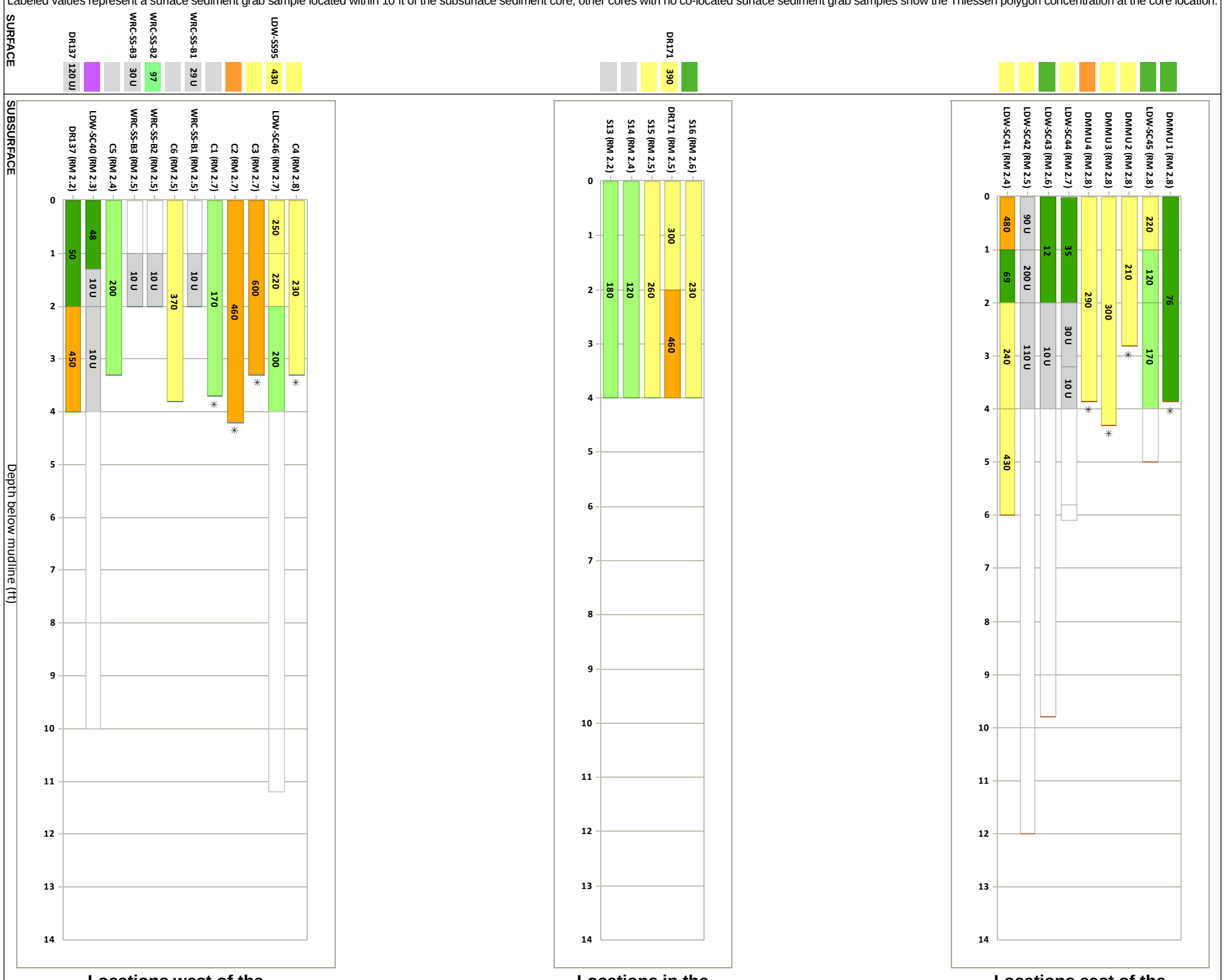
[a] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[b] Subsurface sediment data at locations in dredged areas were collected prior to dredging; surface sediment data were collected after dredging.

[c] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has Thiessen polygon values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has Thiessen polygon concentrations ≤ 990 µg/kg dw). Thiessen polygon concentrations were calculated including locations with non-detected values. For locations with non-detects, a value of one-half the RL at that location was used.

BEHP concentrations (µg/kg dw) in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment grab sample located within 10 ft of the subsurface sediment core; other cores with no co-located surface sediment grab samples show the Thiessen polygon concentration at the core location.



✳ This core was collected prior to dredging at that location.

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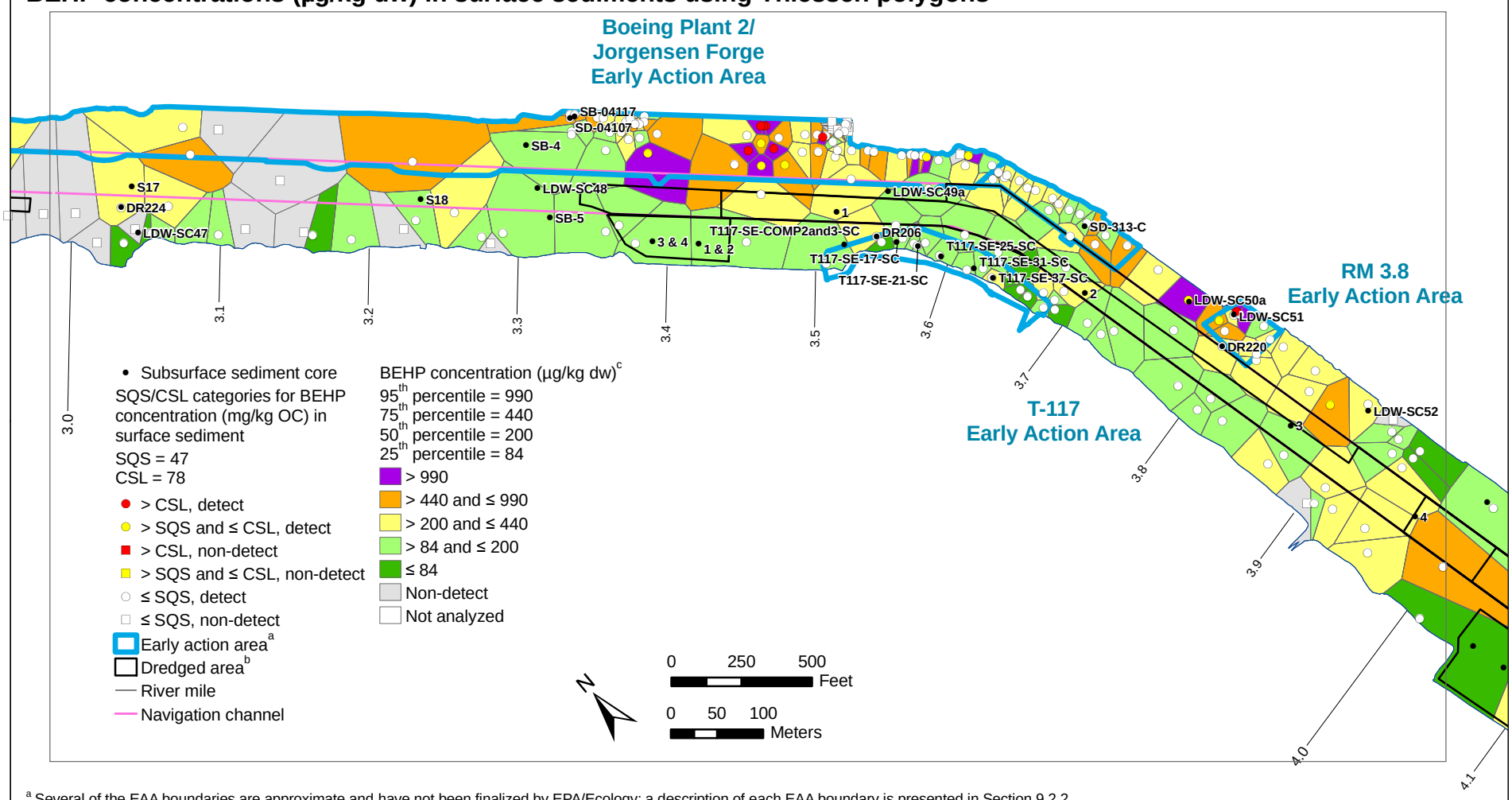
Map 4-47c. BEHP concentrations in surface sediment and subsurface sediment cores, RM 2.2 to RM 3.0

Prepared by CEH, 07/15/2010; MAP 3303; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.

BEHP concentrations (µg/kg dw) in surface sediments using Thiessen polygons



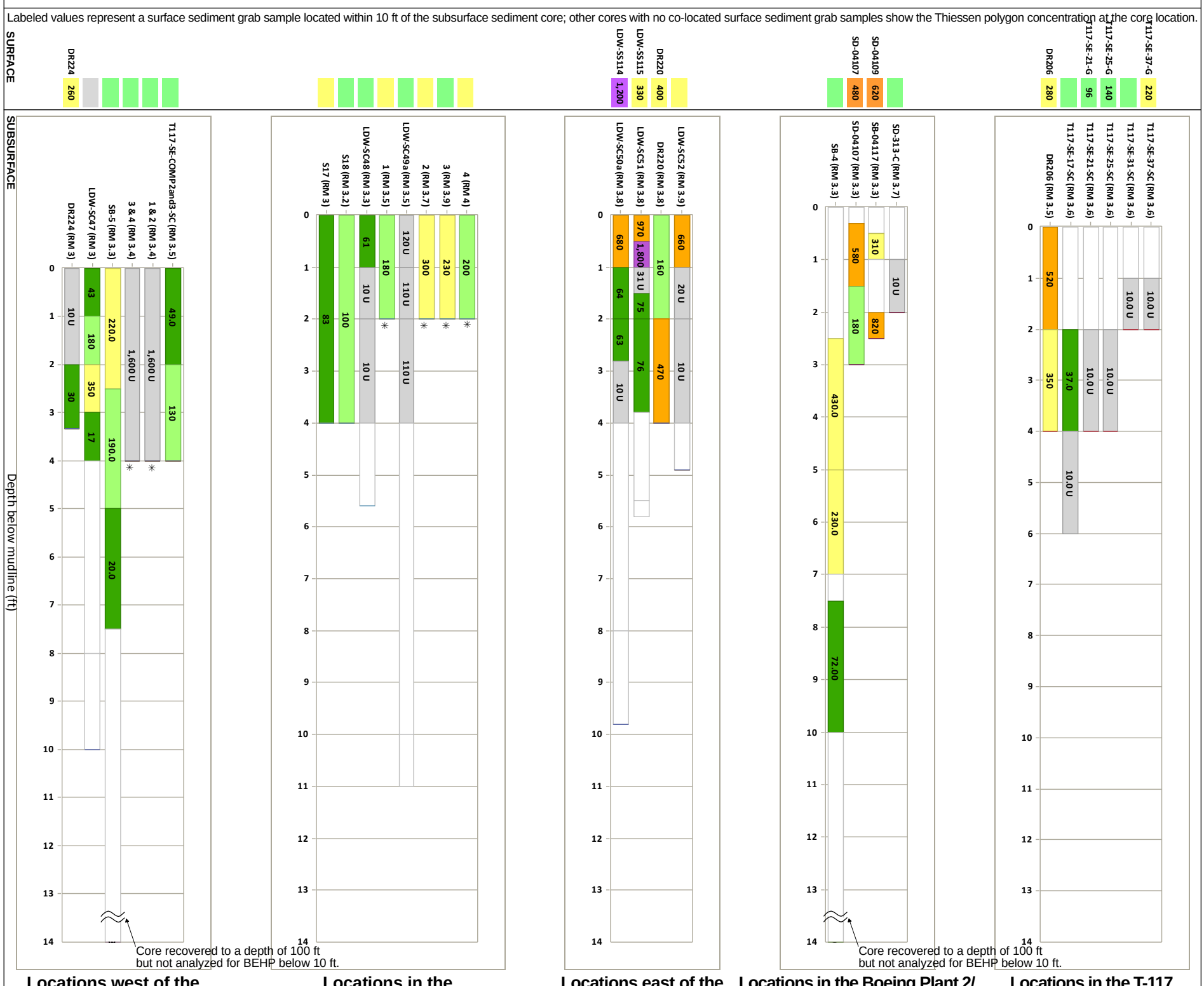
[a] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[b] Subsurface sediment data at locations in dredged areas were collected prior to dredging; surface sediment data were collected after dredging.

[c] Interpolated concentrations are based on data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has Thiessen polygon values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has Thiessen polygon concentrations ≤ 990 µg/kg dw). Thiessen polygon concentrations were calculated including locations with non-detected values. For locations with non-detects, a value of one-half the RL at that location was used.

BEHP concentrations (µg/kg dw) in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment grab sample located within 10 ft of the subsurface sediment core; other cores with no co-located surface sediment grab samples show the Thiessen polygon concentration at the core location.



✳ This core was collected prior to dredging at that location.

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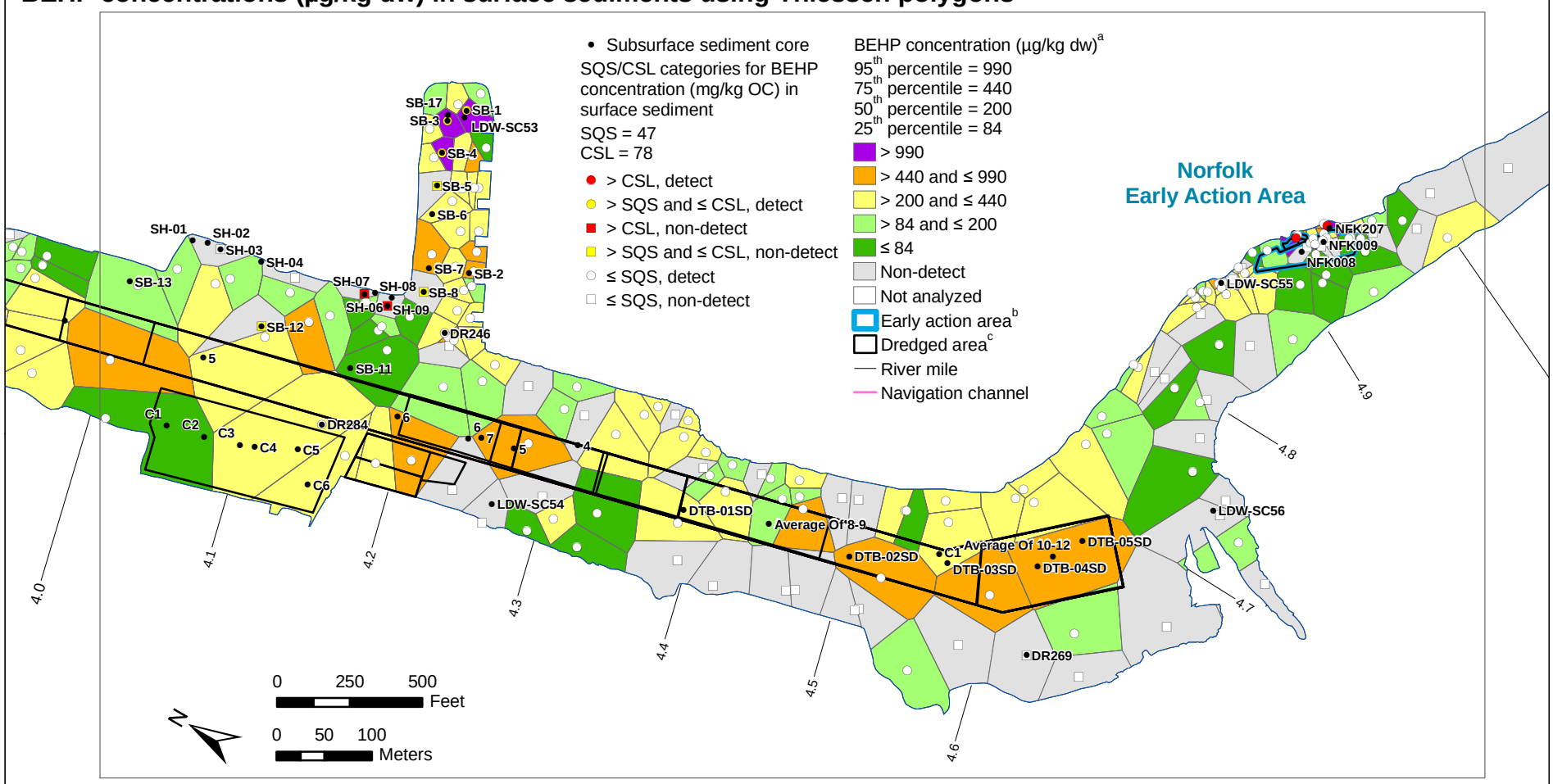
Map 4-47d. BEHP concentrations in surface sediment and subsurface sediment cores, RM 3.0 to RM 4.0

Prepared by CEH, 07/15/2010; MAP 3303; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.

BEHP concentrations (µg/kg dw) in surface sediments using Thiessen polygons



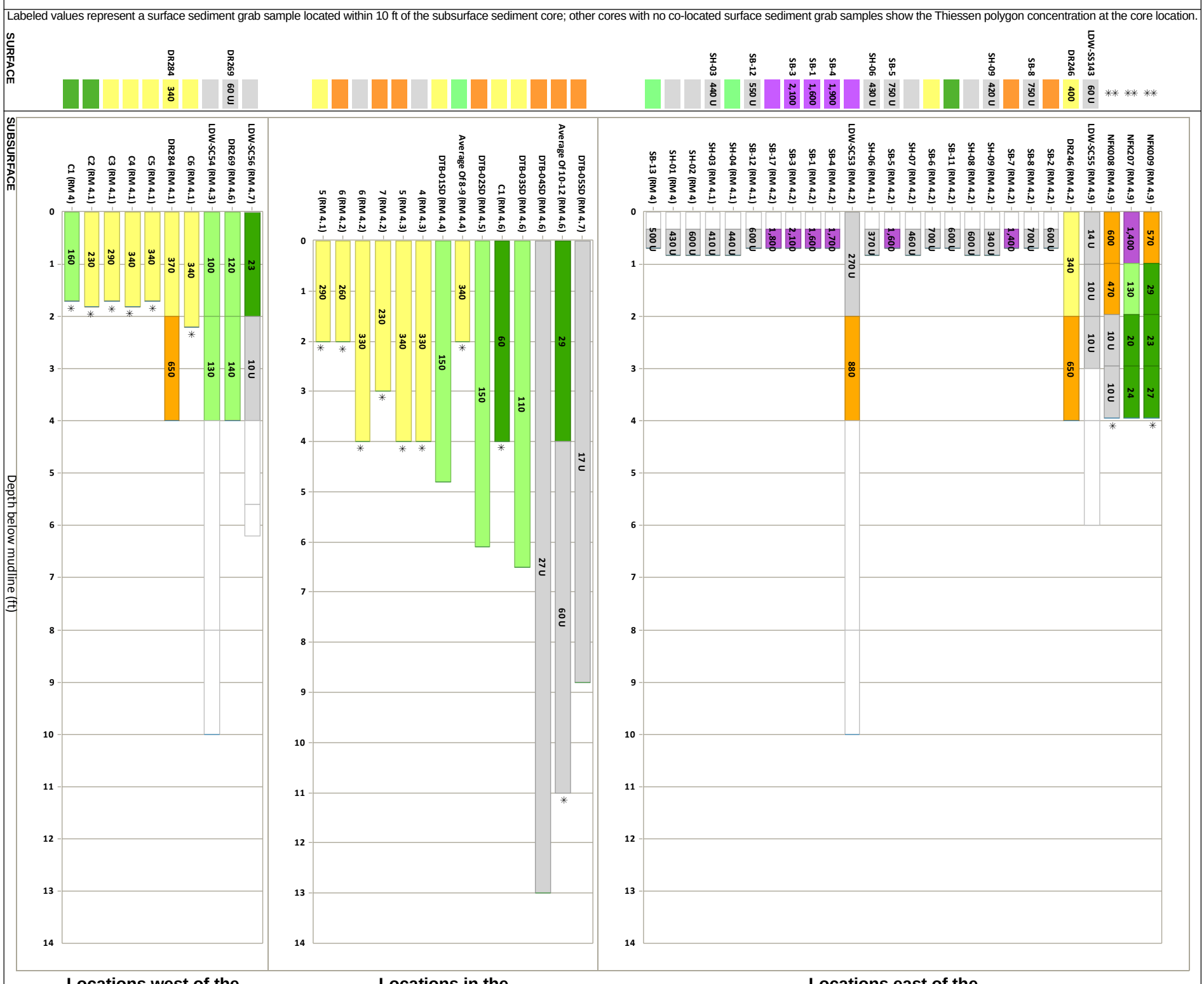
[a] Interpolated concentrations are based on data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has Thiessen polygon values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has Thiessen polygon concentrations ≤ 990 µg/kg dw). Thiessen polygon concentrations were calculated including locations with non-detected values. For locations with non-detects, a value of one-half the RL at that location was used.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Norfolk Early Action Area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO/SD removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003. Subsurface sediment data at locations in dredged areas were collected prior to dredging.

BEHP concentrations (µg/kg dw) in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment grab sample located within 10 ft of the subsurface sediment core; other cores with no co-located surface sediment grab samples show the Thiessen polygon concentration at the core location.



✳ This core was collected prior to dredging at that location.

✳✳ At the Norfolk EAA, surface sediment data, which were collected after the removal action at the Norfolk CSO area in 1999 but before the removal action at the BDC south storm drain outfall area in 2003, do not reflect conditions at the time subsurface cores were collected in 1995.

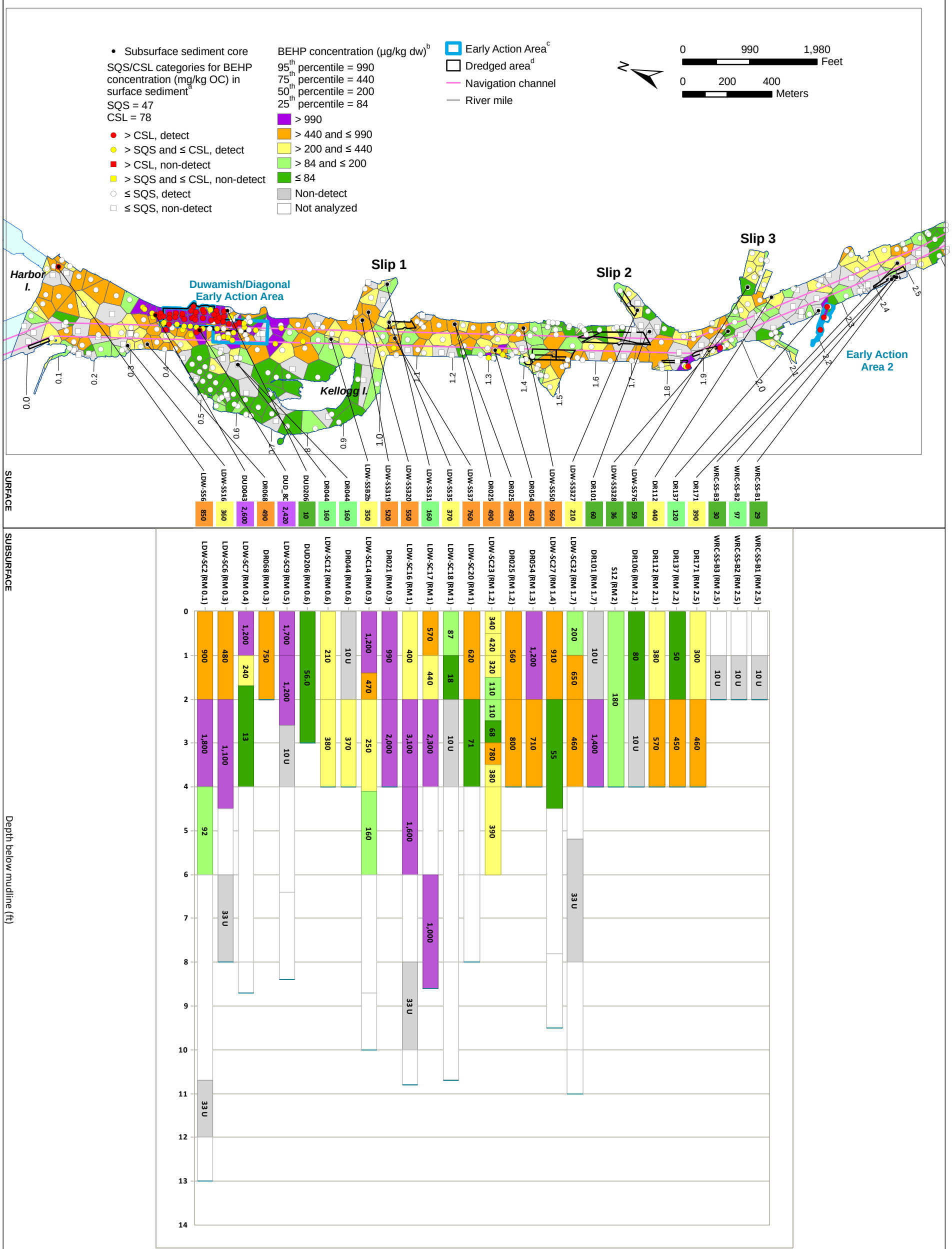
Map 4-47e. BEHP concentrations in surface sediment and subsurface sediment cores, RM 4.0 to RM 5.0

Wind Ward environmental LLC

Prepared by CEH, 07/15/2010; MAP 3303; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.

BEHP concentrations (µg/kg dw) in surface sediments, subsurface core data, and co-located (within 10 ft) surface sediment data



[a] When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations were compared instead to the LAET and 2LAET.

[b] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has Thiessen polygon values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has Thiessen polygon concentrations ≤ 990 µg/kg dw). Thiessen polygon concentrations were calculated including locations with non-detected values. For locations with non-detects, a value of one-half the RL at that location was used.

[c] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[d] For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, and thin-layer placement in 2003 to 2005. Subsurface sediment data in dredged areas were collected prior to dredging.

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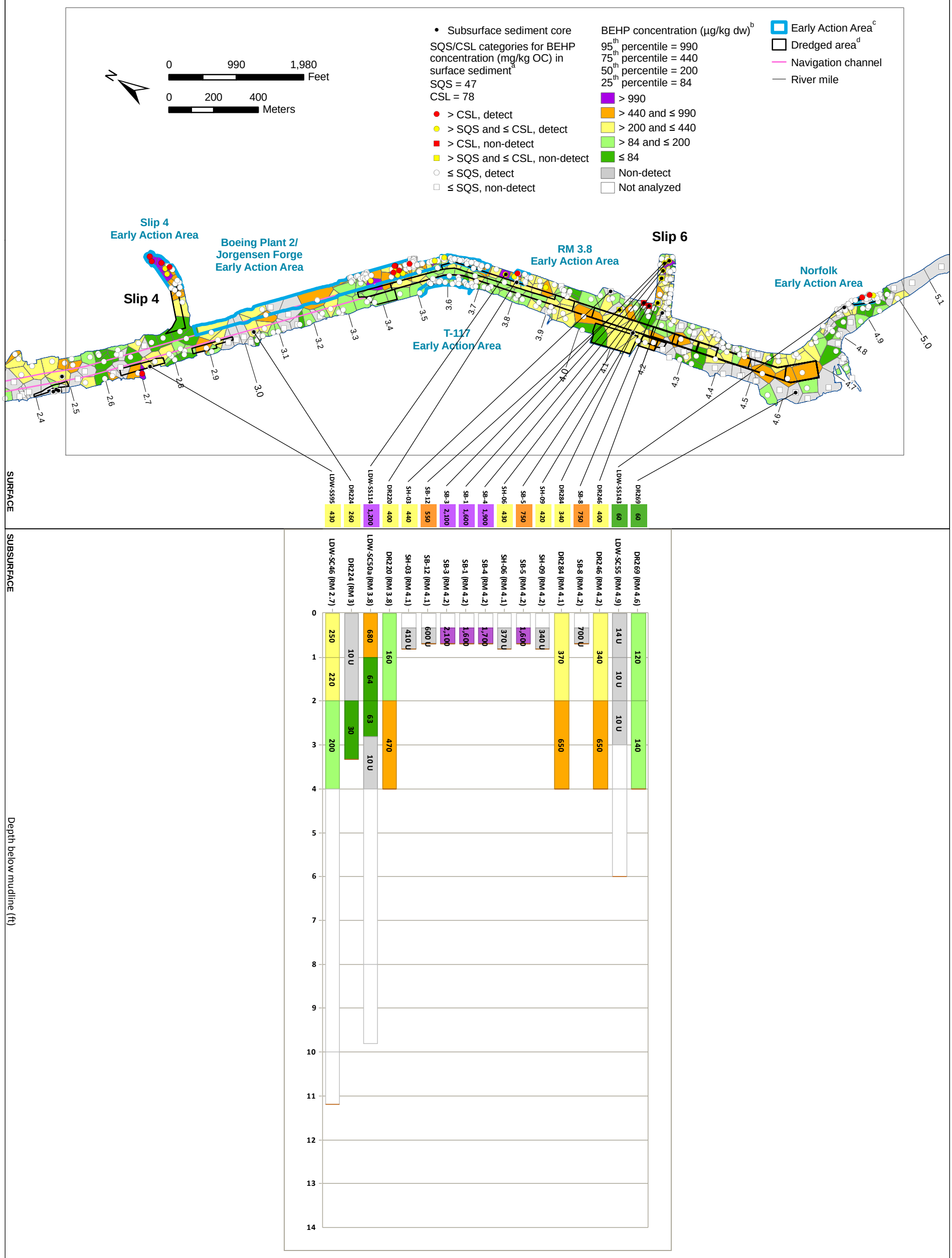
Map 4-48a. Comparison of BEHP concentrations in subsurface cores to co-located surface sediment locations, RM 0.0 to RM 2.5

Prepared by CEH, 07/15/2010; MAP 3797; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Nature and Extent\Subsurface\Colocation

Dredging information provided by AECOM.

BEHP concentrations (µg/kg dw) in surface sediments, subsurface core data, and co-located (within 10 ft) surface sediment data



[a] When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations were compared instead to the LAET and 2LAET.

[b] Interpolated concentrations are based on the data from the baseline surface sediment dataset. Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has Thiessen polygon values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has Thiessen polygon concentrations ≤ 990 µg/kg dw). Thiessen polygon concentrations were calculated including locations with non-detected values. For locations with non-detects, a value of one-half the RL at that location was used.

[c] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[d] For the Norfolk Early Action Area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003. Subsurface sediment data in dredged areas were collected prior to dredging.

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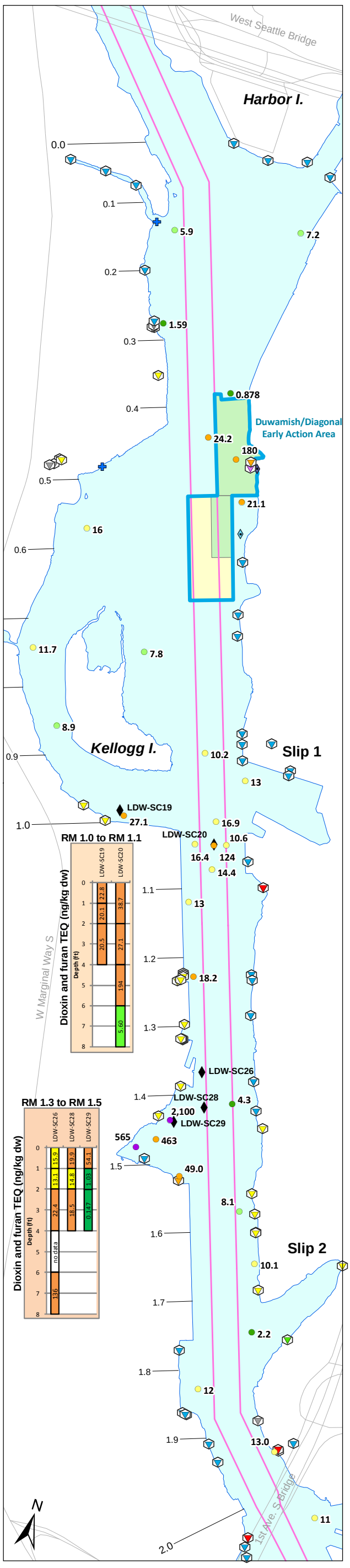
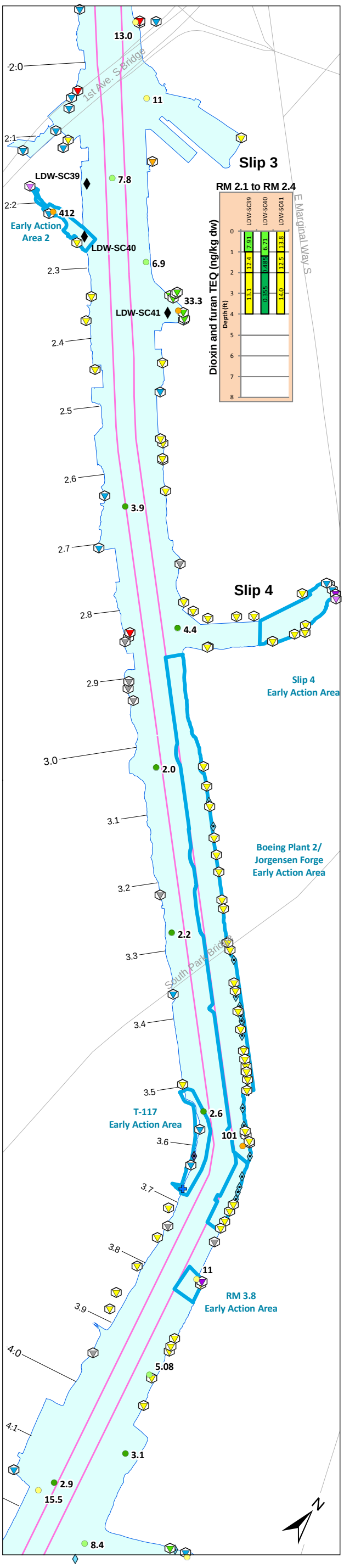
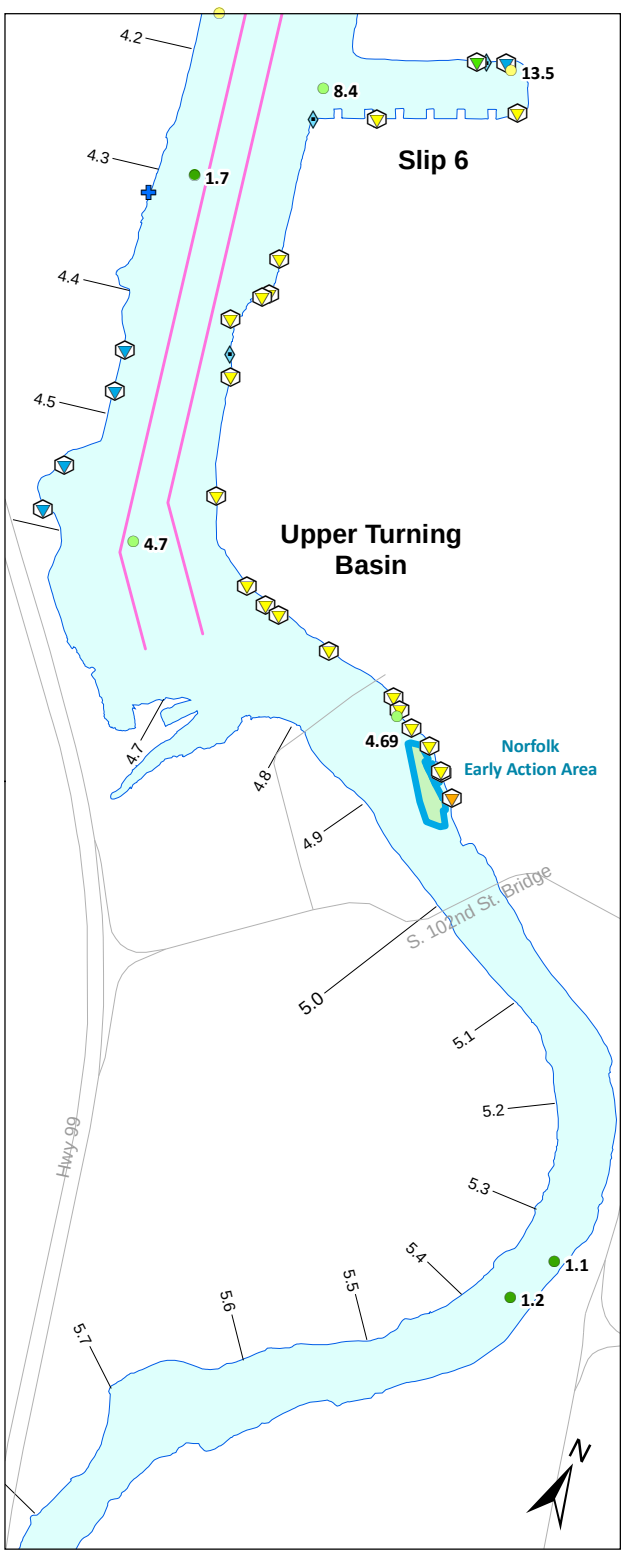
Map 4-48b. Comparison of BEHP concentrations in subsurface cores to co-located surface sediment locations, RM 2.5 to RM 5.0

Prepared by CEH, 07/15/2010; MAP 3797; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Nature and Extent\Subsurface\Colocation
Dredging information provided by AECOM.







Dioxin and furan TEQ (ng/kg dw)[a]

- > 490
- > 17 and ≤ 490
- > 10 and ≤ 17
- > 4.4 and ≤ 10
- ≤ 4.4
- Dioxin and furan TEQ subsurface core location
- Early Action Area[b]
- Dredged and capped area[c]
- Thin-layer placement[c]
- Road
- Navigation channel
- River mile

95th percentile = 490
75th percentile = 17
50th percentile = 10
25th percentile = 4.4

Outfall classification[d]

- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale

[a] TEQs were calculated with mammalian TEFs for individual dioxin and furan congeners (Van den Berg et al. 2006), using one-half the reporting limit for undetected congeners. Percentiles were calculated on a numerical basis using all values from the baseline surface sediment, dataset. Seven samples shown on this map were not included in the RI baseline dataset for reasons discussed in Section 4.2.7.1. The samples were collected at RM 0.4 (0.878 and 24.2 ng/kg dw), RM 0.5 (21.1 ng/kg dw), RM 0.9 (13 ng/kg dw), RM 1.4 (4.3 ng/kg dw), RM 3.8 (11 ng/kg dw) and RM 4.1 (3.1 ng/kg dw).

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Duwamish/Diagonal early action area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005. For the Norfolk early action area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

[d] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

0 0.1 0.2 Miles

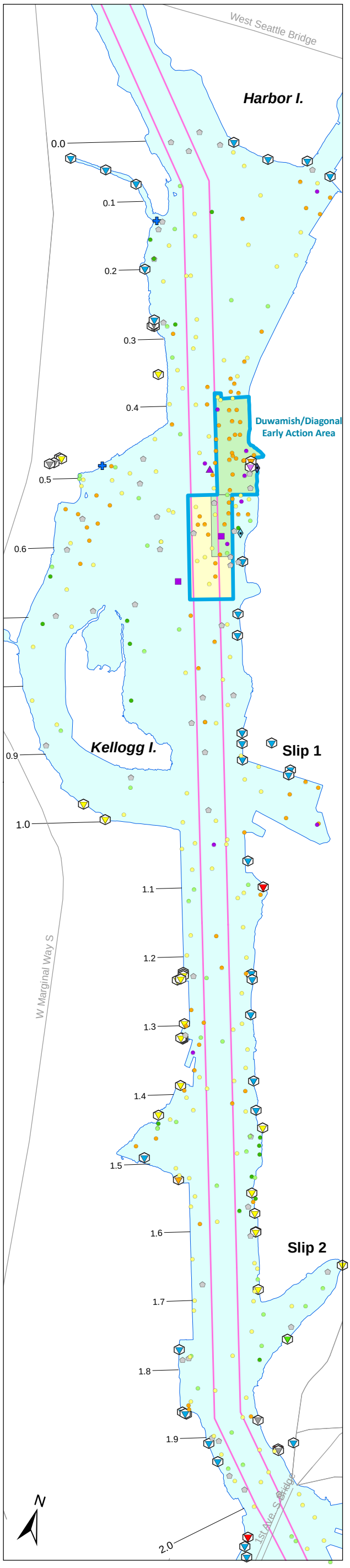
0 0.1 0.2 Kilometers

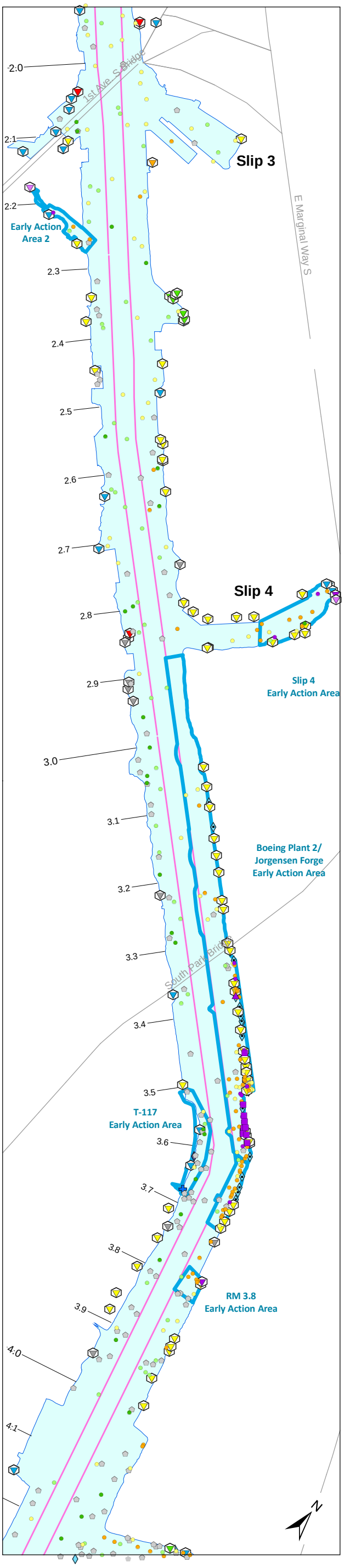
Scale is the same for each inset map

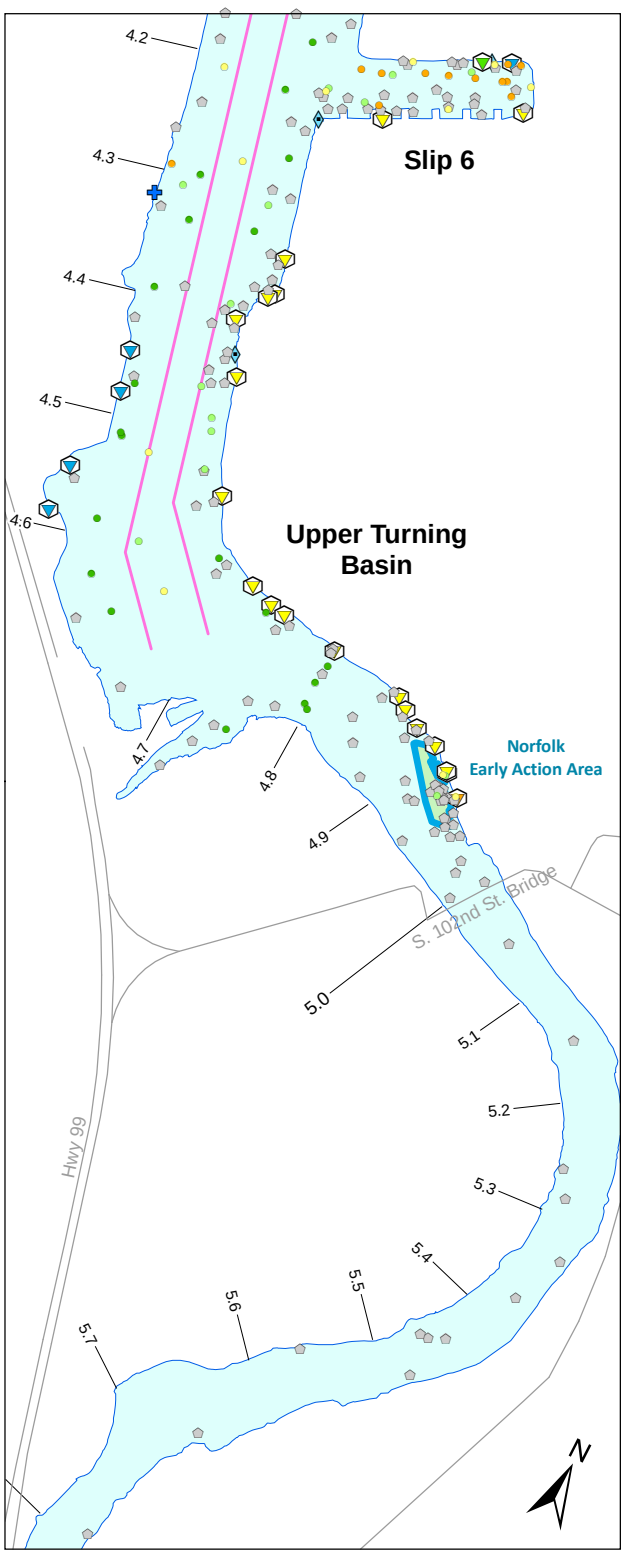
Wind Ward environmental LLC

Map 4-49. Dioxin and furan TEQs in surface sediment and subsurface sediment cores

Prepared by CEH, 07/15/2010; MAP 2663; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\Other COCs







Cadmium concentration (mg/kg dw)[a]

- > 1.8
- > 0.66 and ≤ 1.8
- > 0.39 and ≤ 0.66
- > 0.20 and ≤ 0.39
- ≤ 0.20
- Non-detect
- > CSL
- > SQS and ≤ CSL
- ≤ SQS
- Early Action Area[b]
- Dredged and capped area[c]
- Thin-layer placement[c]
- Road
- Navigation channel
- River mile

95th percentile = 1.8
75th percentile = 0.66
50th percentile = 0.39
25th percentile = 0.20
CSL = 6.7
SQS = 5.1

Outfall classification[d]

- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, a value of one-half the RL at that location was used.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Duwamish/Diagonal early action area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005. For the Norfolk early action area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

[d] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

Wind Ward environmental LLC

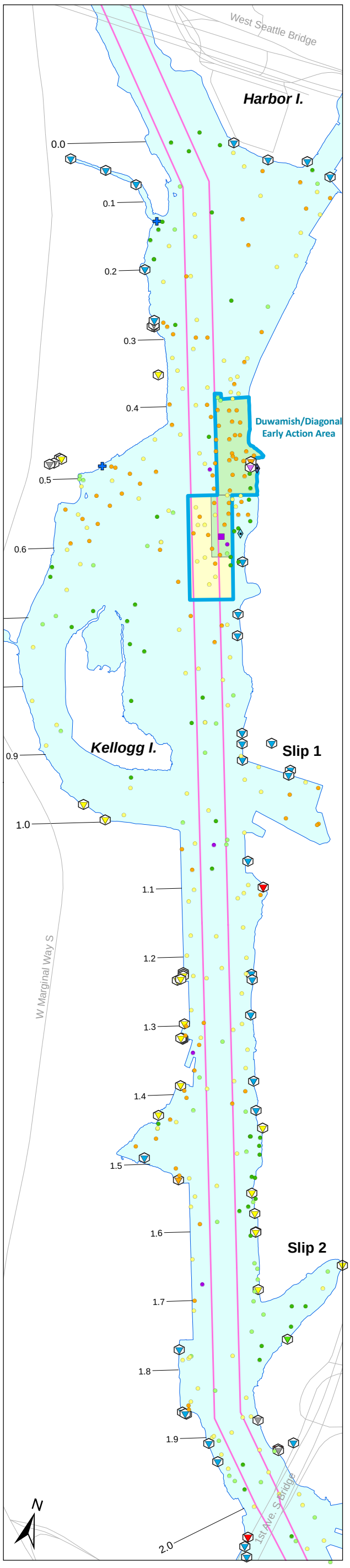
0 0.1 0.2 Miles

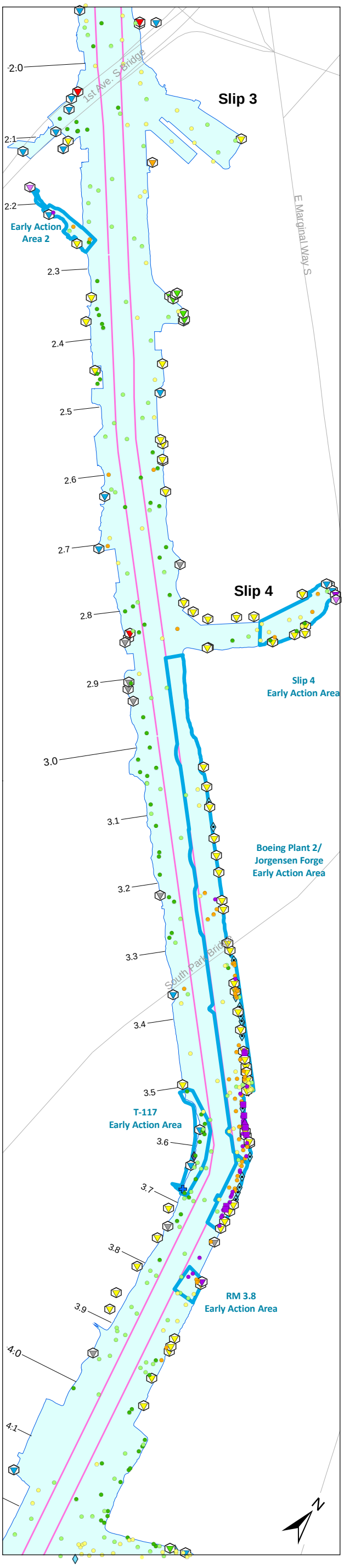
0 0.1 0.2 Kilometers

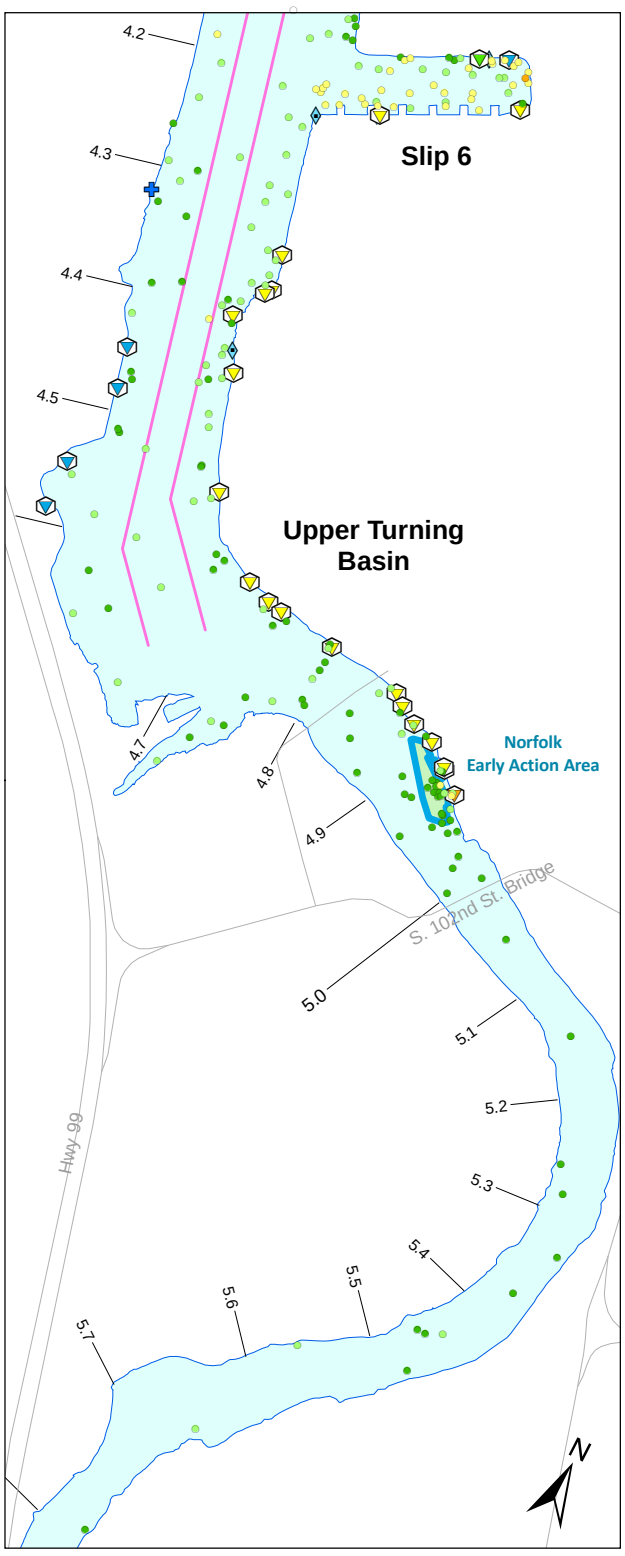
Scale is the same for each inset map

Map 4-50. Cadmium concentrations in surface sediment

Prepared by CEH, 07/15/2010; MAP 2773; W:\Projects\00-08-08_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\Other COCs







Chromium concentration (mg/kg dw)[a]

- > 70
- > 38 and ≤ 70
- > 29 and ≤ 38
- > 22 and ≤ 29
- ≤ 22
- Non-detect
- > CSL
- > SQS and ≤ CSL
- ≤ SQS
- Early Action Area[b]
- Dredged and capped area[c]
- Thin-layer placement[c]
- Road
- Navigation channel
- River mile

95th percentile = 70
75th percentile = 38
50th percentile = 29
25th percentile = 22
CSL = 270
SQS = 260

Outfall classification[d]

- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, a value of one-half the RL at that location was used.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Duwamish/Diagonal early action area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005. For the Norfolk early action area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

[d] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

Wind Ward environmental LLC

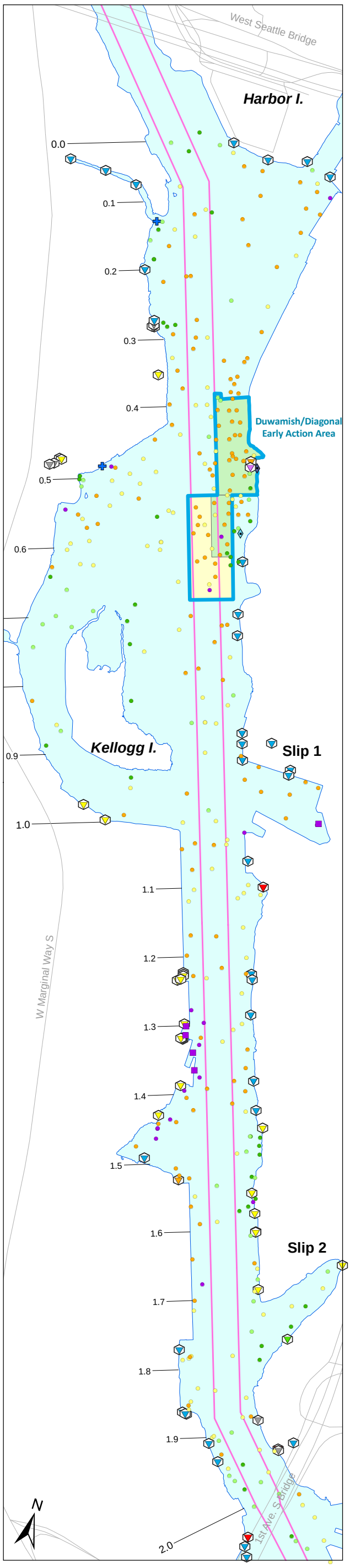
0 0.1 0.2 Miles

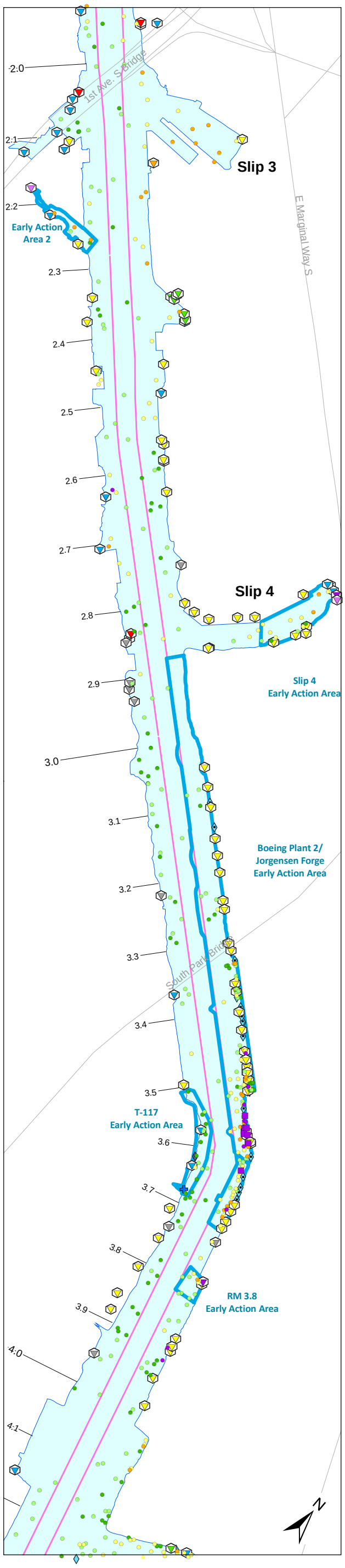
0 0.1 0.2 Kilometers

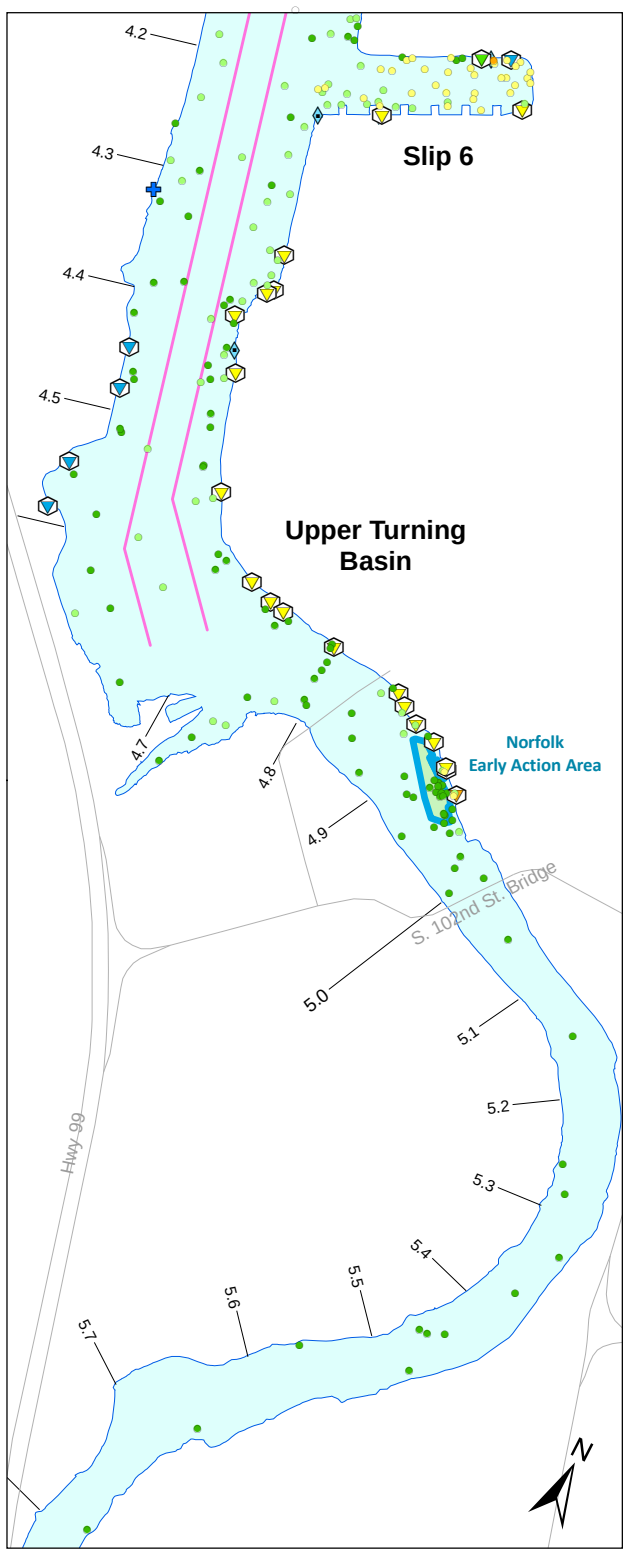
Scale is the same for each inset map

Map 4-51. Chromium concentrations in surface sediment

Prepared by CEH, 07/15/2010, MAP 2774, W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\Other COCs







Copper concentration (mg/kg dw)[a]

- > 150
- > 81 and ≤ 150
- > 52 and ≤ 80
- > 34 and ≤ 52
- ≤ 34
- Non-detect
- > CSL
- > SQS and ≤ CSL
- ≤ SQS
- Early Action Area[b]
- Dredged and capped area[c]
- Thin-layer placement[c]
- Road
- Navigation channel
- River mile

95th percentile =150
75th percentile = 81
50th percentile = 52
25th percentile = 34
CSL = SQS = 390

Outfall classification[d]

- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, a value of one-half the RL at that location was used.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Duwamish/Diagonal early action area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005. For the Norfolk early action area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

[d] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

Wind Ward environmental LLC

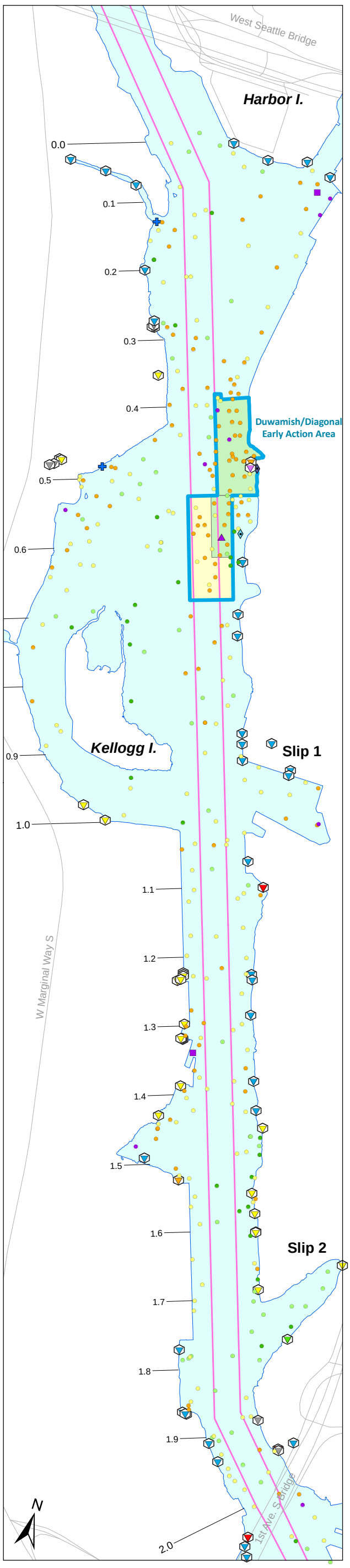
0 0.1 0.2 Miles

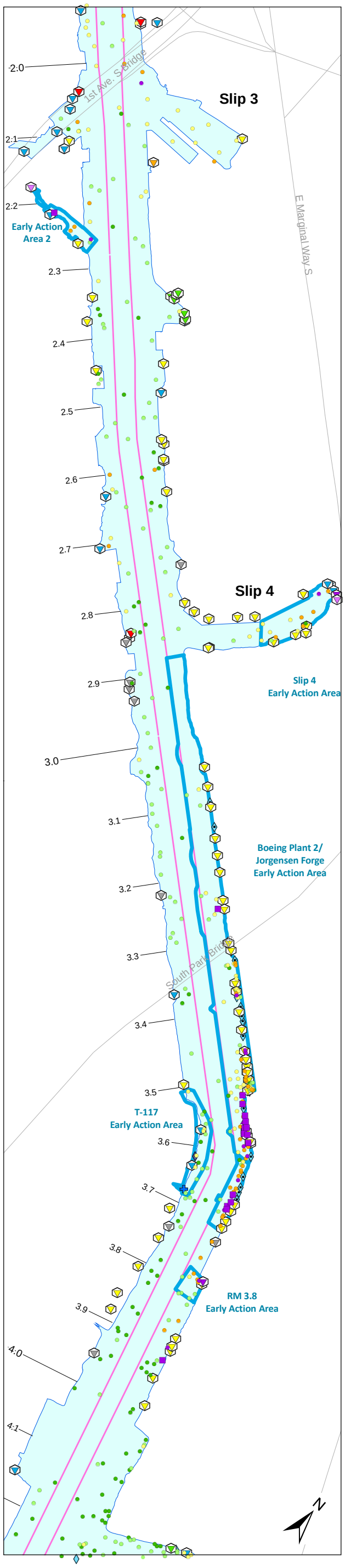
0 0.1 0.2 Kilometers

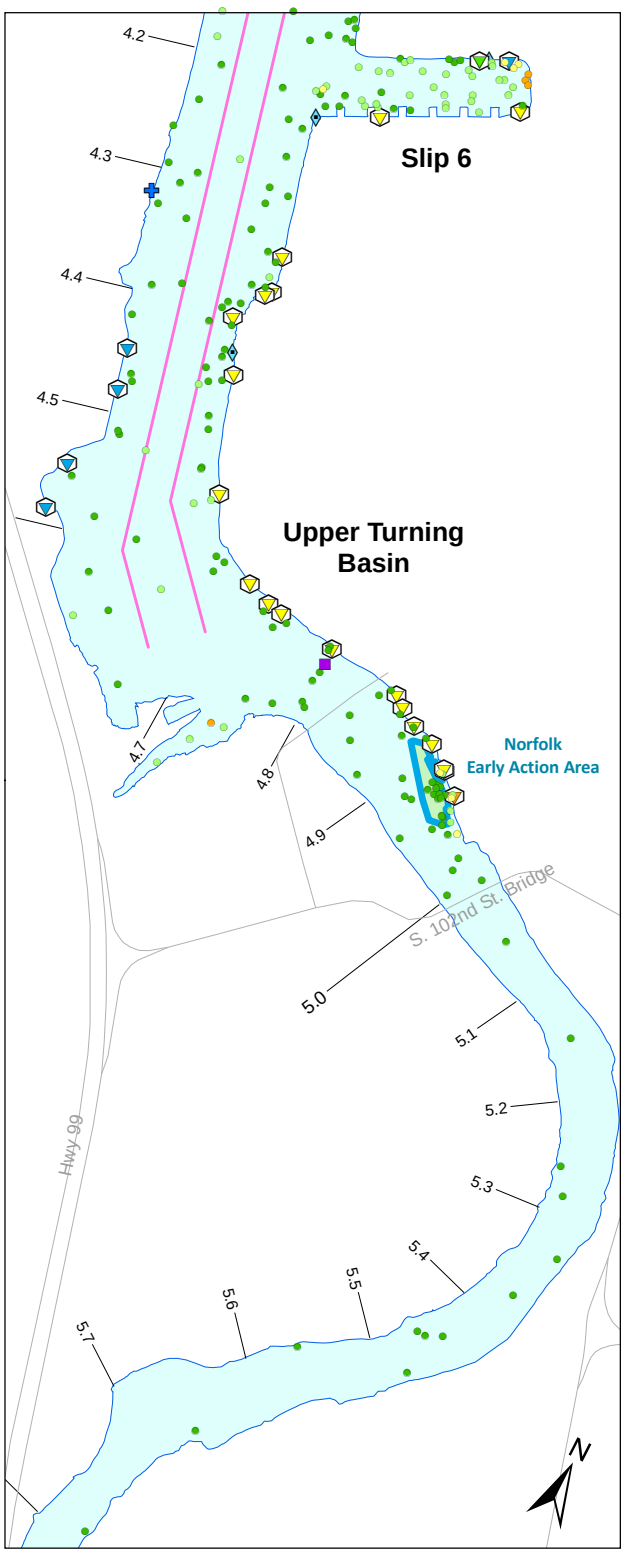
Scale is the same for each inset map

Map 4-52. Copper concentrations in surface sediment

Prepared by CEH, 07/15/2010; MAP 2775; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\Other COCs







Lead concentration (mg/kg dw)[a]

- > 210
- > 66 and ≤ 210
- > 36 and ≤ 66
- > 20 and ≤ 36
- ≤ 20
- Non-detect
- > CSL
- > SQS and ≤ CSL
- ≤ SQS
- Early Action Area[b]
- Dredged and capped area[c]
- Thin-layer placement[c]
- Road
- Navigation channel
- River mile

95th percentile = 210
75th percentile = 66
50th percentile = 36
25th percentile = 20
CSL = 530
SQS = 450

Outfall classification[d]

- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, a value of one-half the RL at that location was used. One sample within the Boeing Plant 2/Jorgensen Forge EAA had a lead concentration (1,300 mg/kg dw) greater than the CSL. However, according to data management rules (Section 4.1.2.1), data for this location were replaced with data from a more recent sample (SD-343) that was collected within 10 ft of the original location, but was not analyzed for lead.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Duwamish/Diagonal early action area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005. For the Norfolk early action area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

[d] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

Windward environmental LLC

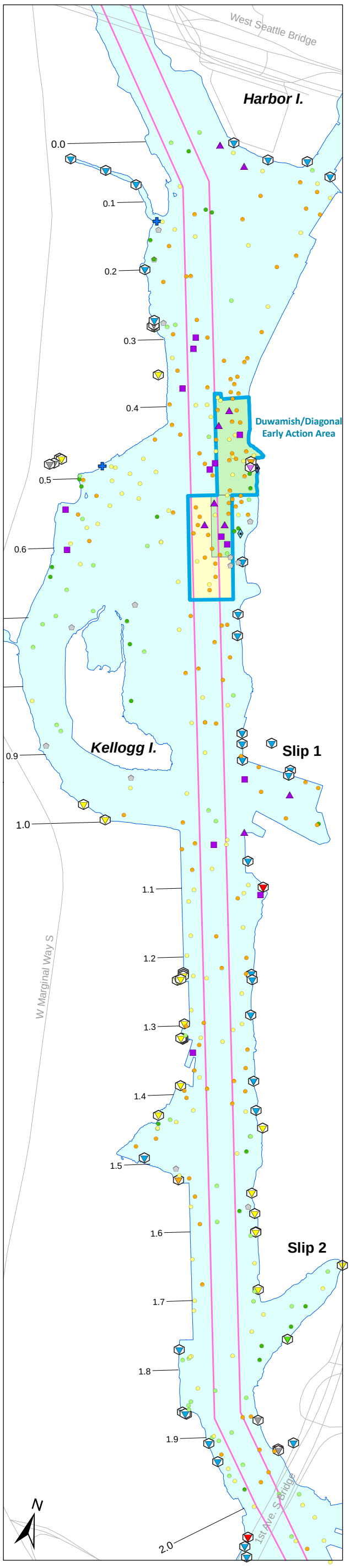
0 0.1 0.2 Miles

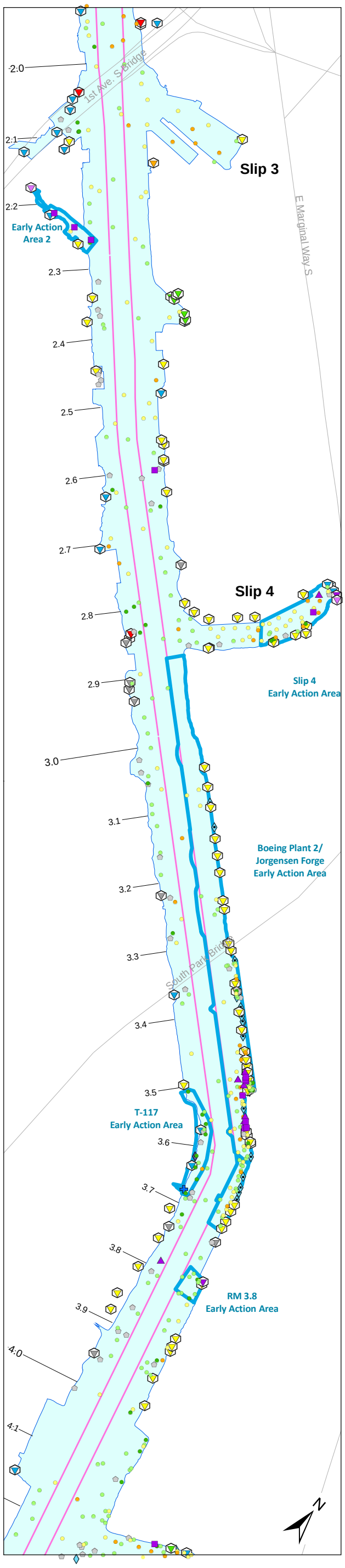
0 0.1 0.2 Kilometers

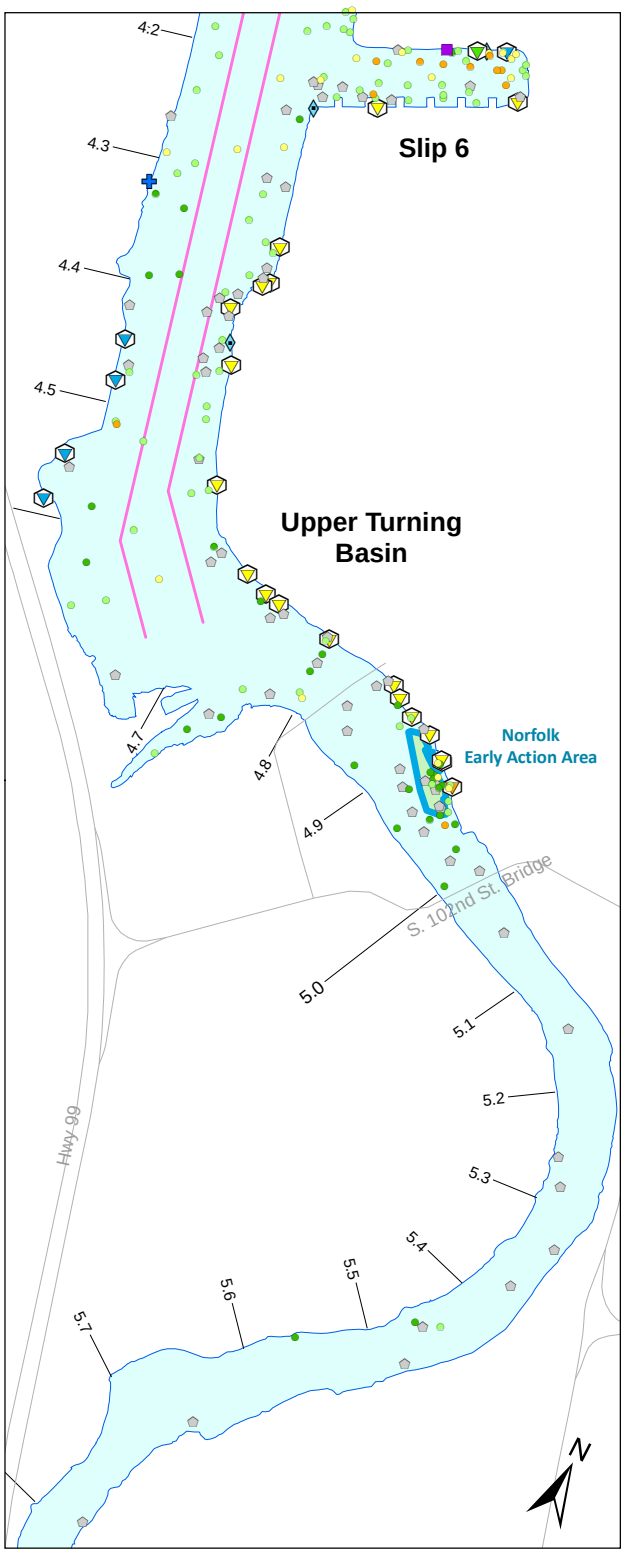
Scale is the same for each inset map

Map 4-53. Lead concentrations in surface sediment

Prepared by CEH, 07/15/2010; MAP 2776; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\Other COCs







Mercury concentration (mg/kg dw)[a]

- > 0.41
- > 0.23 and ≤ 0.41
- > 0.14 and ≤ 0.23
- > 0.08 and ≤ 0.14
- ≤ 0.08
- Non-detect
- > CSL
- > SQS and ≤ CSL
- ≤ SQS
- Early Action Area[b]
- Dredged and capped area[c]
- Thin-layer placement[c]
- Road
- Navigation channel
- River mile

95th percentile = 0.41
75th percentile = 0.23
50th percentile = 0.14
25th percentile = 0.08
CSL = 0.59
SQS = 0.41

Outfall classification[d]

- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, a value of one-half the RL at that location was used.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Duwamish/Diagonal early action area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005. For the Norfolk early action area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

[d] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

Wind Ward environmental LLC

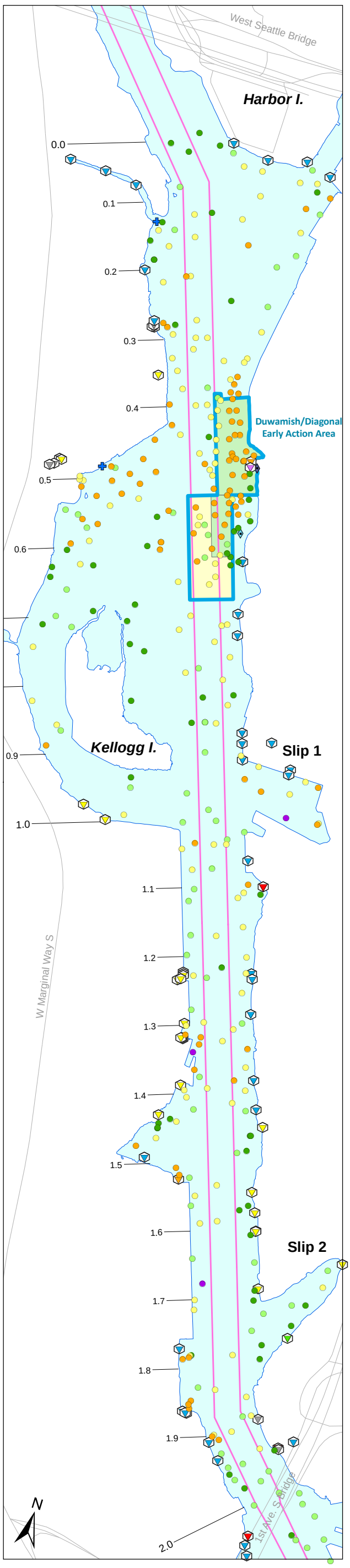
0 0.1 0.2 Miles

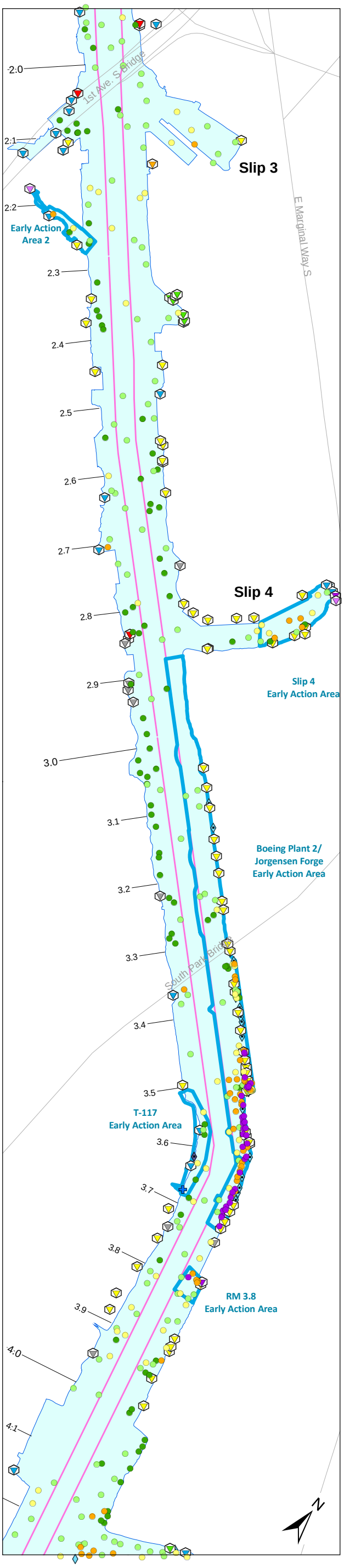
0 0.1 0.2 Kilometers

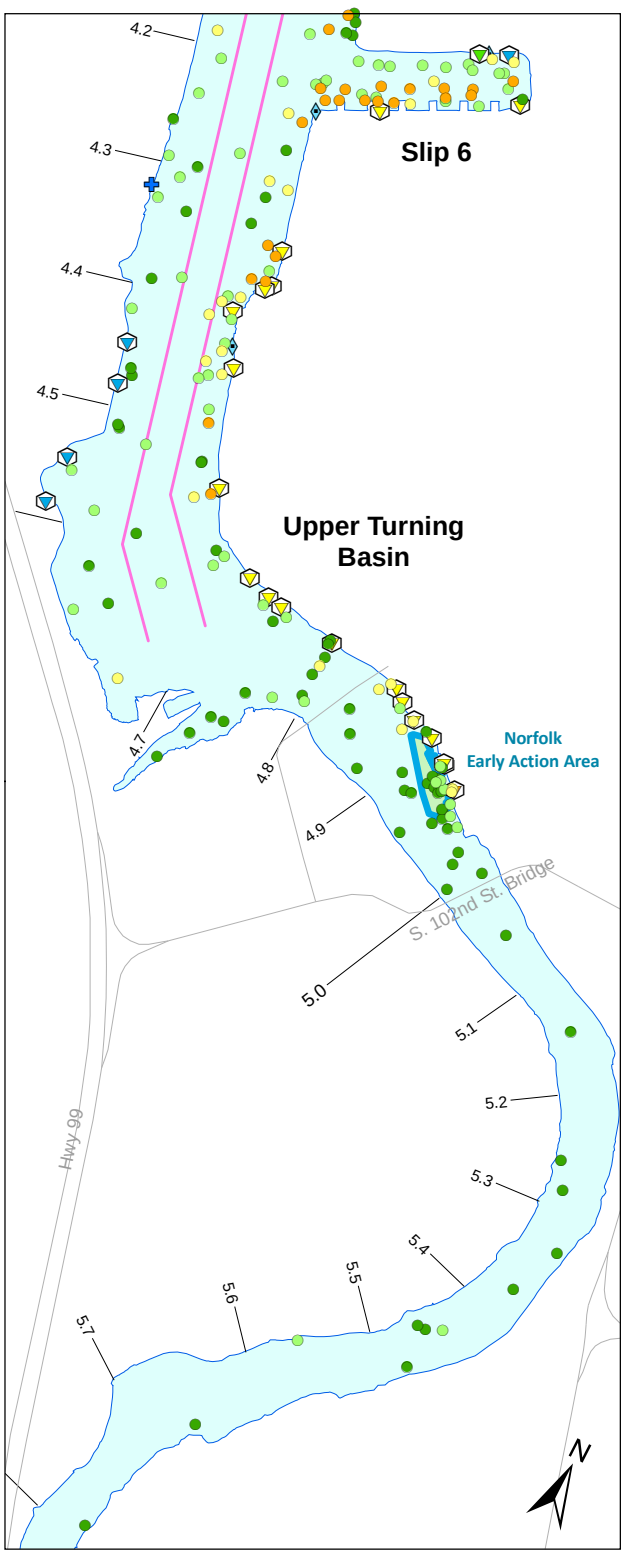
Scale is the same for each inset map

Map 4-54. Mercury concentrations in surface sediment

Prepared by CEH, 07/15/2010. MAP 2777: W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\Other COCs







Nickel concentration (mg/kg dw)[a]

- > 43
- > 27 and ≤ 43
- > 22 and ≤ 27
- > 17 and ≤ 22
- ≤ 17
- Non-detect
- Early Action Area[b]
- Dredged and capped area[c]
- Thin-layer placement[c]
- Road
- Navigation channel
- River mile

95th percentile = 43
75th percentile = 27
50th percentile = 22
25th percentile = 17

Outfall classification[d]

- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, a value of one-half the RL at that location was used.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Duwamish/Diagonal early action area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005. For the Norfolk early action area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

[d] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

Wind Ward environmental LLC

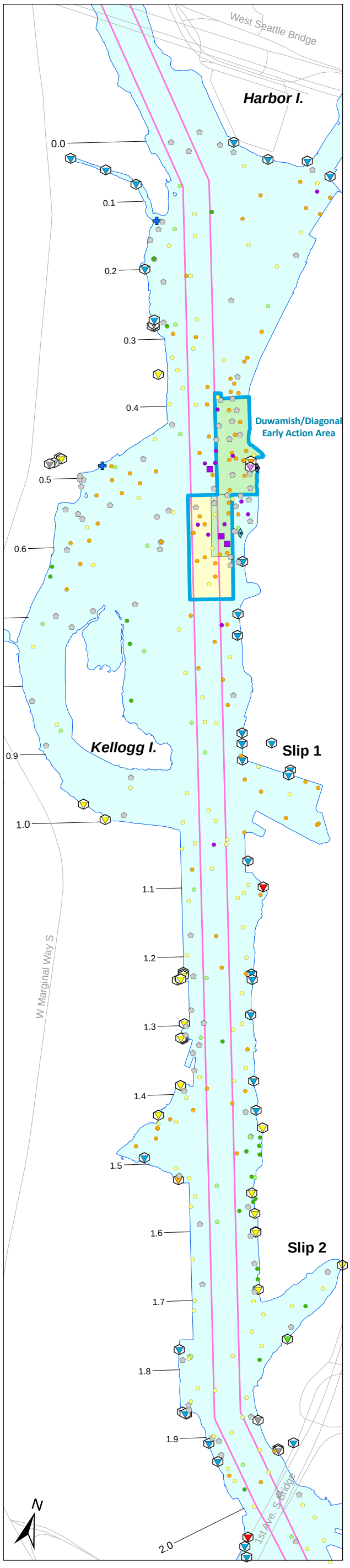
0 0.1 0.2 Miles

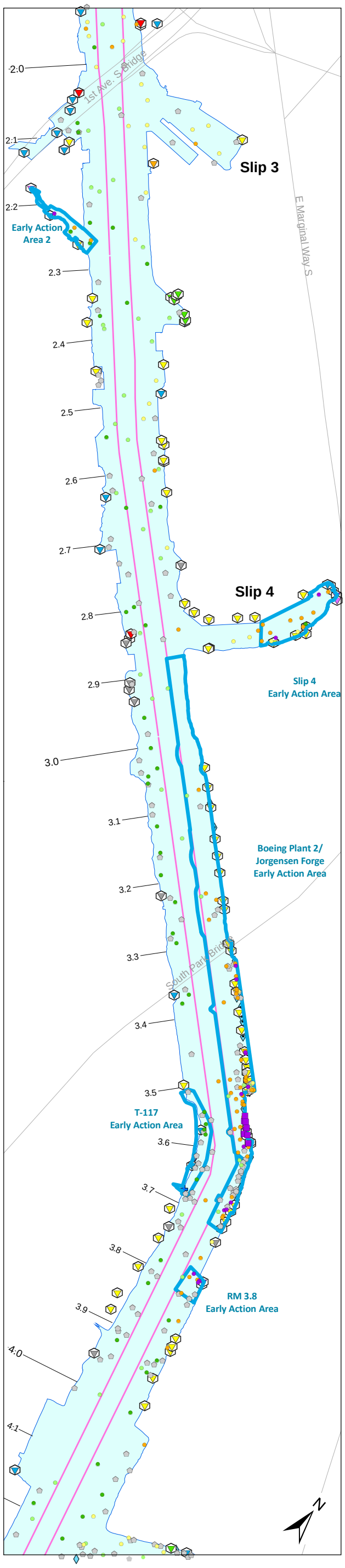
0 0.1 0.2 Kilometers

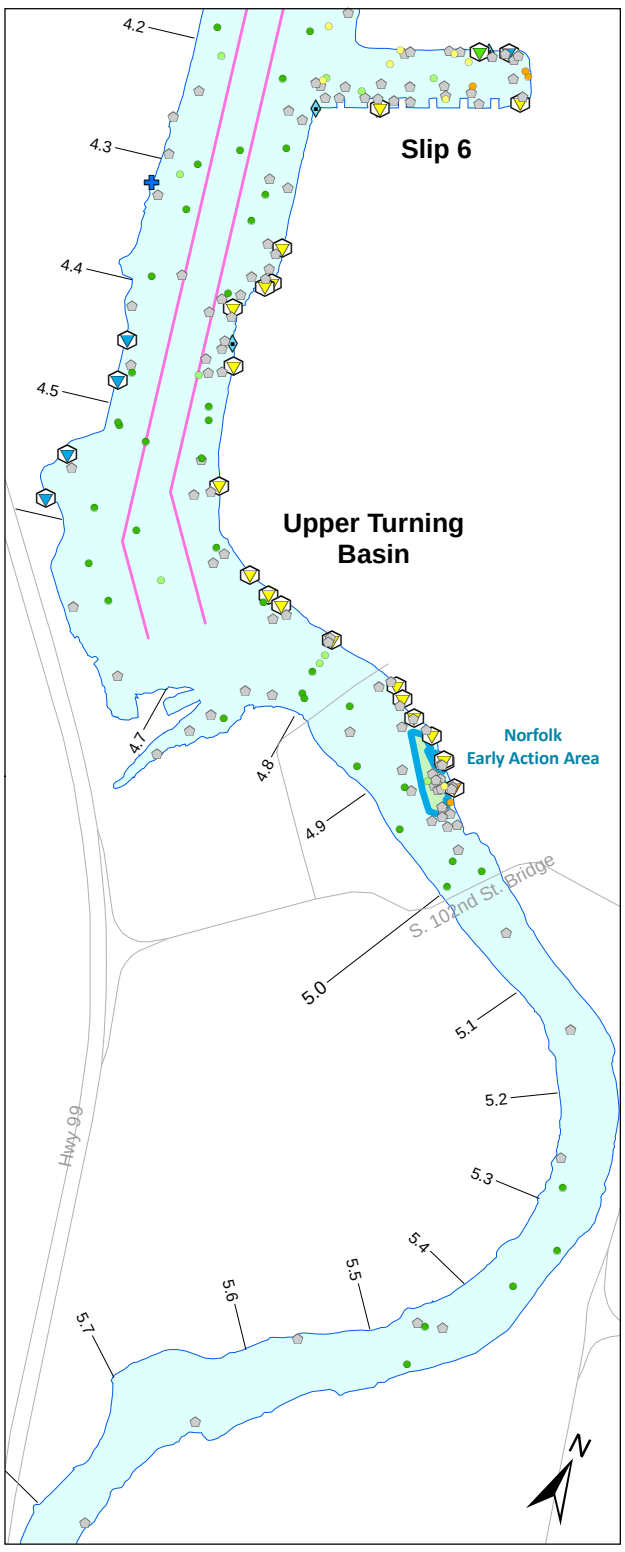
Scale is the same for each inset map

Map 4-55. Nickel concentrations in surface sediment

Prepared by CEH, 07/15/2010; MAP 2788; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\Other COCs







Silver concentration (mg/kg dw)[a]

- > 1.7
- > 0.51 and ≤ 1.7
- > 0.30 and ≤ 0.51
- > 0.20 and ≤ 0.30
- ≤ 0.20
- Non-detect
- > CSL
- > SQS and ≤ CSL
- ≤ SQS
- Early Action Area[b]
- Dredged and capped area[c]
- Thin-layer placement[c]
- Road
- Navigation channel
- River mile

95th percentile = 1.7
75th percentile = 0.51
50th percentile = 0.30
25th percentile = 0.20
CSL = SQS = 6.1

Outfall classification[d]

- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, a value of one-half the RL at that location was used.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Duwamish/Diagonal early action area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005. For the Norfolk early action area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

[d] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

Windward environmental LLC

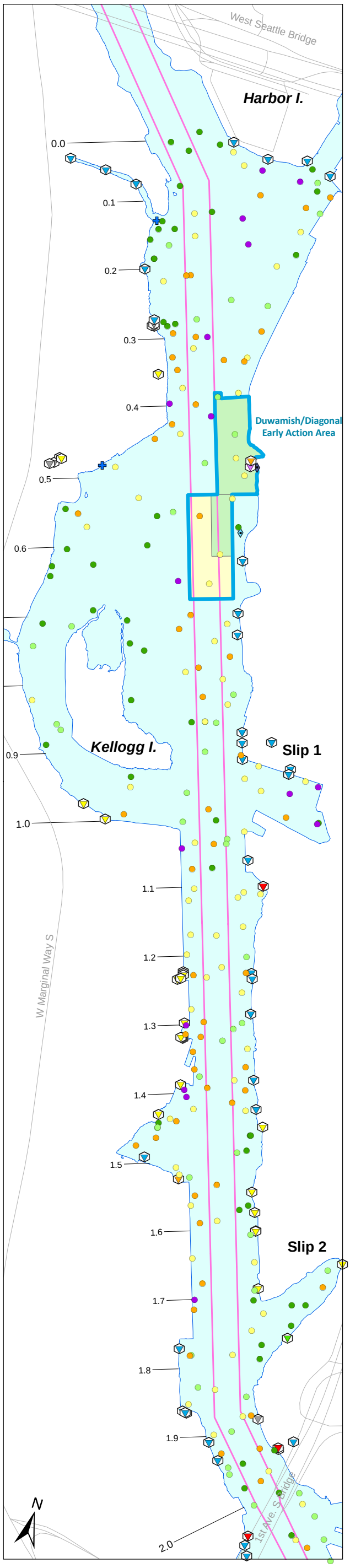
0 0.1 0.2 Miles

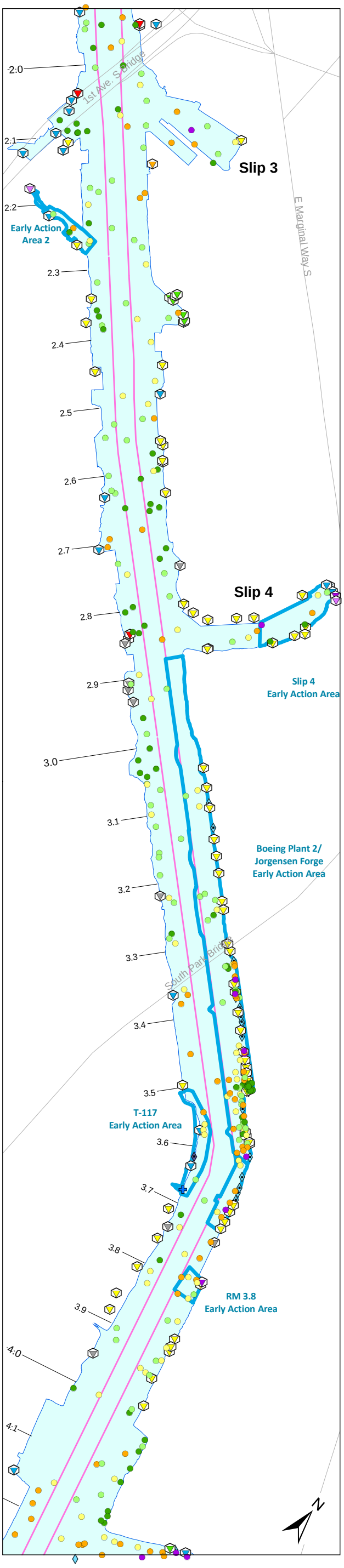
0 0.1 0.2 Kilometers

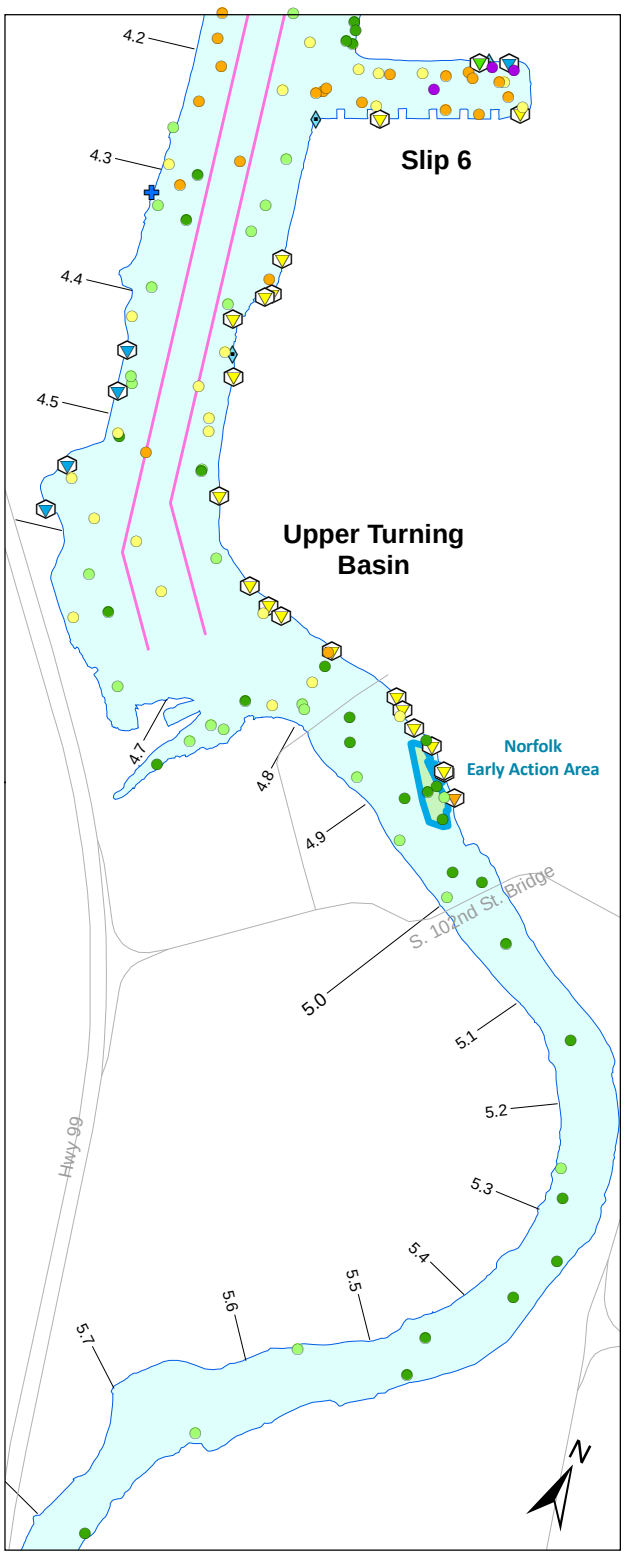
Scale is the same for each inset map

Map 4-56. Silver concentrations in surface sediment

Prepared by CEH, 07/15/2010; MAP 2789; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\Other COCs







Vanadium concentration (mg/kg dw)[a]

- > 81
- > 68 and ≤ 81
- > 57 and ≤ 68
- > 48 and ≤ 57
- ≤ 48
- Non-detect
- Early Action Area[b]
- Dredged and capped area[c]
- Thin-layer placement[c]
- Road
- Navigation channel
- River mile

95th percentile = 81
75th percentile = 68
50th percentile = 57
25th percentile = 48

Outfall classification[d]

- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, a value of one-half the RL at that location was used.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Duwamish/Diagonal early action area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005. For the Norfolk early action area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

[d] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

Wind Ward environmental LLC

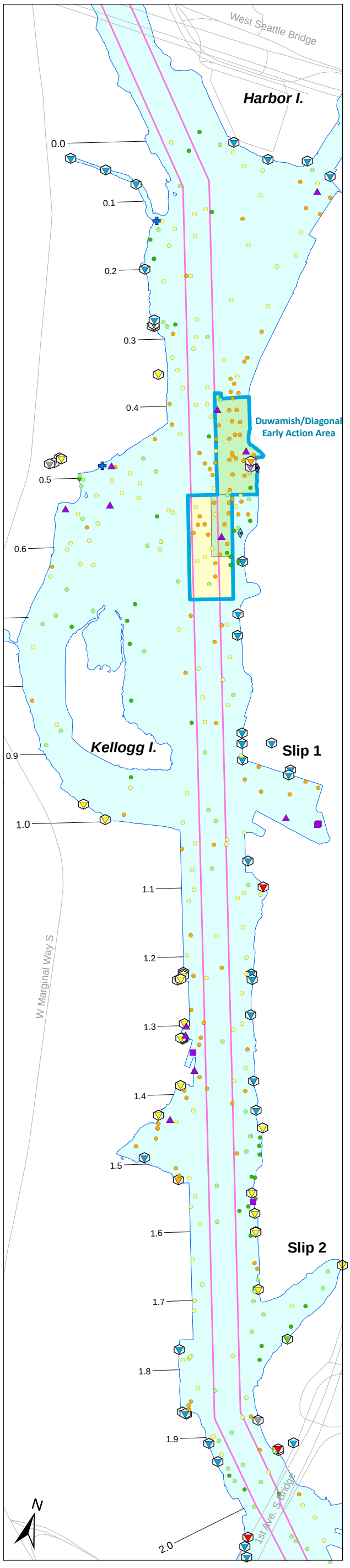
0 0.1 0.2 Miles

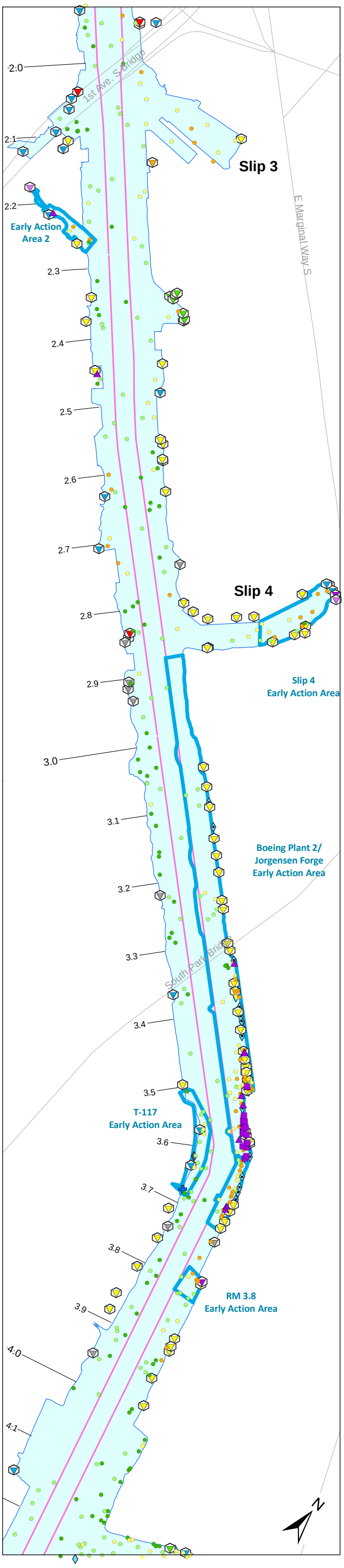
0 0.1 0.2 Kilometers

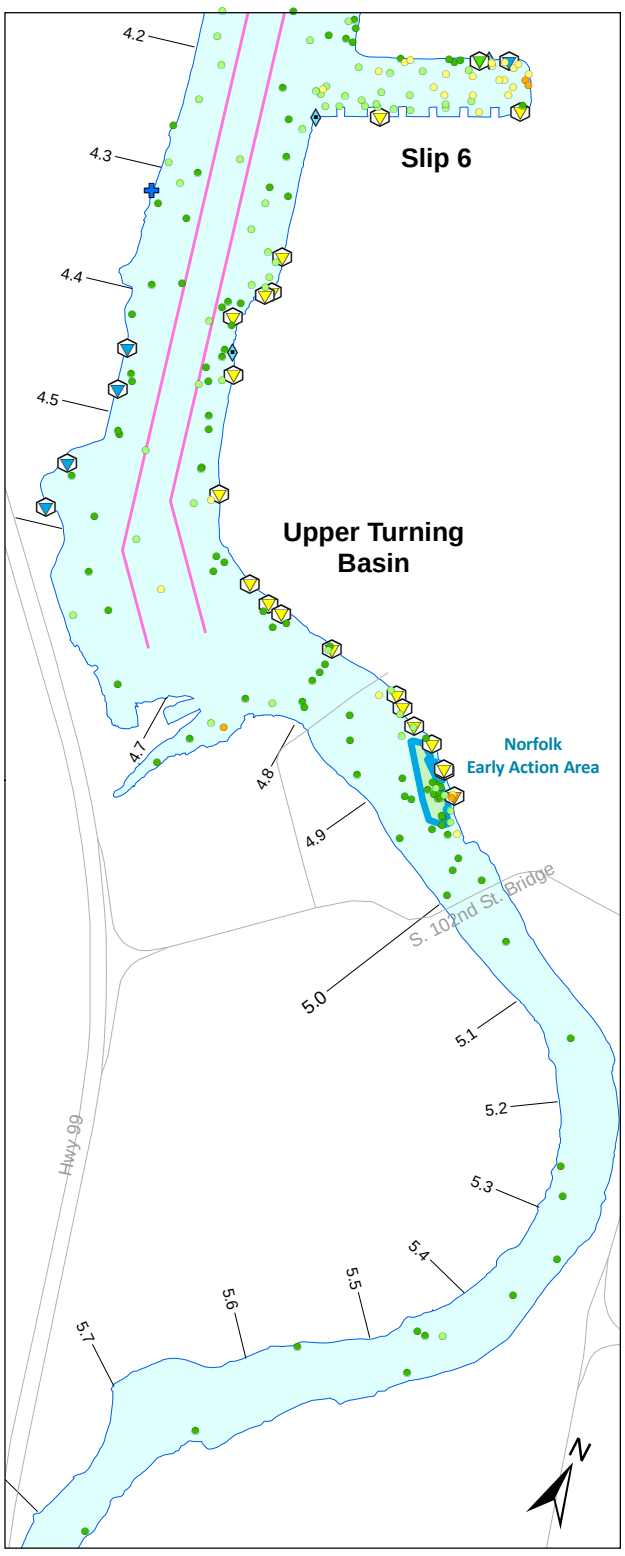
Scale is the same for each inset map

Map 4-57. Vanadium concentrations in surface sediment

Prepared by CEH, 07/15/2010; MAP 2778; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\Other COCs







Zinc concentration (mg/kg dw)[a]

- > 410
- > 160 and ≤ 410
- > 110 and ≤ 160
- > 79 and ≤ 110
- ≤ 79
- Non-detect
- > CSL
- > SQS and ≤ CSL
- ≤ SQS
- Early Action Area[b]
- Dredged and capped area[c]
- Thin-layer placement[c]
- Road
- Navigation channel
- River mile

95th percentile = 410
75th percentile = 160
50th percentile = 110
25th percentile = 79
CSL = 960
SQS = 410

Outfall classification[d]

- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, a value of one-half the RL at that location was used.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Duwamish/Diagonal early action area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005. For the Norfolk early action area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

[d] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

Wind Ward environmental LLC

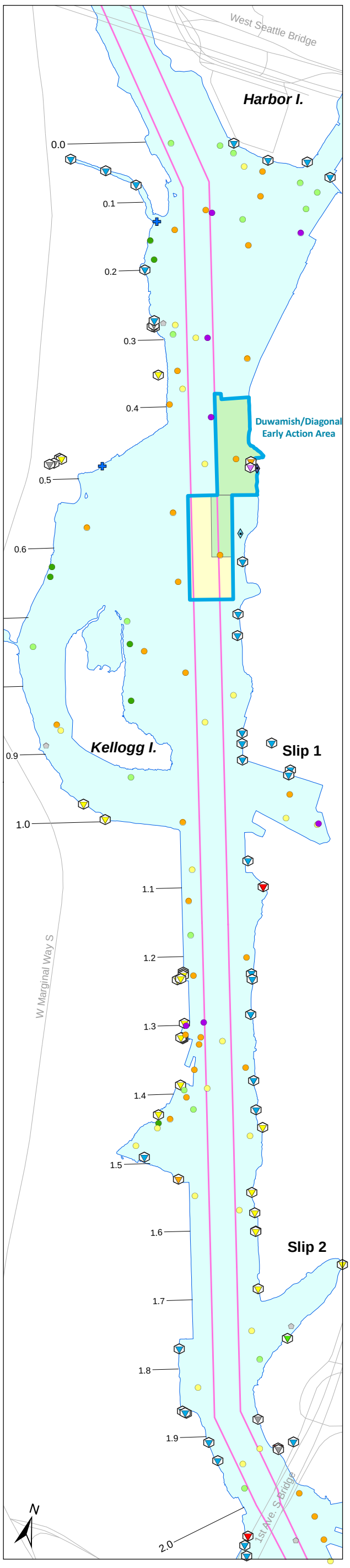
0 0.1 0.2 Miles

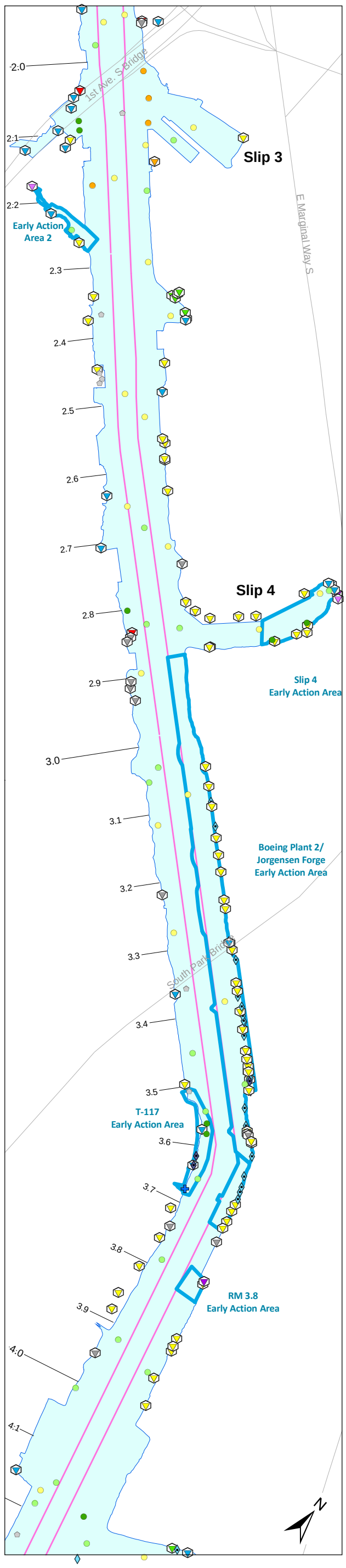
0 0.1 0.2 Kilometers

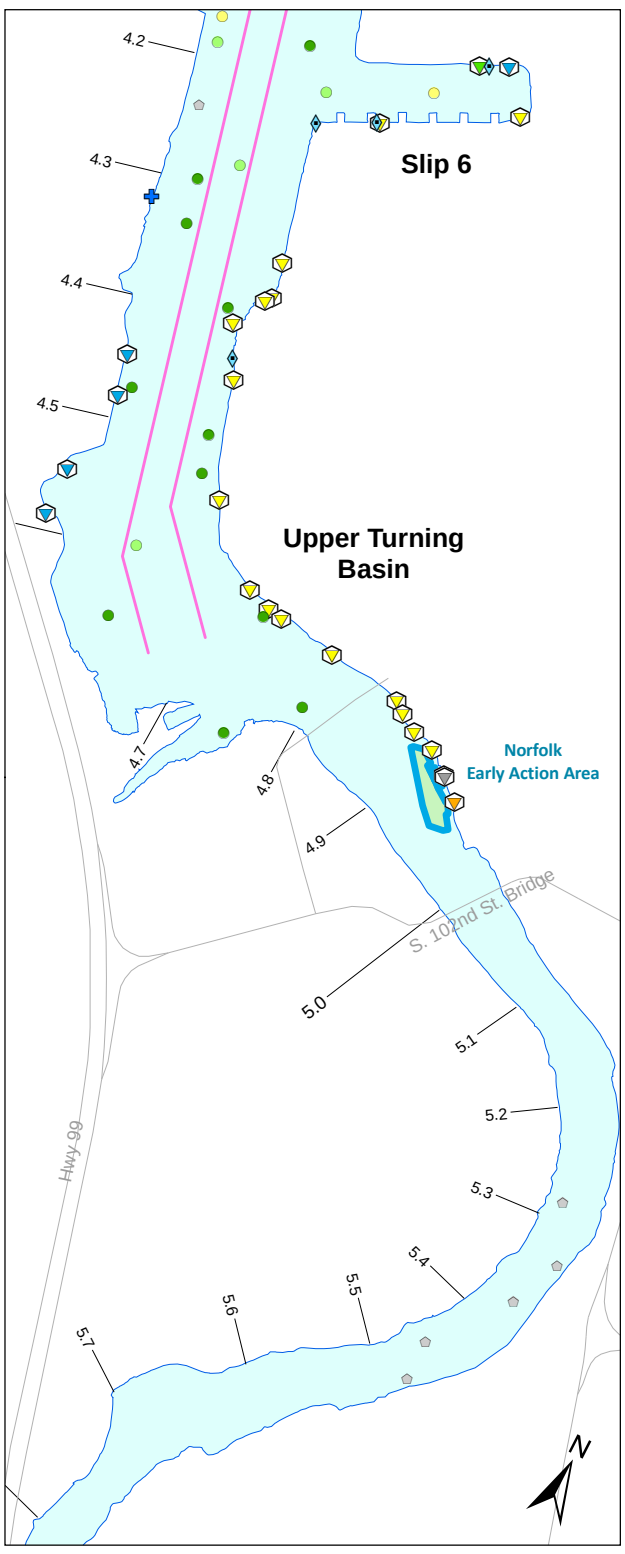
Scale is the same for each inset map

Map 4-58. Zinc concentrations in surface sediment

Prepared by CEH, 07/15/2010, MAP 2790, W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\Other COCs







TBT concentration (µg/kg dw)[a]

- > 250
- > 88 and ≤ 250
- > 22 and ≤ 88
- > 4.0 and ≤ 22
- ≤ 4.0
- Non-detect
- Early Action Area[b]
- Dredged and capped area[c]
- Thin-layer placement[c]
- Road
- Navigation channel
- River mile

95th percentile = 250
75th percentile = 88
50th percentile = 22
25th percentile = 4.0

Outfall classification[d]

- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, a value of one-half the RL at that location was used.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Duwamish/Diagonal early action area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005. For the Norfolk early action area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

[d] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

Windward environmental LLC

0 0.1 0.2 Miles

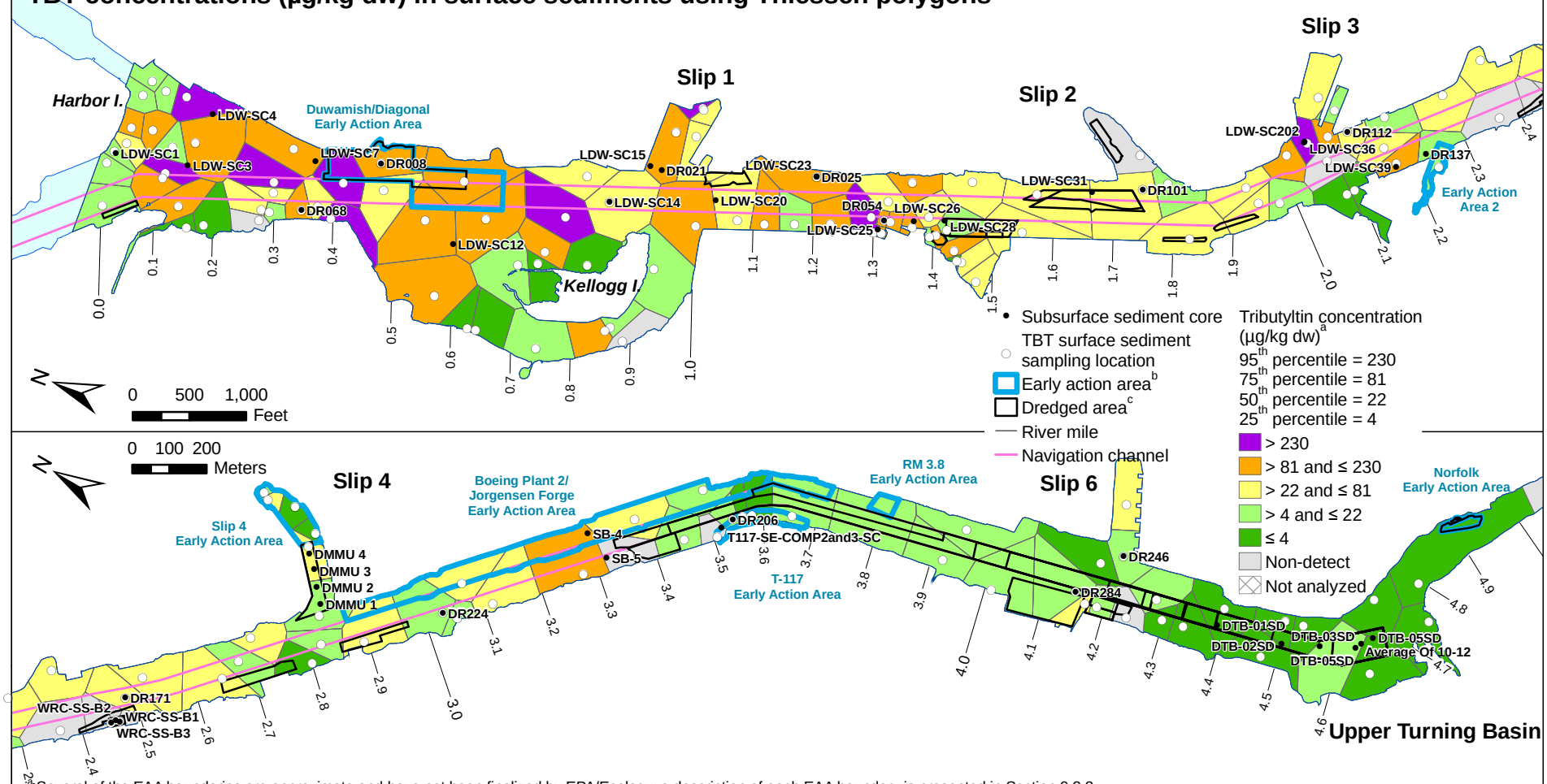
0 0.1 0.2 Kilometers

Scale is the same for each inset map

Map 4-59. TBT concentrations in surface sediment

Prepared by CEH, 07/15/2010; MAP 2779; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\Other COCs

TBT concentrations (µg/kg dw) in surface sediments using Thiessen polygons



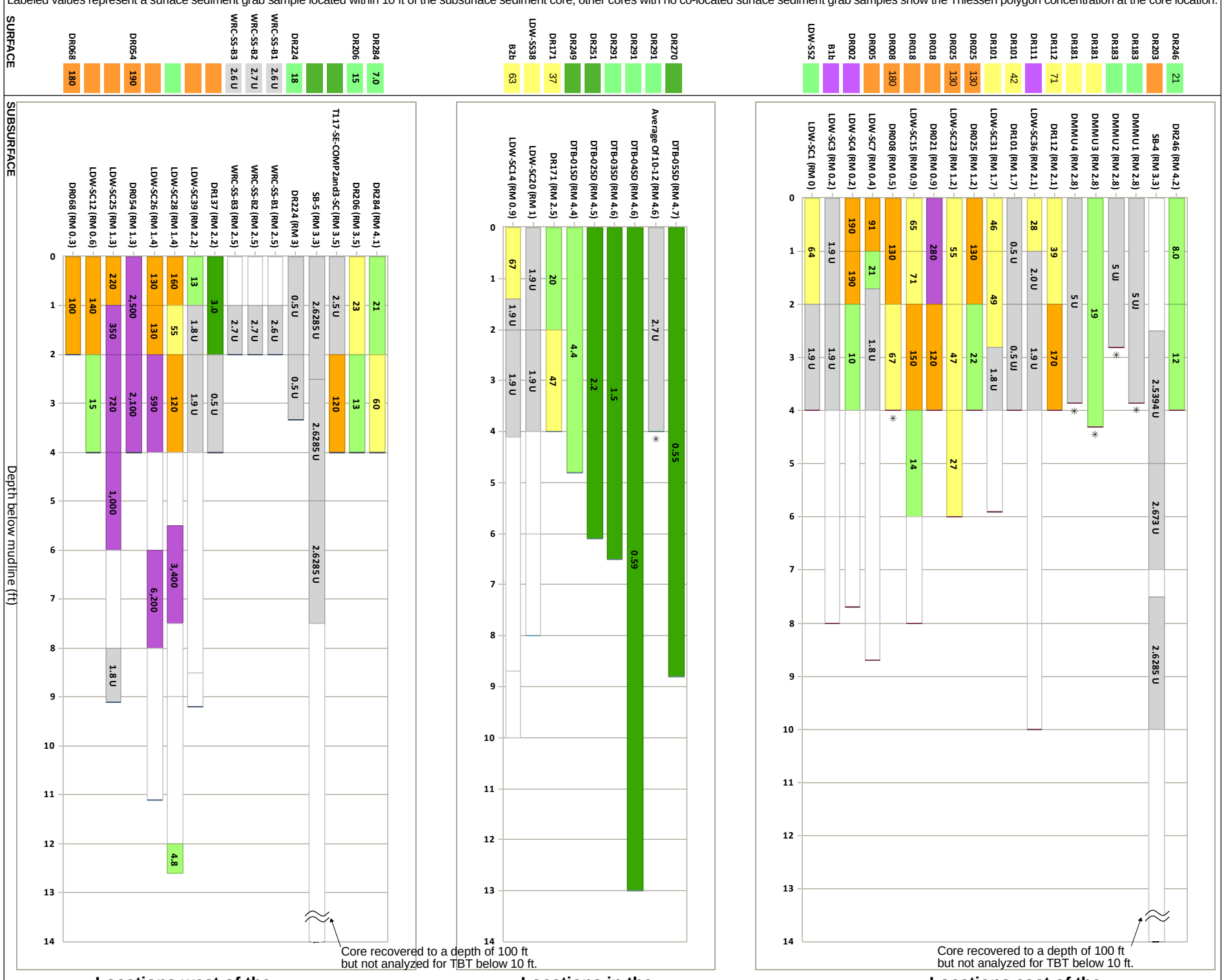
[a] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[b] For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, and thin-layer placement in 2003 to 2005. For the Norfolk Early Action Area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO/SD removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003. Subsurface sediment data at locations in dredged areas were collected prior to dredging.

[c] Interpolated concentrations are based on data from the baseline surface sediment dataset. Percentiles were calculated on an area-basis as the concentration at which a particular percentage of the LDW area has Thiessen polygon values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 230 µg/kg dw). Thiessen polygon concentrations were calculated including locations with non-detected values. For locations with non-detects, a value of one-half the RL at that location was used.

TBT concentrations (µg/kg dw) in subsurface sediment cores and co-located (within 10 ft) surface sediment samples

Labeled values represent a surface sediment grab sample located within 10 ft of the subsurface sediment core; other cores with no co-located surface sediment grab samples show the Thiessen polygon concentration at the core location.



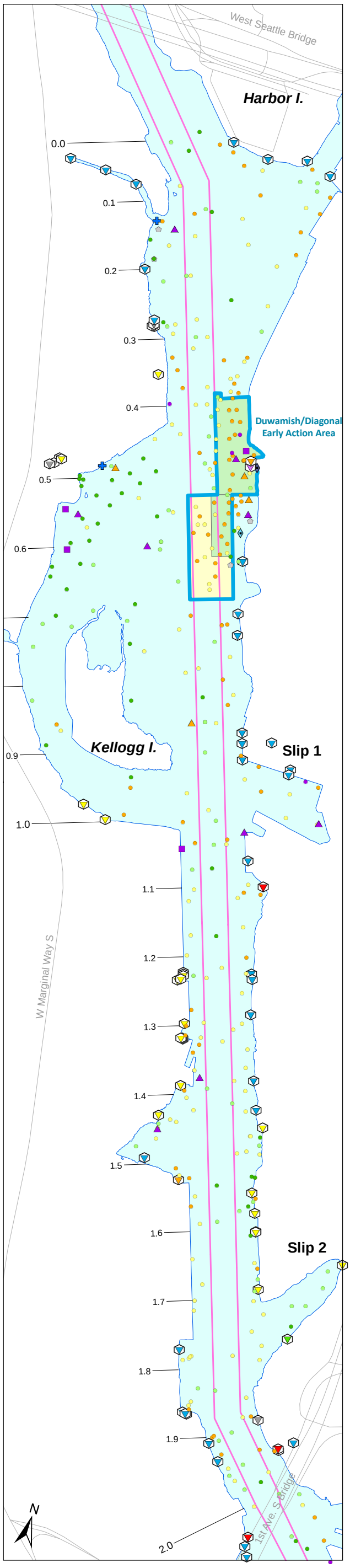
∗ This core was collected prior to dredging at that location.

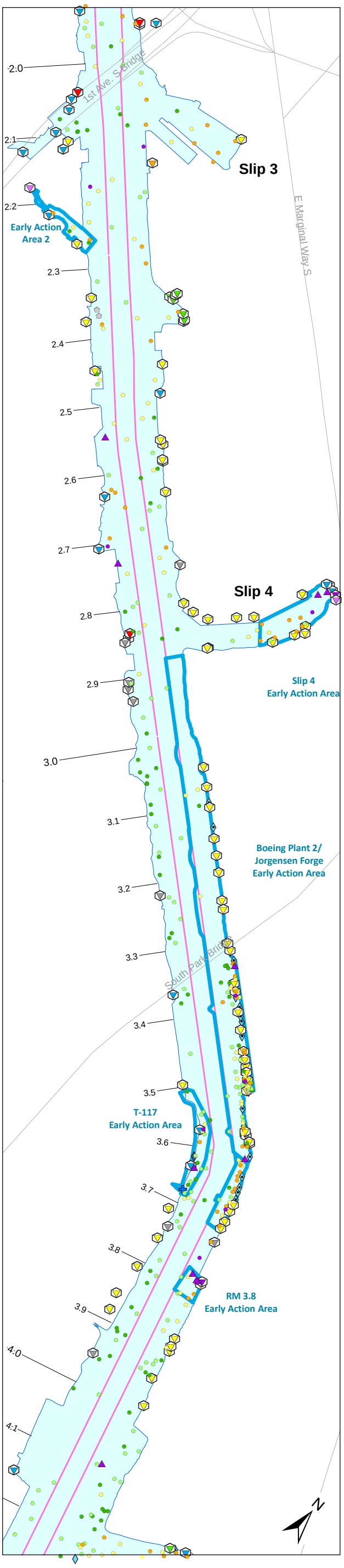
Wind Ward environmental LLC

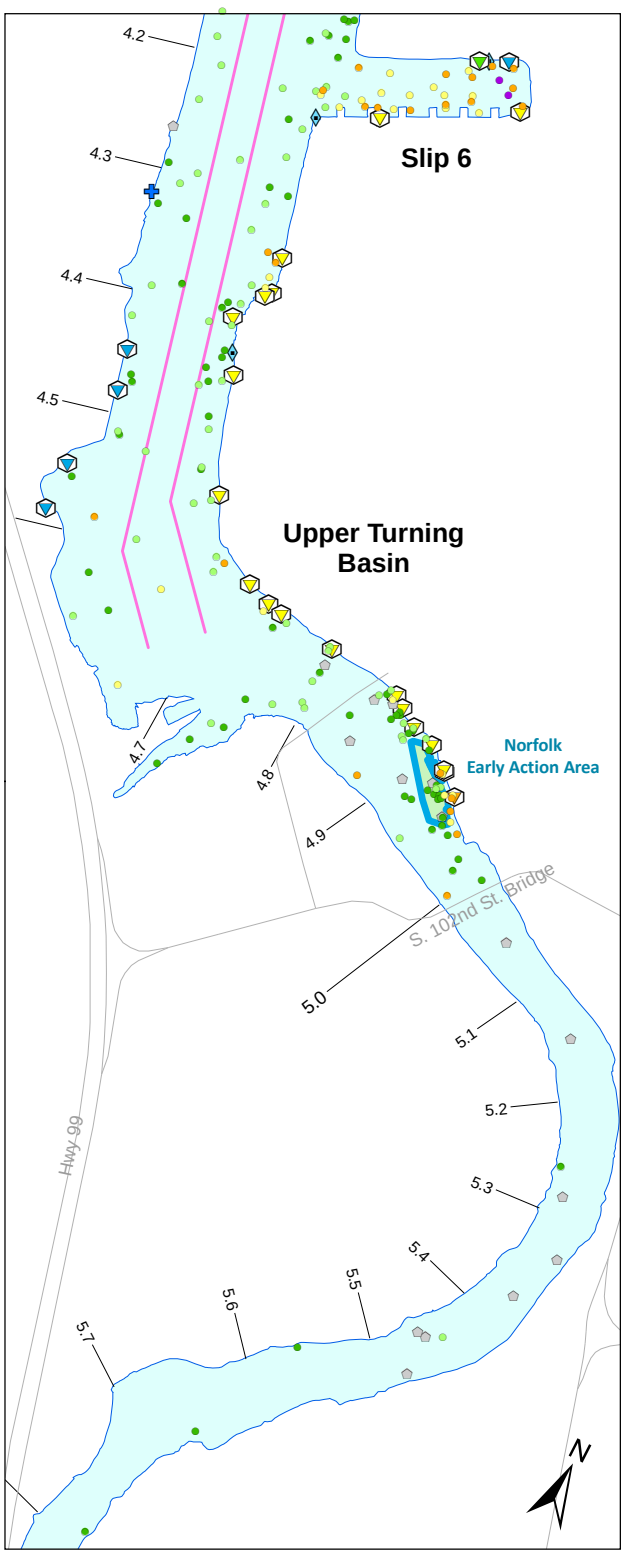
Map 4-60. TBT concentrations in surface sediment and subsurface sediment cores

Prepared by CEH, 07/15/2010; MAP 3378; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Bar charts

Dredging information provided by AECOM.







HPAH concentration (µg/kg dw)[a]

- > 13,000
- > 4,200 and ≤ 13,000
- > 2,000 and ≤ 4,200
- > 830 and ≤ 2,000
- ≤ 830
- Non-detect
- > CSL
- > SQS and ≤ CSL
- ≤ SQS
- Early Action Area[b]
- Dredged and capped area[c]
- Thin-layer placement[c]
- Road
- Navigation channel
- River mile

95th percentile = 13,000
75th percentile = 4,200
50th percentile = 2,000
25th percentile = 830

Outfall classification[d]

- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale

[a]Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, one-half the non-detect value was used. When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations are compared instead to the LAET and 2LAET.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Duwamish/Diagonal early action area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005. For the Norfolk early action area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

[d] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

Windward environmental LLC

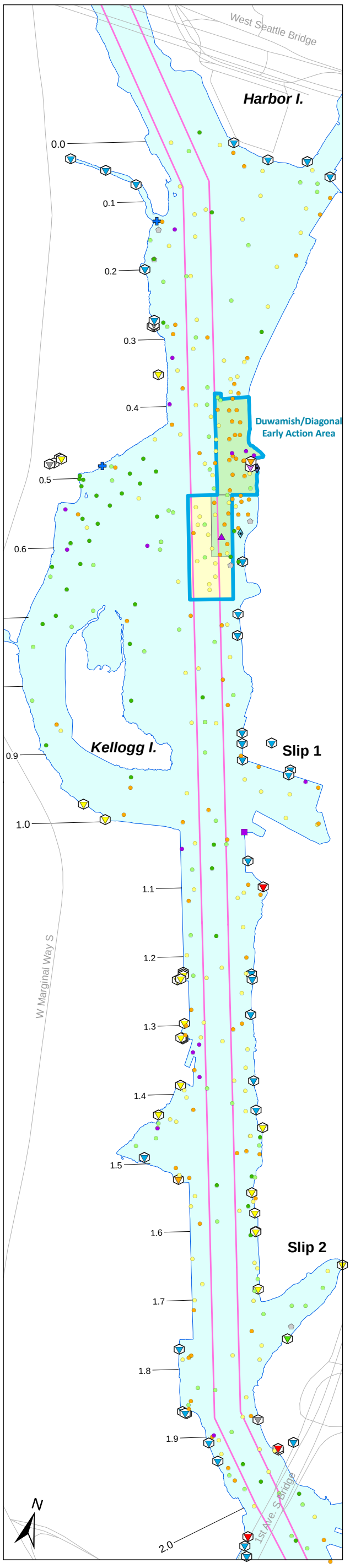
0 0.1 0.2 Miles

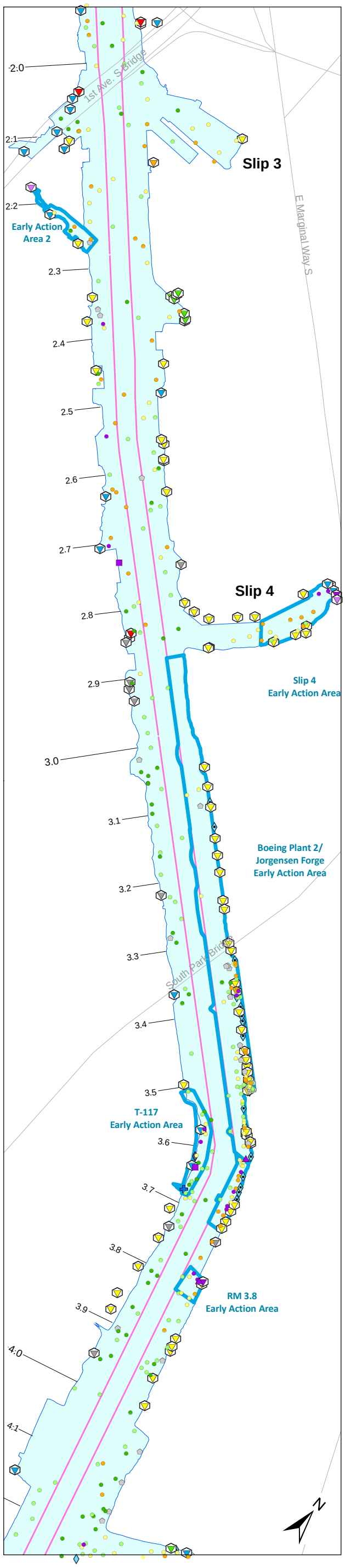
0 0.1 0.2 Kilometers

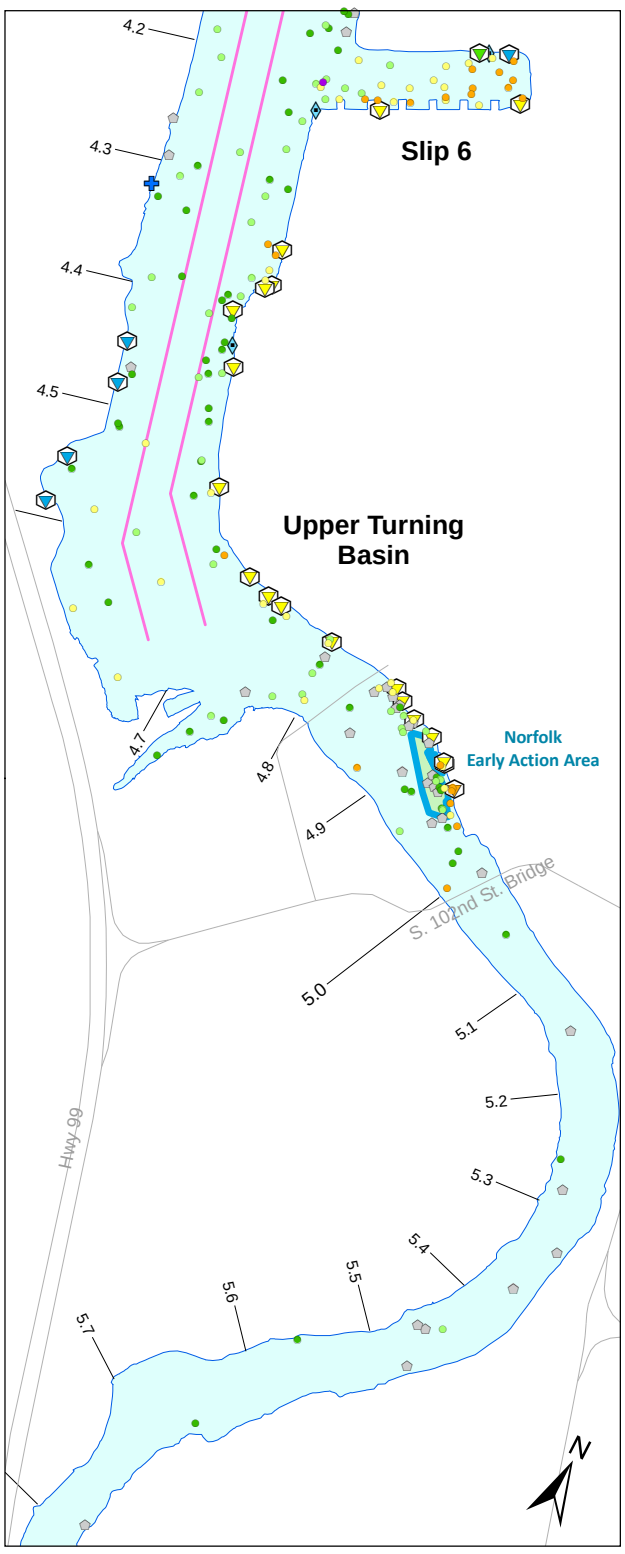
Scale is the same for each inset map

Map 4-61. Total HPAH concentrations in surface sediment

Prepared by CEH, 07/15/2010; MAP 2767; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\CPAHs







LPAH concentration (µg/kg dw)[a]

- > 2,300
- > 550 and ≤ 2,300
- > 230 and ≤ 550
- > 84 and ≤ 230
- ≤ 84
- Non-detect
- > CSL
- > SQS and ≤ CSL
- ≤ SQS
- Early Action Area[b]
- Dredged and capped area[c]
- Thin-layer placement[c]
- Road
- Navigation channel
- River mile

95th percentile = 2,300
75th percentile = 550
50th percentile = 230
25th percentile = 84

Outfall classification[d]

- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale

[a]Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, one-half the non-detect value was used. When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations are compared instead to the LAET and 2LAET.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Duwamish/Diagonal early action area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005. For the Norfolk early action area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

[d] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

Windward environmental LLC

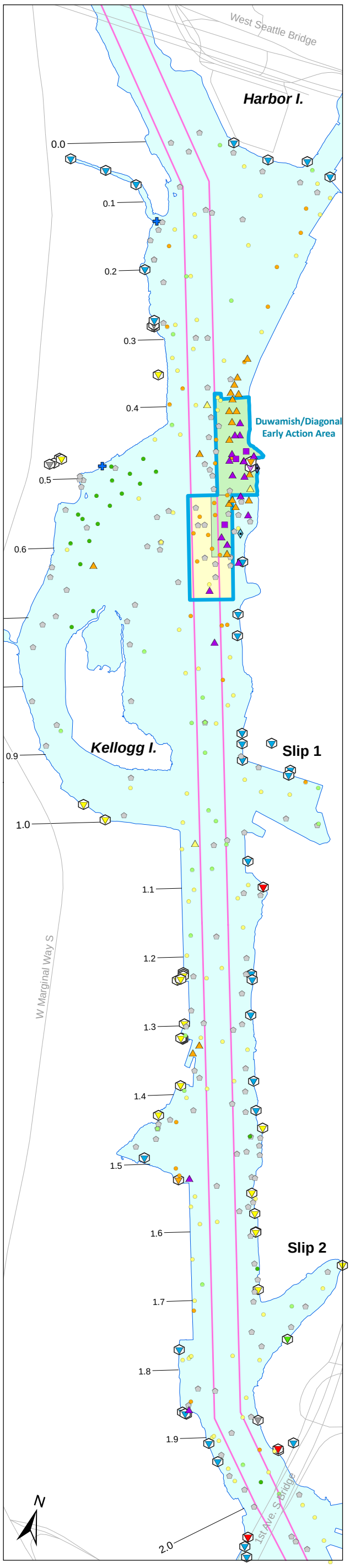
0 0.1 0.2 Miles

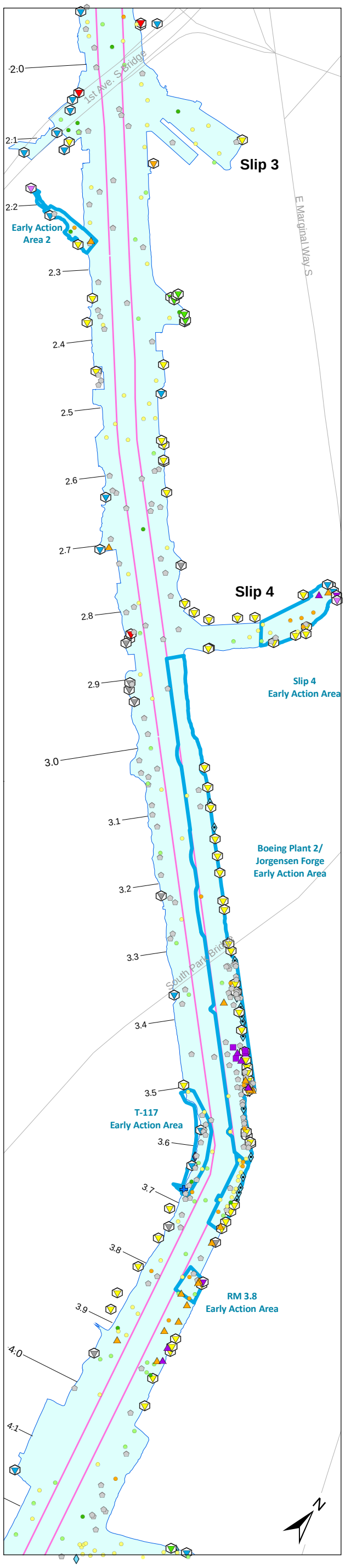
0 0.1 0.2 Kilometers

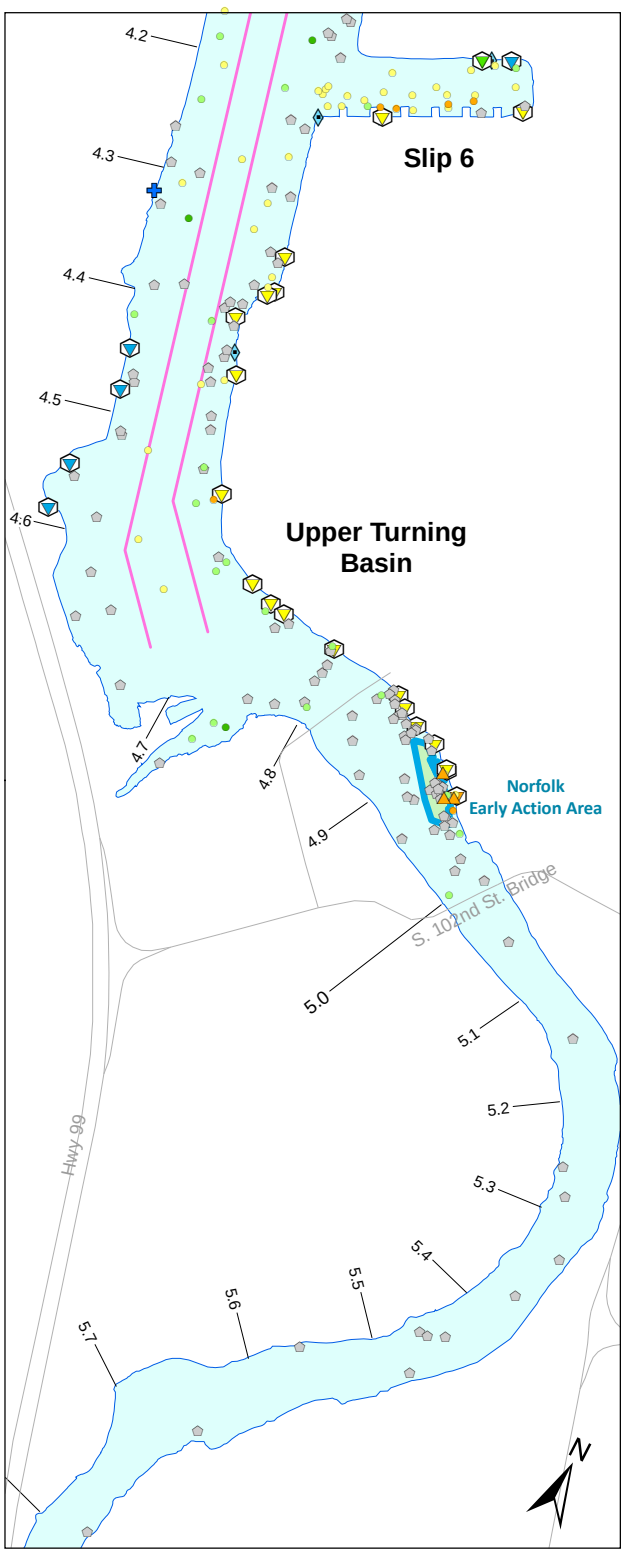
Scale is the same for each inset map

Map 4-62. Total LPAH concentrations in surface sediment

Prepared by CEH, 07/15/2010; MAP 2766; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\cPAHs







BBP concentration (µg/kg dw)[a]

- > 230
- > 50 and ≤ 230
- > 28 and ≤ 50
- > 10 and ≤ 28
- > 0.90 and ≤ 10
- Non-detect
- > CSL
- > SQS and ≤ CSL
- ≤ SQS
- Early Action Area[b]
- Dredged and capped area[c]
- Thin-layer placement[c]
- Road
- Navigation channel
- River mile

95th percentile = 230
75th percentile = 50
50th percentile = 28
25th percentile = 10

Outfall classification[d]

- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, a value of one-half the RL at that location was used. When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations are compared instead to the LAET and 2LAET.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Duwamish/Diagonal early action area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005. For the Norfolk early action area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

[d] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

Wind Ward environmental LLC

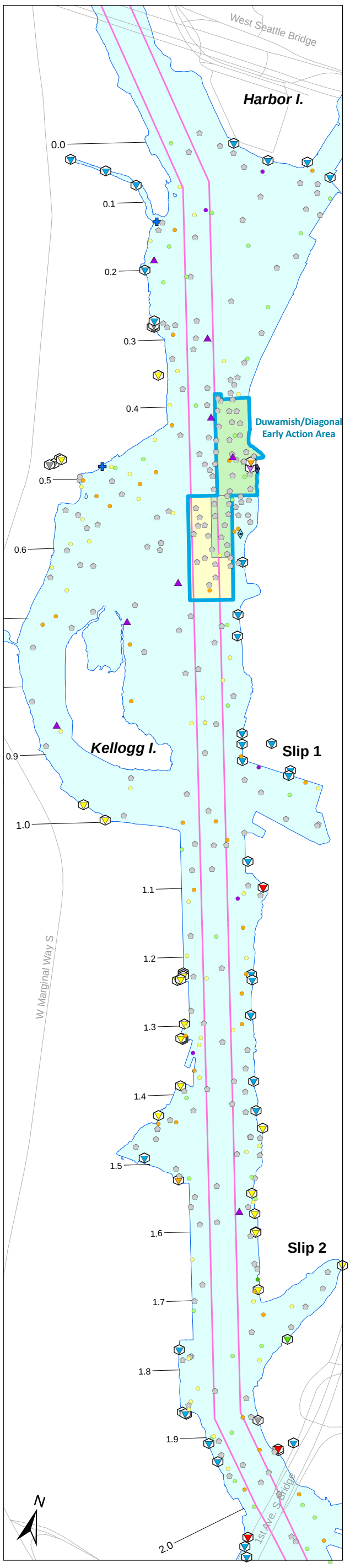
0 0.1 0.2 Miles

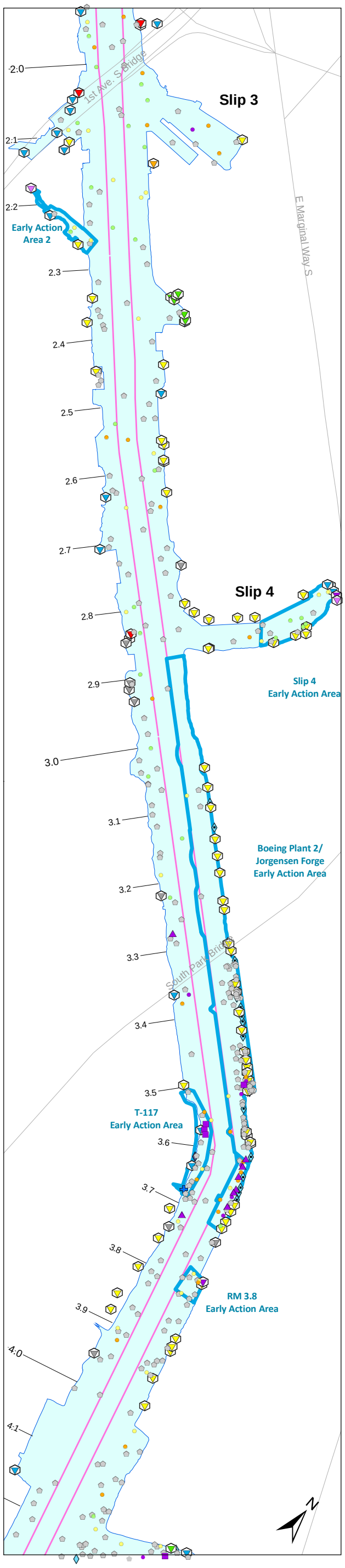
0 0.1 0.2 Kilometers

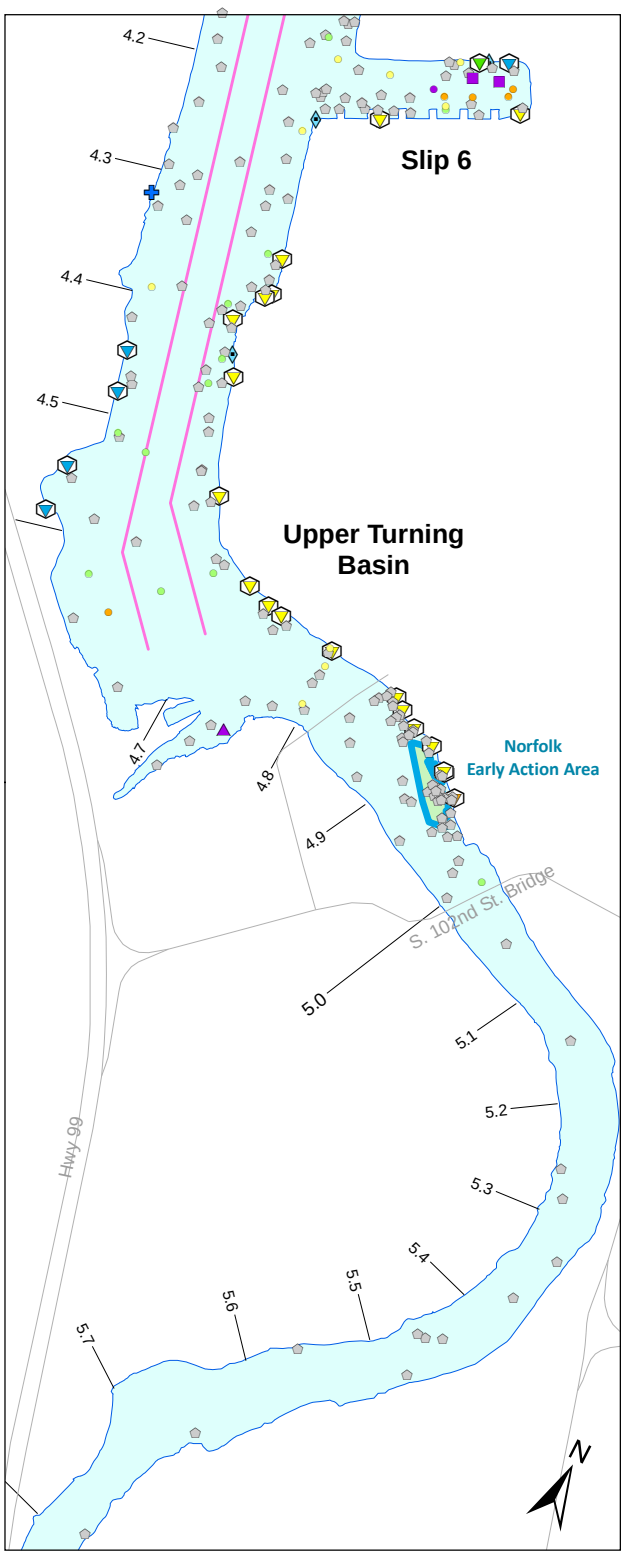
Scale is the same for each inset map

Map 4-63. BBP concentrations in surface sediment

Prepared by CEH, 07/15/2010; MAP 2772; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\Other COCs







Phenol concentration (µg/kg dw)[a]

- > 320
- > 95 and ≤ 320
- > 31 and ≤ 95
- > 10 and ≤ 31
- ≤ 10
- Non-detect
- > CSL
- > SQS and ≤ CSL
- ≤ SQS
- Early Action Area[b]
- Dredged and capped area[c]
- Thin-layer placement[c]
- Road
- Navigation channel
- River mile

95th percentile = 320
75th percentile = 95
50th percentile = 31
25th percentile = 10
CSL = 1,200
SQS = 420

Outfall classification[d]

- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, a value of one-half the RL at that location was used.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Duwamish/Diagonal early action area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005. For the Norfolk early action area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

[d] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

Windward environmental LLC

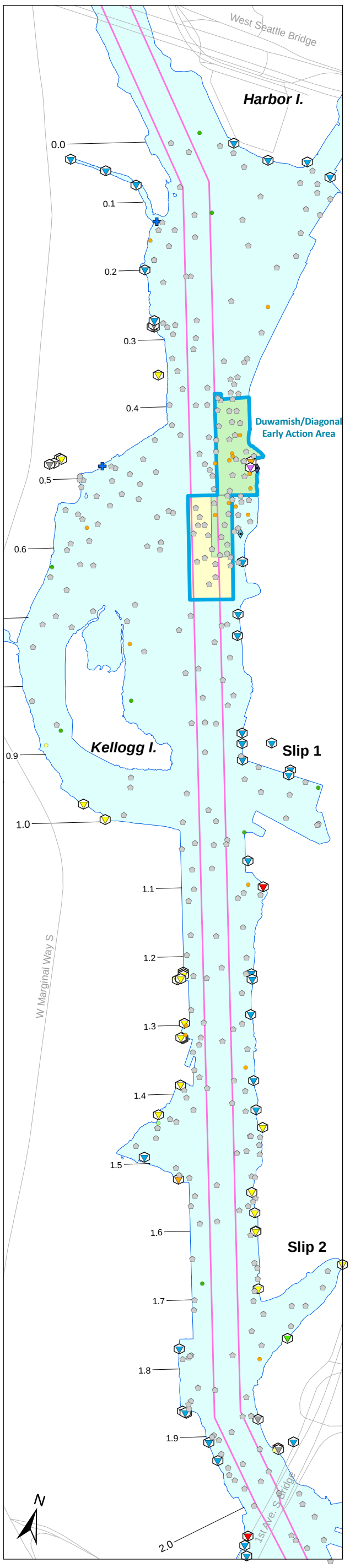
0 0.1 0.2 Miles

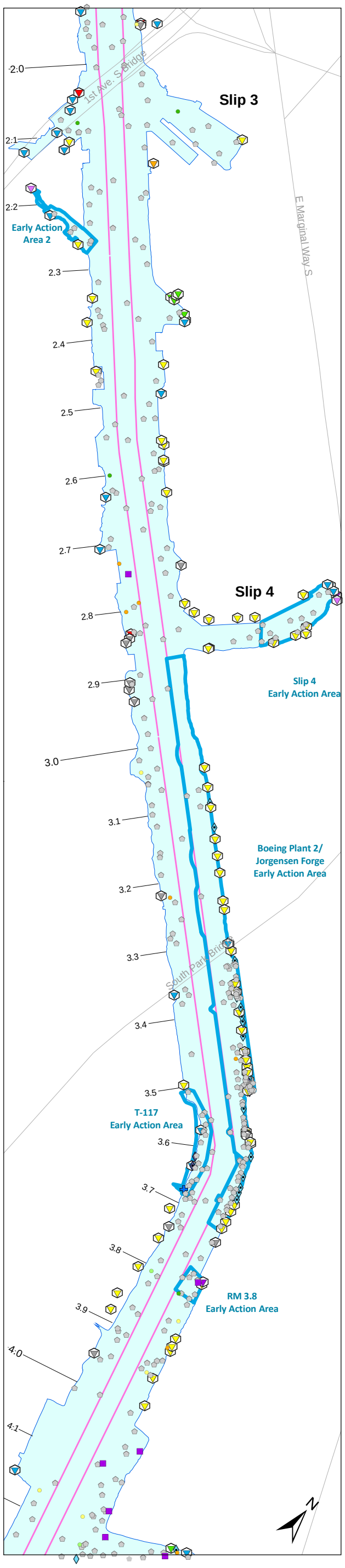
0 0.1 0.2 Kilometers

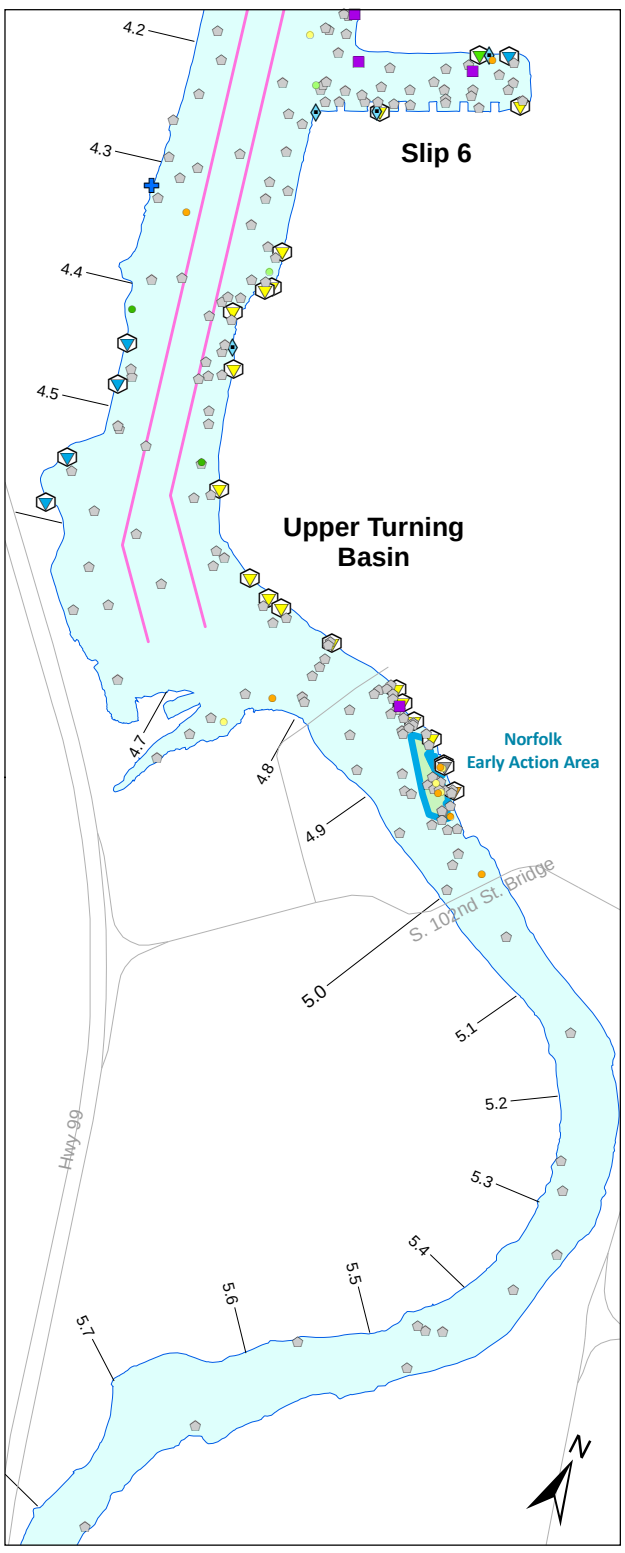
Scale is the same for each inset map

Map 4-64. Phenol concentrations in surface sediment

Prepared by CEH, 07/15/2010, MAP 2787, W:\Projects\03-08-06 Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\Other COCs







Benzoic acid concentration (µg/kg dw)[a]

- > 640
- > 190 and ≤ 640
- > 100 and ≤ 190
- > 95 and ≤ 100
- ≤ 95
- Non-detect
- > CSL
- > SQS and ≤ CSL
- ≤ SQS
- Early Action Area[b]
- Dredged and capped area[c]
- Thin-layer placement[c]
- Road
- Navigation channel
- River mile

95th percentile = 640
75th percentile = 190
50th percentile = 100
25th percentile = 95
CSL = SQS = 650

Outfall classification[d]

- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, a value of one-half the RL at that location was used.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Duwamish/Diagonal early action area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005. For the Norfolk early action area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

[d] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

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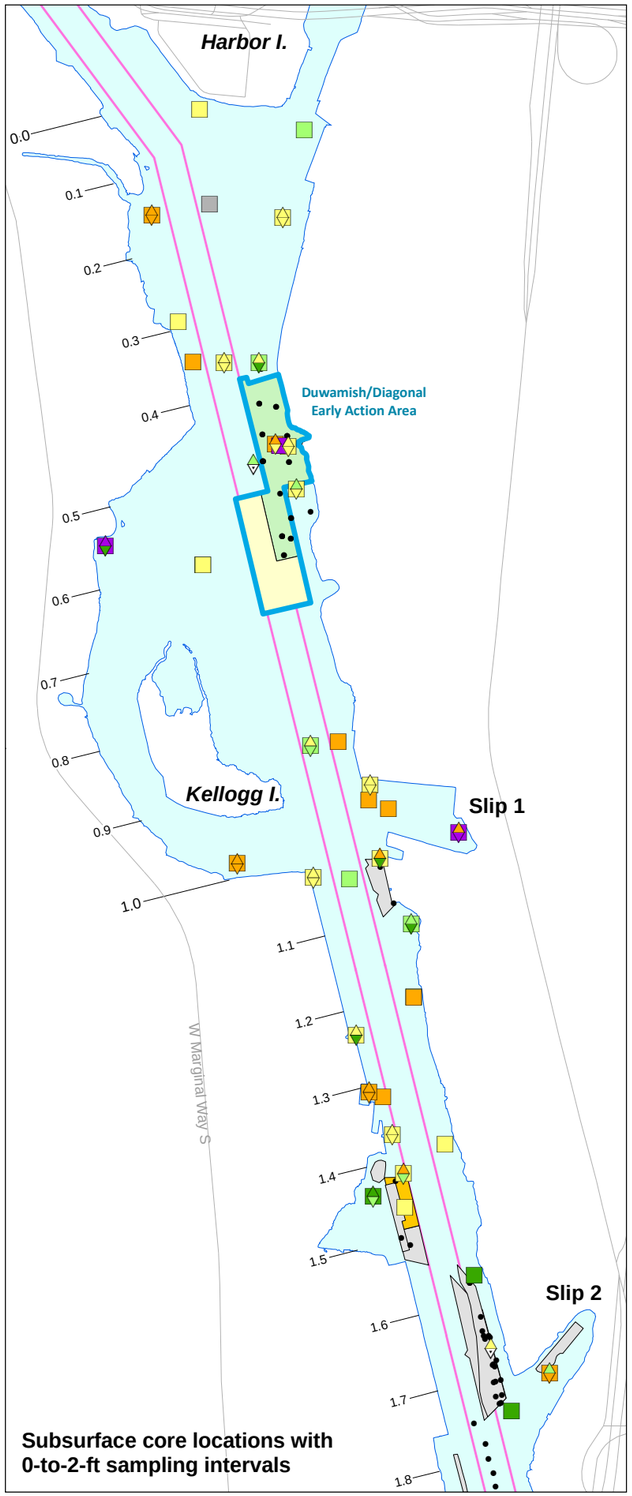
0 0.1 0.2 Miles

0 0.1 0.2 Kilometers

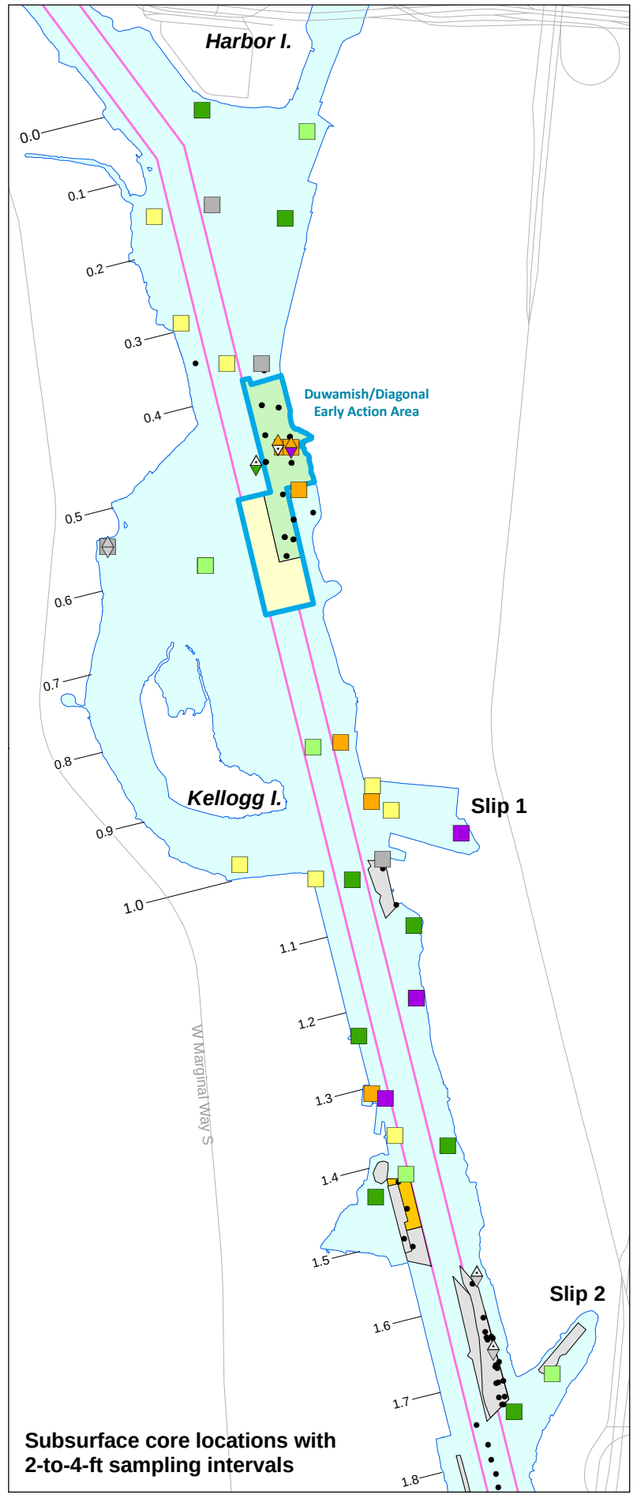
Scale is the same for each inset map

Map 4-65. Benzoic acid concentrations in surface sediment

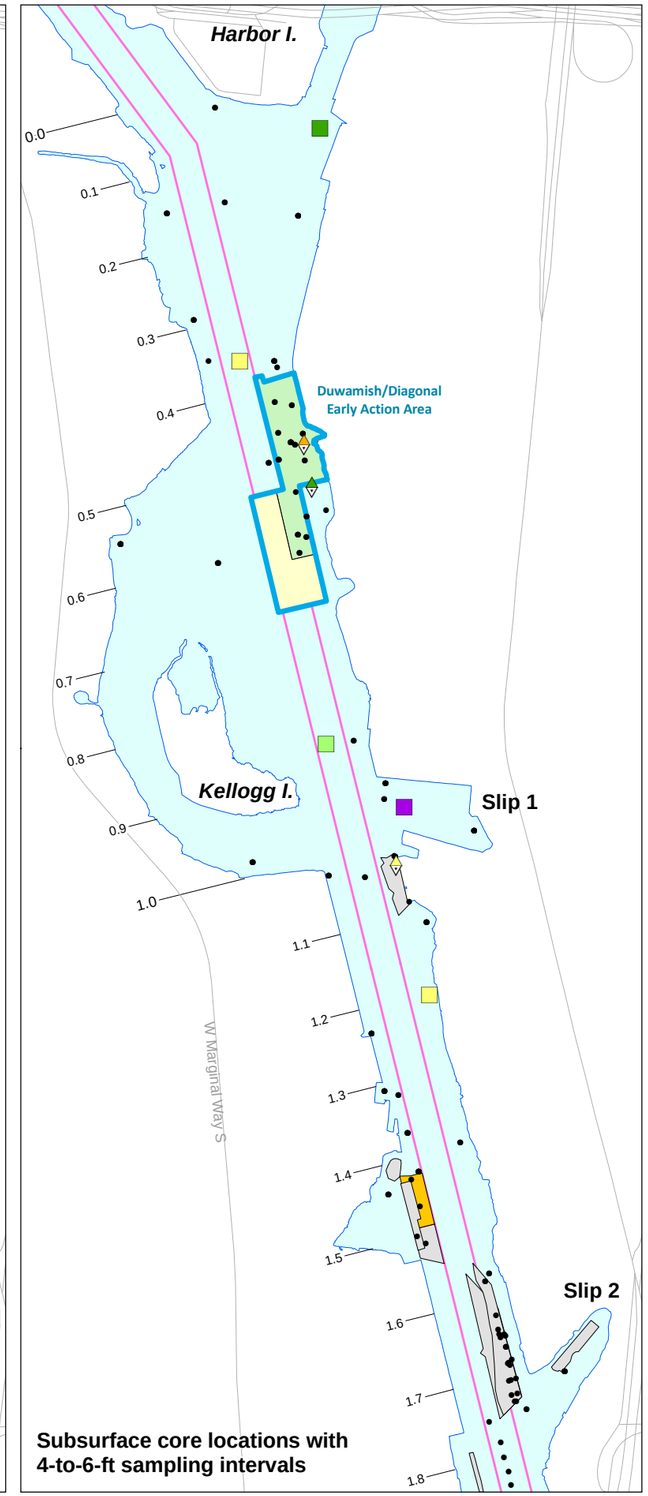
Prepared by CEH, 07/15/2010, MAP 2786: W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\Other COCs



Subsurface core locations with 0-to-2-ft sampling intervals



Subsurface core locations with 2-to-4-ft sampling intervals



Subsurface core locations with 4-to-6-ft sampling intervals

Total HPAH concentration (µg/kg dw)[a]

> 13,000	95th percentile = 13,000
> 4,200 and ≤ 13,000	75th percentile = 4,200
> 2,000 and ≤ 4,200	50th percentile = 2,000
> 830 and ≤ 2,000	25th percentile = 830
≤ 830	
Non-detect	

Sampling interval

	Left panel	Middle panel	Right panel
	0-to-2-ft[b]	2-to-4-ft[b]	4-to-6-ft[b]
	0-to-1-ft[c]	2-to-3-ft[c]	4-to-5-ft[c]
	1-to-2-ft[c]	3-to-4-ft[c]	5-to-6-ft[c]

Not analyzed in that sampling interval

Other subsurface sampling location analyzed for HPAHs, but not in the illustrated sampling intervals

Early Action Area[d]

Dredged area[e]

Dredged and capped area[e]

Dredged and thin-layer placement[e]

Thin-layer placement

Navigation channel

River mile

[a] In accordance with the Washington State SMS, Total HPAH represents the sum of the concentrations of detected HPAH compounds. Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, one-half the non-detect value was used.

[b] Data from 2-foot sampling intervals; some locations show an average of data from both 1-foot intervals within that 2-foot interval at a given location.

[c] Data from 1-foot sampling intervals are shown if available. If both 1-foot intervals within the 2-foot interval were collected, the average of the two intervals is also shown.

[d] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[e] Subsurface sediment data at locations in dredged areas were collected prior to dredging.

N

0 0.1 0.2 Kilometers

0 0.1 0.2 Miles

Scale is the same for each map frame

Map 4-66a. Total HPAH concentrations in subsurface sediment within the 0-to-2-ft, 2-to-4-ft, and 4-to-6-ft sampling intervals, RM 0.0 to RM 1.8

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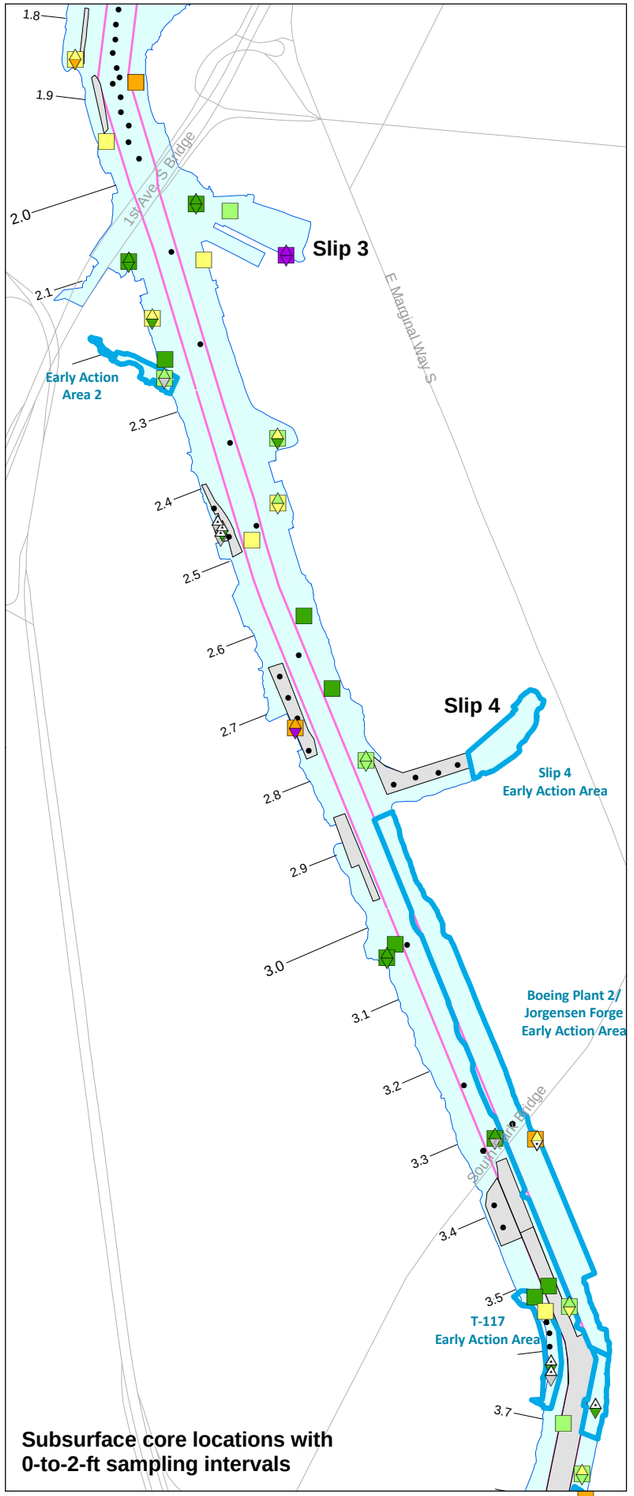
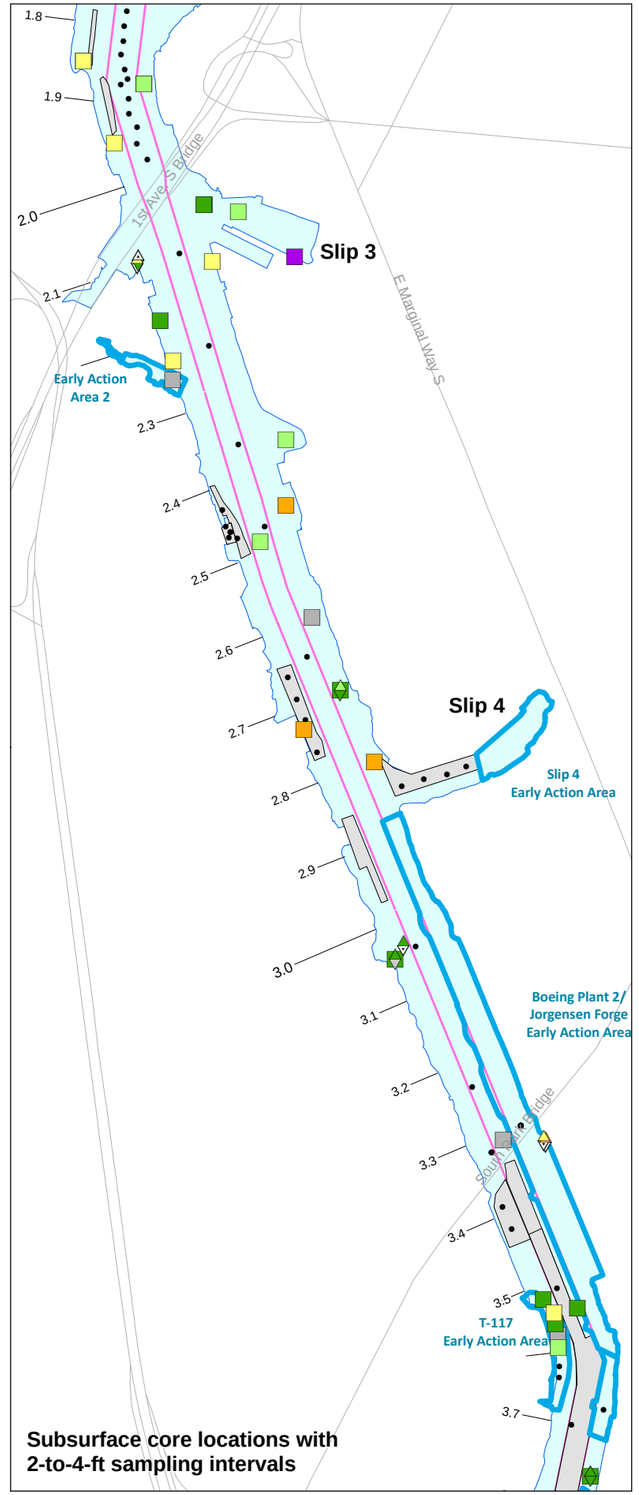
Prepared by CEH, 07/15/2010. MAP 2815: W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Depth Intervals\Other COCs

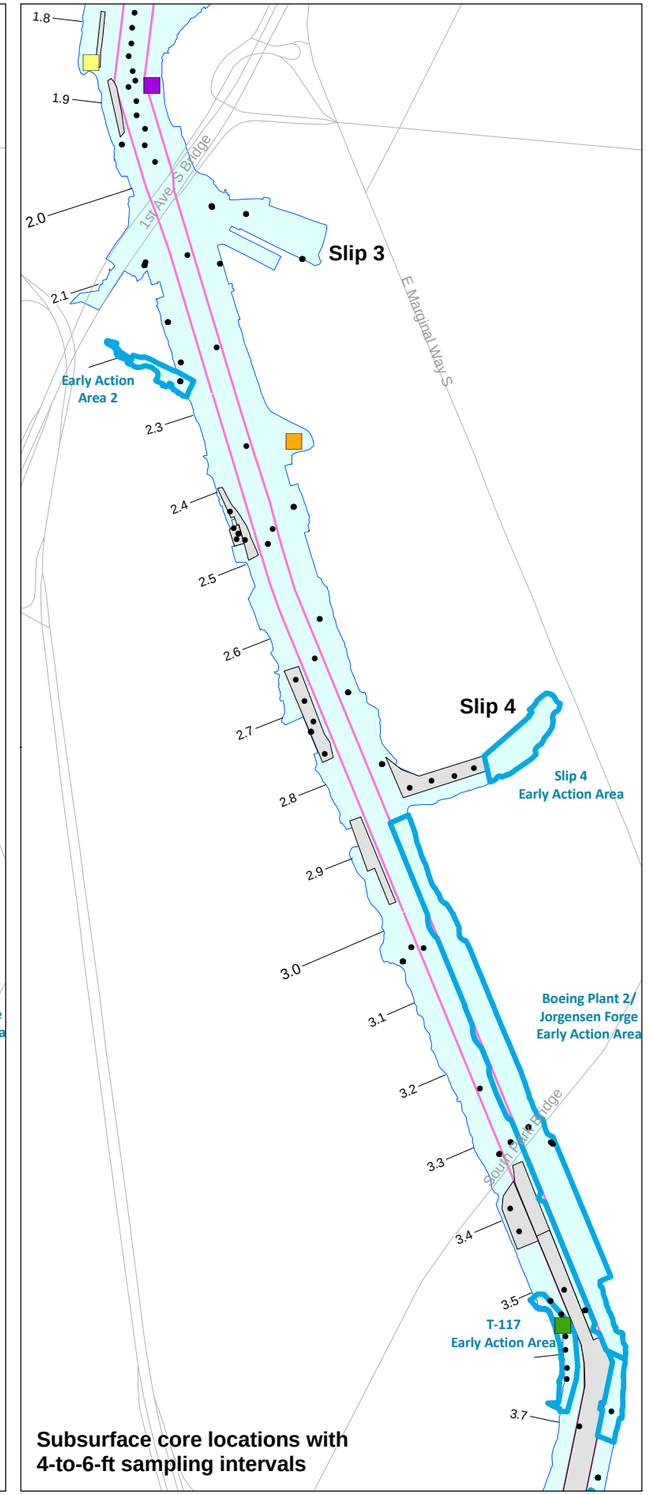
Dredging information provided by AECOM.



Subsurface core locations with 0-to-2-ft sampling intervals



Subsurface core locations with 2-to-4-ft sampling intervals



Subsurface core locations with 4-to-6-ft sampling intervals

Total HPAH concentration (µg/kg dw)[a]

> 13,000	95th percentile = 13,000
> 4,200 and ≤ 13,000	75th percentile = 4,200
> 2,000 and ≤ 4,200	50th percentile = 2,000
> 830 and ≤ 2,000	25th percentile = 830
≤ 830	
Non-detect	

Sampling interval

	Left panel	Middle panel	Right panel
	0-to-2-ft[b]	2-to-4-ft[b]	4-to-6-ft[b]
	0-to-1-ft[c]	2-to-3-ft[c]	4-to-5-ft[c]
	1-to-2-ft[c]	3-to-4-ft[c]	5-to-6-ft[c]

Not analyzed in that sampling interval

Other subsurface sampling location analyzed for HPAHs, but not in the illustrated sampling intervals

Early Action Area[d]

Dredged area[e]

Navigation channel

River mile

[a] In accordance with the Washington State SMS, Total HPAH represents the sum of the concentrations of detected HPAH compounds. Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, one-half the non-detect value was used.

[b] Data from 2-foot sampling intervals; some locations show an average of data from both 1-foot intervals within that 2-foot interval at a given location.

[c] Data from 1-foot sampling intervals are shown if available. If both 1-foot intervals within the 2-foot interval were collected, the average of the two intervals is also shown.

[d] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[e] Subsurface sediment data at locations in dredged areas were collected prior to dredging.

N

0 0.1 0.2 Kilometers

0 0.1 0.2 Miles

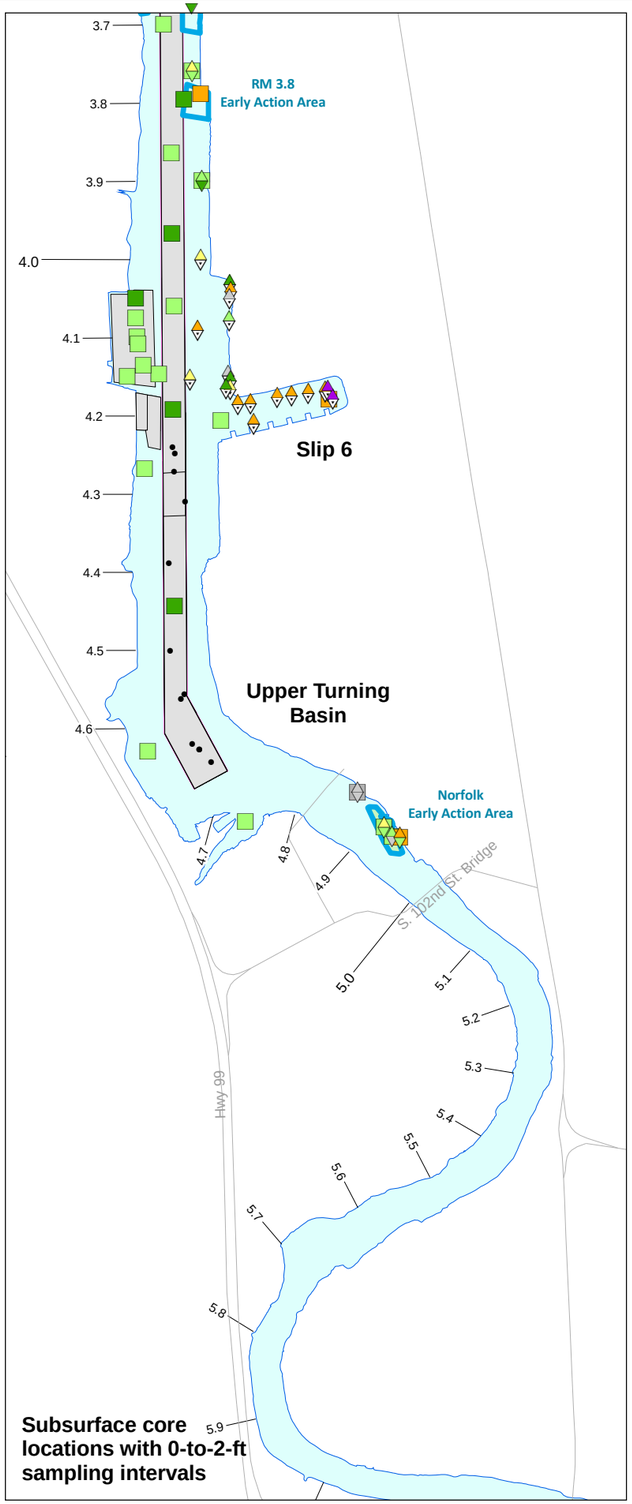
Scale is the same for each map frame

Map 4-66b. Total HPAH concentrations in subsurface sediment within the 0-to-2-ft, 2-to-4-ft, and 4-to-6-ft sampling intervals, RM 1.8 to RM 3.7

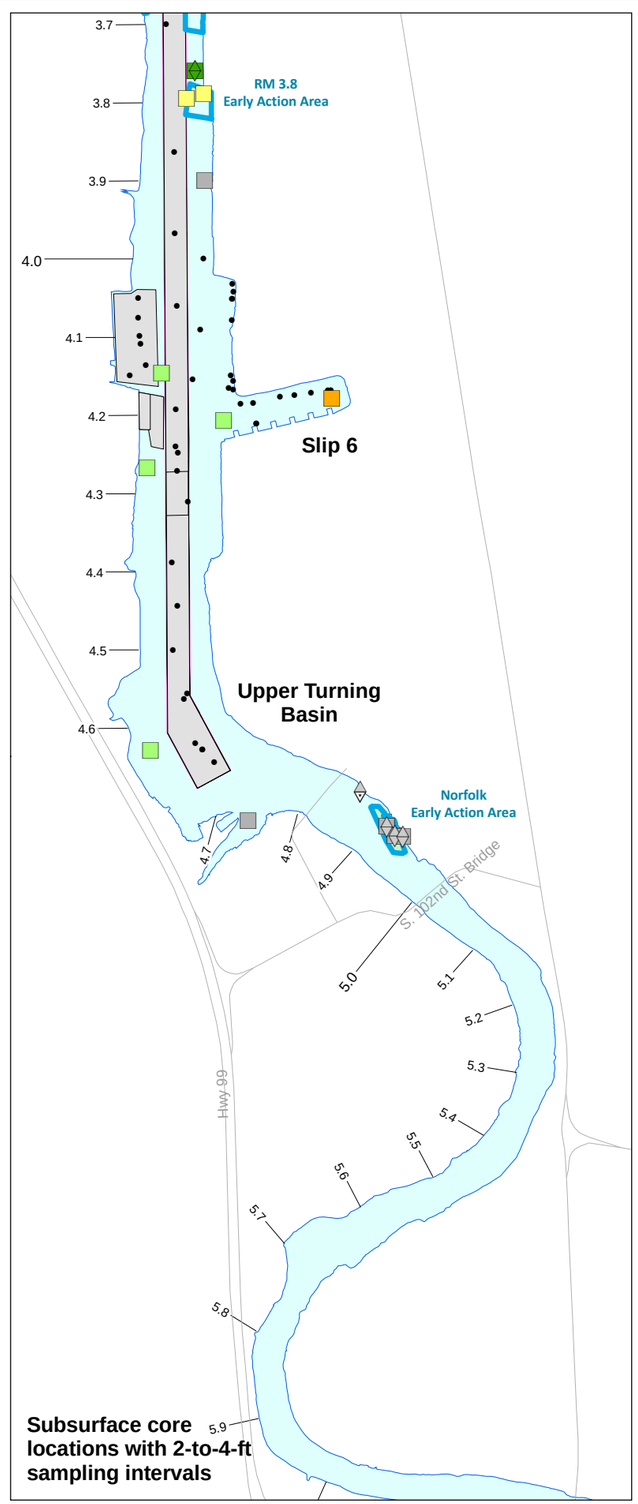
Windward environmental LLC

Prepared by: CEH, 07/15/2010, MAP 2815, W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Depth Interval\Other COCs

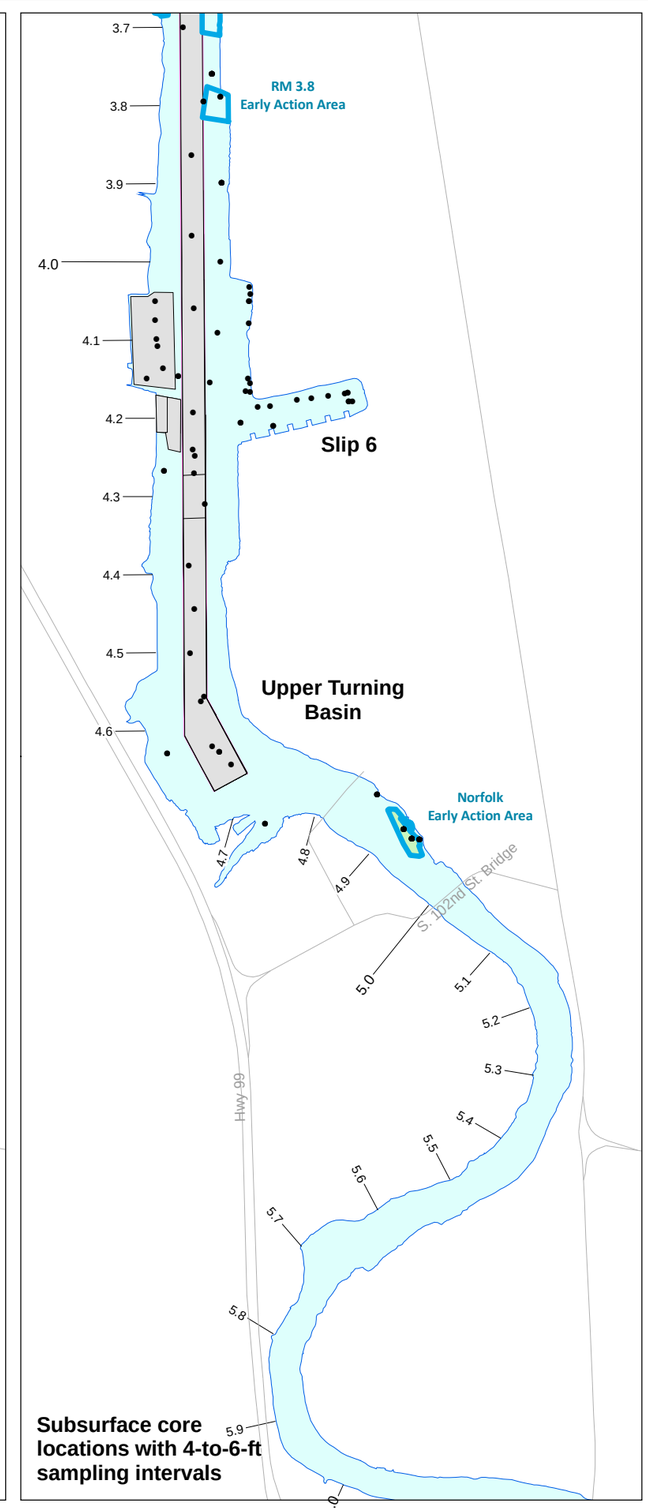
Dredging information provided by AECOM.



Subsurface core locations with 0-to-2-ft sampling intervals



Subsurface core locations with 2-to-4-ft sampling intervals



Subsurface core locations with 4-to-6-ft sampling intervals

Total HPAH concentration (µg/kg dw)[a]

- > 13,000 — 95th percentile = 13,000
- > 4,200 and ≤ 13,000 — 75th percentile = 4,200
- > 2,000 and ≤ 4,200 — 50th percentile = 2,000
- > 830 and ≤ 2,000 — 25th percentile = 830
- ≤ 830
- Non-detect

Sampling interval

	Left panel	Middle panel	Right panel
	0-to-2-ft[b]	2-to-4-ft[b]	4-to-6-ft[b]
	0-to-1-ft[c]	2-to-3-ft[c]	4-to-5-ft[c]
	1-to-2-ft[c]	3-to-4-ft[c]	5-to-6-ft[c]

- Not analyzed in that sampling interval
- Other subsurface sampling location analyzed for HPAHs, but not in the illustrated sampling intervals
- Early Action Area[d]
- Dredged area[e]
- Dredged and capped area[e]
- Navigation channel
- River mile

[a] In accordance with the Washington State SMS, Total HPAH represents the sum of the concentrations of detected HPAH compounds. Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, one-half the non-detect value was used.

[b] Data from 2-foot sampling intervals; some locations show an average of data from both 1-foot intervals within that 2-foot interval at a given location.

[c] Data from 1-foot sampling intervals are shown if available. If both 1-foot intervals within the 2-foot interval were collected, the average of the two intervals is also shown.

[d] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[e] Subsurface sediment data at locations in dredged areas were collected prior to dredging.

N

0 0.1 0.2 Kilometers

0 0.1 0.2 Miles

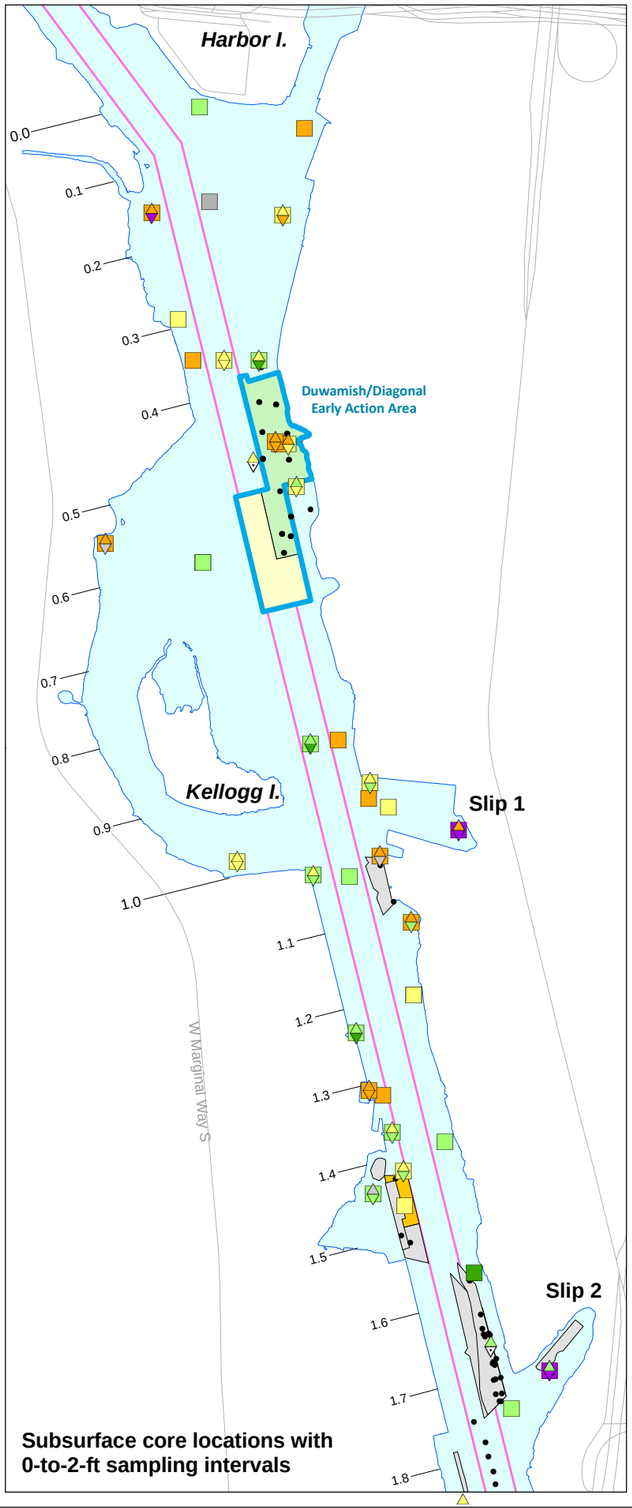
Scale is the same for each map frame

Map 4-66c. Total HPAH concentrations in subsurface sediment within the 0-to-2-ft, 2-to-4-ft, and 4-to-6-ft sampling intervals, RM 3.7 to RM 6.0

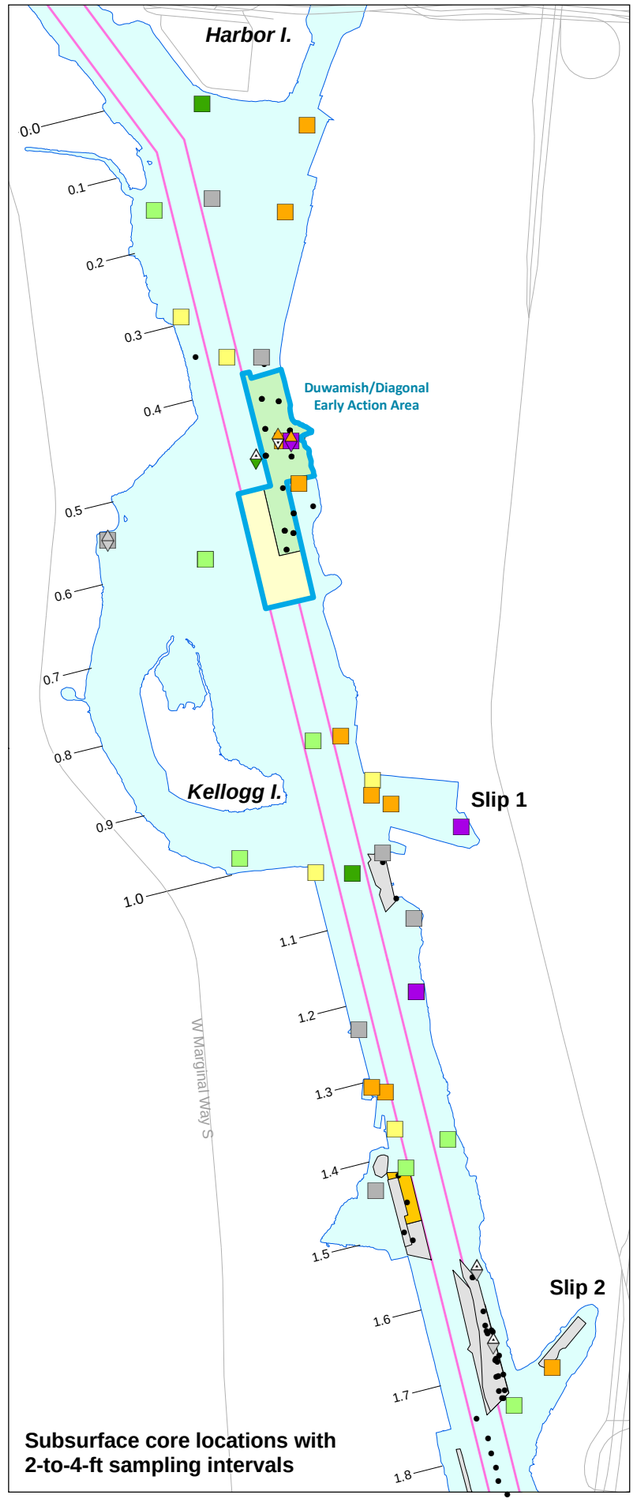
Wind Ward environmental LLC

Prepared by CEH, 07/15/2010. MAP 2815. W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Depth Interval\Other COCs

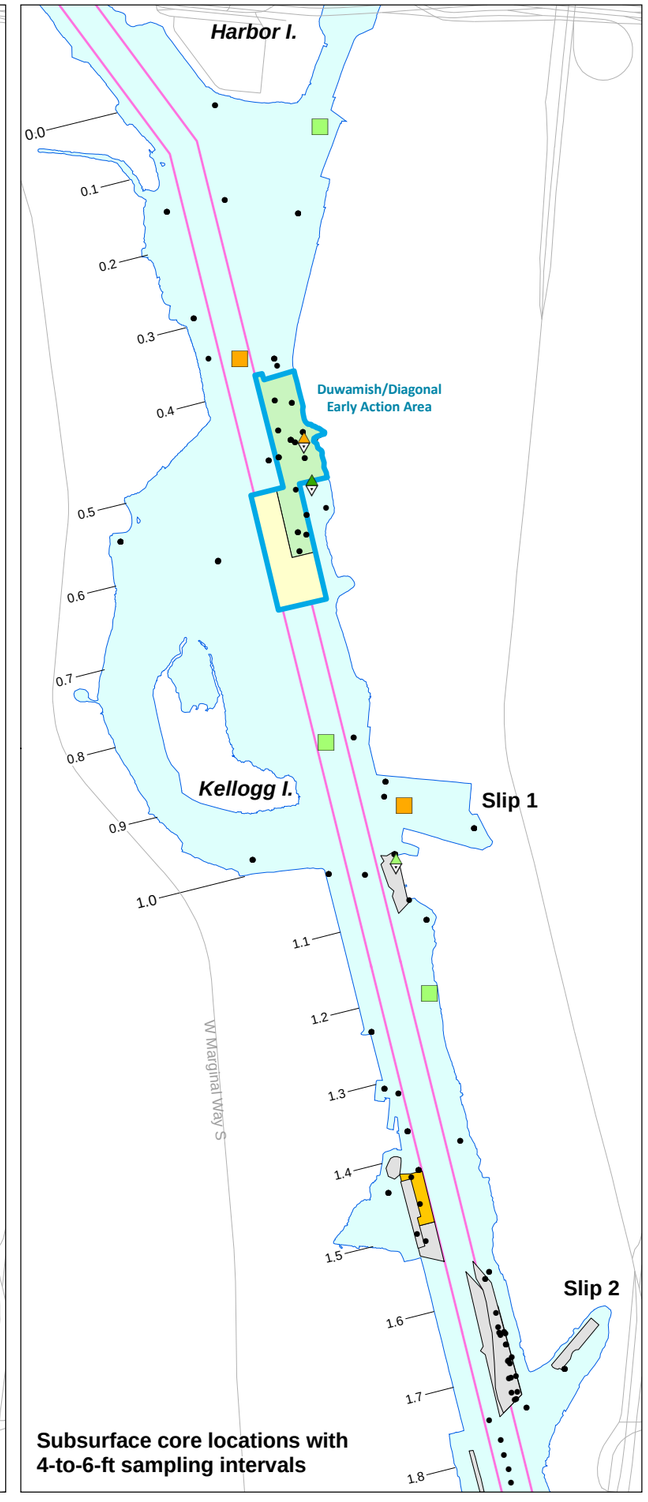
Dredging information provided by AECOM.



Subsurface core locations with 0-to-2-ft sampling intervals



Subsurface core locations with 2-to-4-ft sampling intervals



Subsurface core locations with 4-to-6-ft sampling intervals

Total LPAH concentration (µg/kg dw)[a]

> 2,300	95th percentile = 2,300
> 550 and ≤ 2,300	75th percentile = 550
> 230 and ≤ 550	50th percentile = 230
> 84 and ≤ 230	25th percentile = 84
≤ 84	
Non-detect	

Sampling interval

	Left panel	Middle panel	Right panel
	0-to-2-ft[b]	2-to-4-ft[b]	4-to-6-ft[b]
	0-to-1-ft[c]	2-to-3-ft[c]	4-to-5-ft[c]
	1-to-2-ft[c]	3-to-4-ft[c]	5-to-6-ft[c]

Not analyzed in that sampling interval

Other subsurface sampling location analyzed for LPAHs, but not in the illustrated sampling intervals

Early Action Area[d]

Dredged area[e]

Dredged and capped area[e]

Dredged and thin-layer placement[e]

Thin-layer placement

Navigation channel

River mile

[a] In accordance with the Washington State SMS, Total LPAH represents the sum of the concentrations of detected LPAH compounds. Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, one-half the non-detect value was used.

[b] Data from 2-foot sampling intervals; some locations show an average of data from both 1-foot intervals within that 2-foot interval at a given location.

[c] Data from 1-foot sampling intervals are shown if available. If both 1-foot intervals within the 2-foot interval were collected, the average of the two intervals is also shown.

[d] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[e] Subsurface sediment data at locations in dredged areas were collected prior to dredging.

N

0 0.1 0.2 Kilometers

0 0.1 0.2 Miles

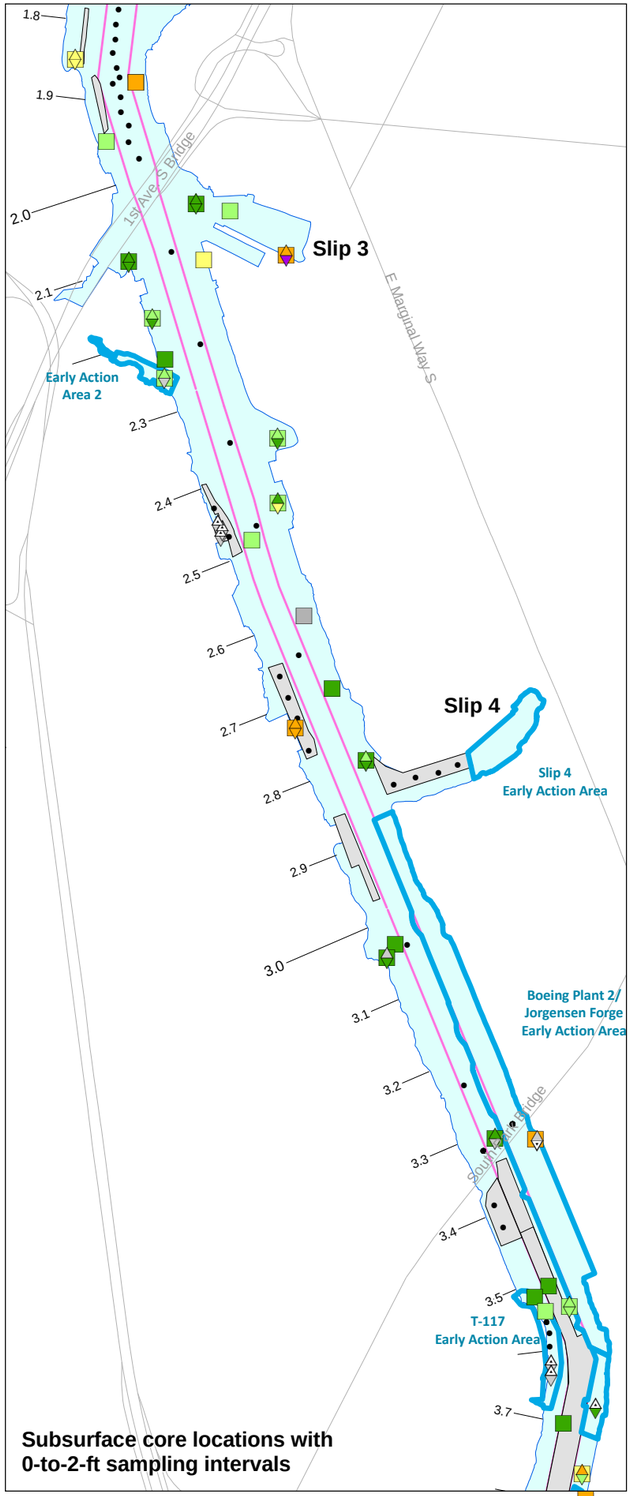
Scale is the same for each map frame

Map 4-67a. Total LPAH concentrations in subsurface sediment within the 0-to-2-ft, 2-to-4-ft, and 4-to-6-ft sampling intervals, RM 0.0 to RM 1.8

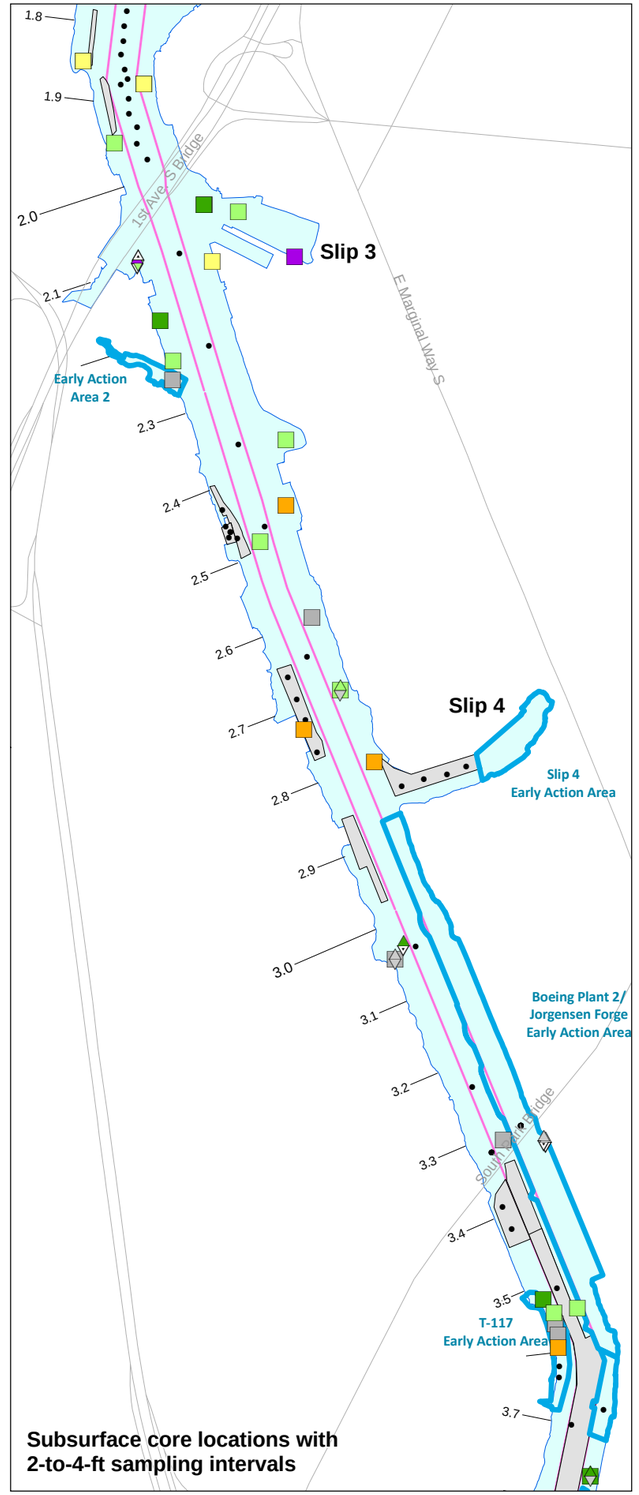
Windward environmental LLC

Prepared by: CEH, 07/15/2010, MAP 2814, W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Depth Intervals\Other COCs

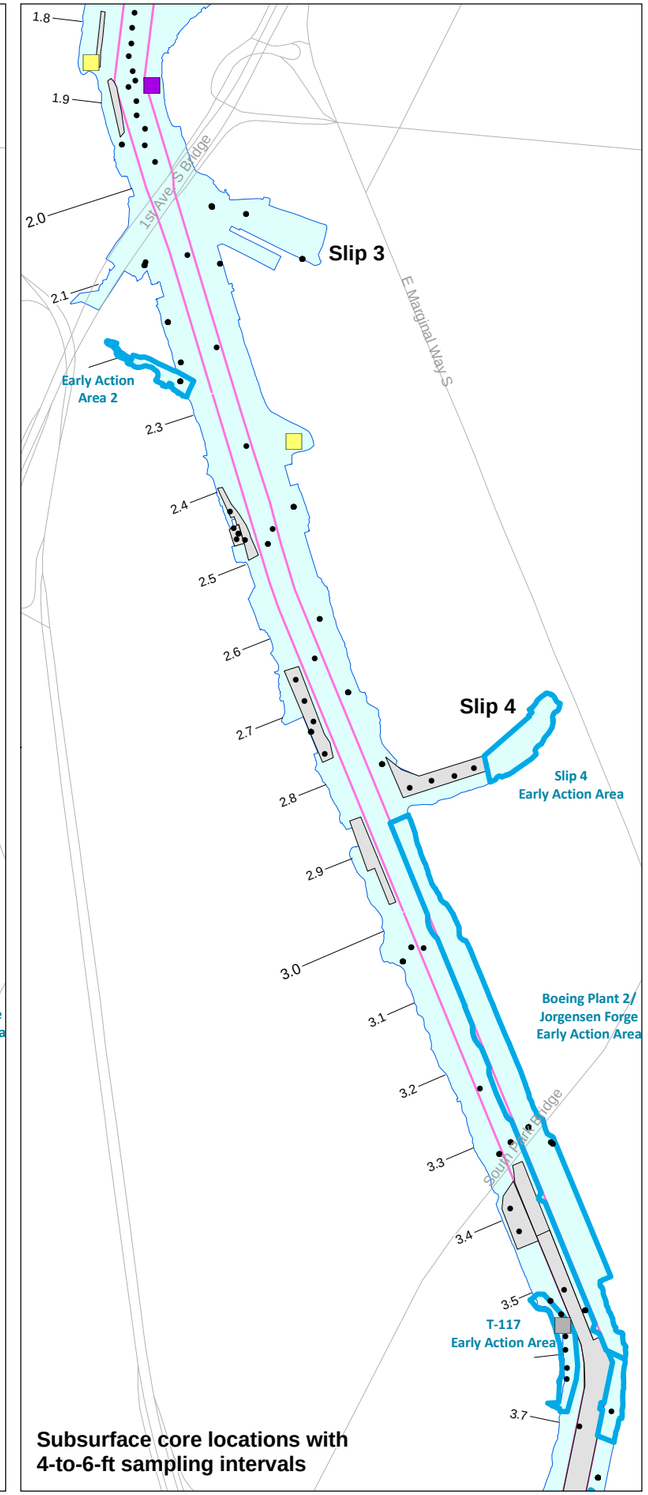
Dredging information provided by AECOM.



Subsurface core locations with 0-to-2-ft sampling intervals



Subsurface core locations with 2-to-4-ft sampling intervals



Subsurface core locations with 4-to-6-ft sampling intervals

Total LPAH concentration (µg/kg dw)[a]

> 2,300	95th percentile = 2,300
> 550 and ≤ 2,300	75th percentile = 550
> 230 and ≤ 550	50th percentile = 230
> 84 and ≤ 230	25th percentile = 84
≤ 84	
Non-detect	

Sampling interval

	Left panel	Middle panel	Right panel
	0-to-2-ft[b]	2-to-4-ft[b]	4-to-6-ft[b]
	0-to-1-ft[c]	2-to-3-ft[c]	4-to-5-ft[c]
	1-to-2-ft[c]	3-to-4-ft[c]	5-to-6-ft[c]

Not analyzed in that sampling interval

Other subsurface sampling location analyzed for LPAHs, but not in the illustrated sampling intervals

Early Action Area[d]

Dredged area[e]

Navigation channel

River mile

[a] In accordance with the Washington State SMS, Total LPAH represents the sum of the concentrations of detected LPAH compounds. Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, one-half the non-detect value was used.

[b] Data from 2-foot sampling intervals; some locations show an average of data from both 1-foot intervals within that 2-foot interval at a given location.

[c] Data from 1-foot sampling intervals are shown if available. If both 1-foot intervals within the 2-foot interval were collected, the average of the two intervals is also shown.

[d] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[e] Subsurface sediment data at locations in dredged areas were collected prior to dredging.

N

0 0.1 0.2 Kilometers

0 0.1 0.2 Miles

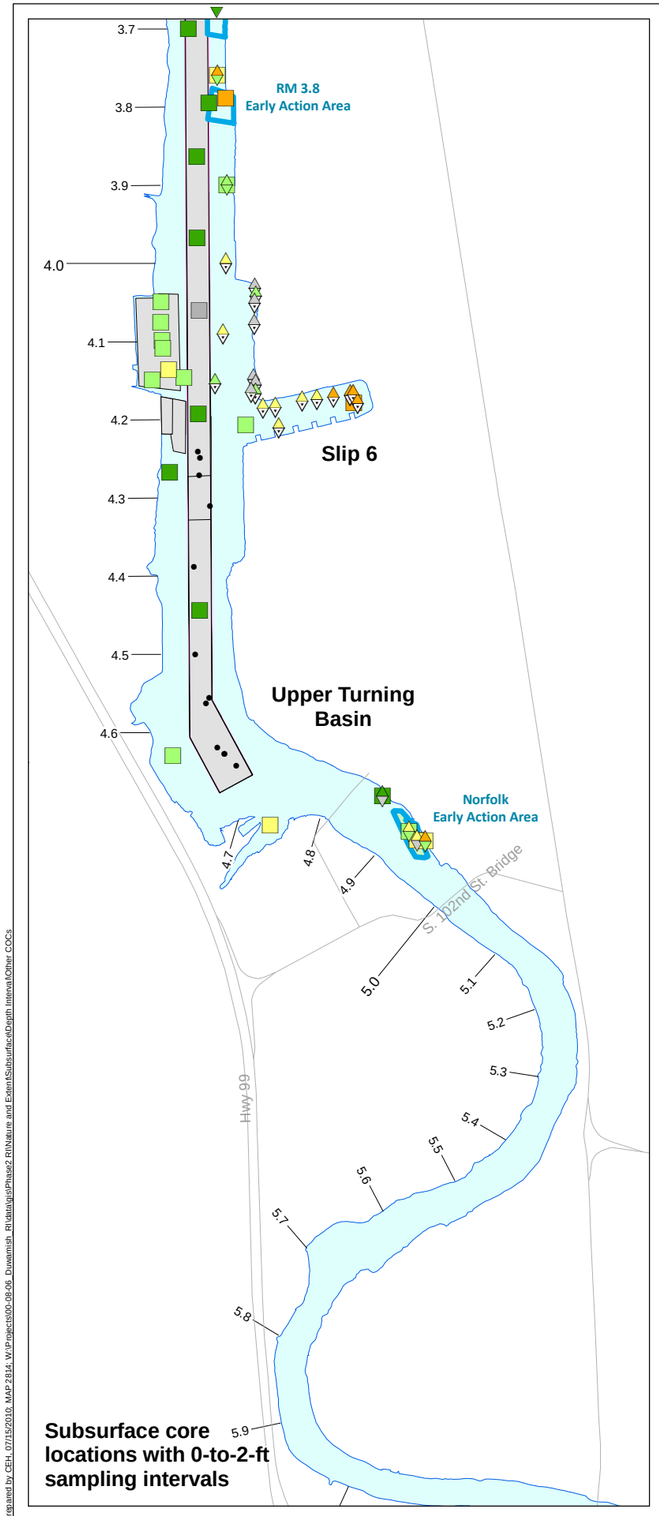
Scale is the same for each map frame

Map 4-67b. Total LPAH concentrations in subsurface sediment within the 0-to-2-ft, 2-to-4-ft, and 4-to-6-ft sampling intervals, RM 1.8 to RM 3.7

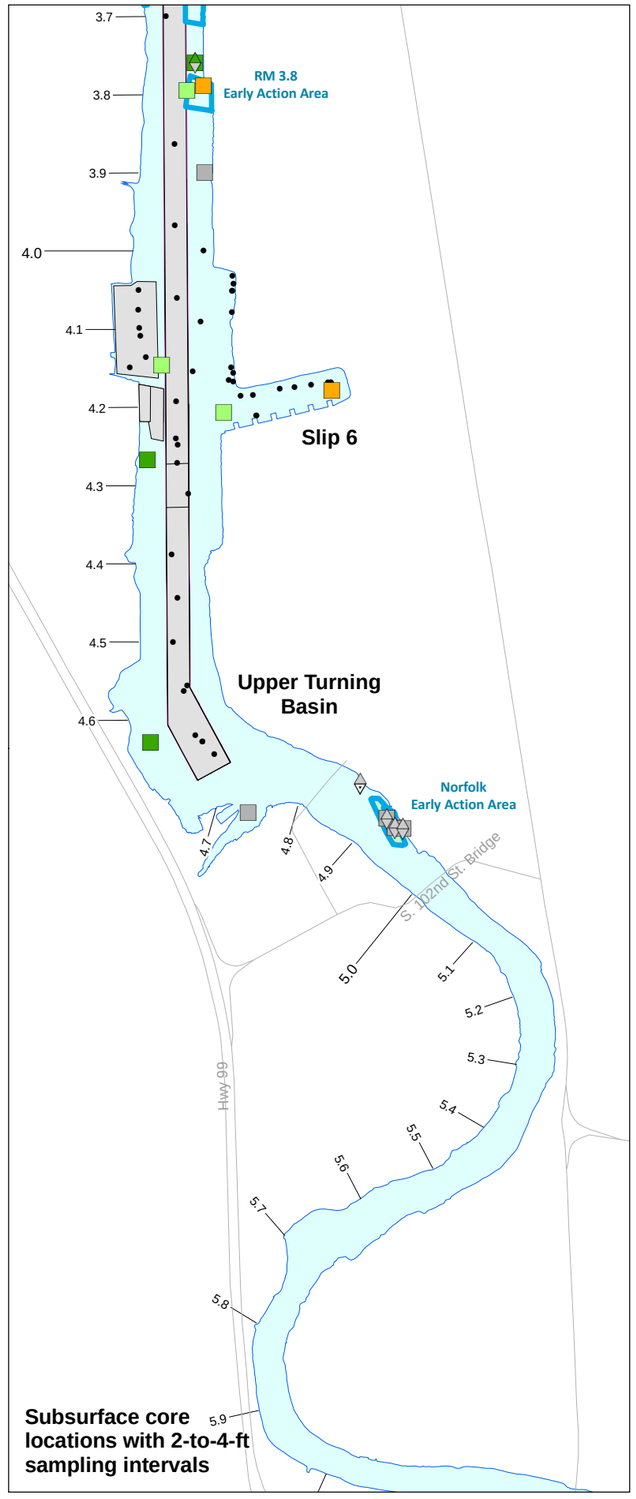
Wind Ward environmental LLC

Prepared by: CEH, 07/15/2010, MAP 2814, W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Depth Interval\Other COCs

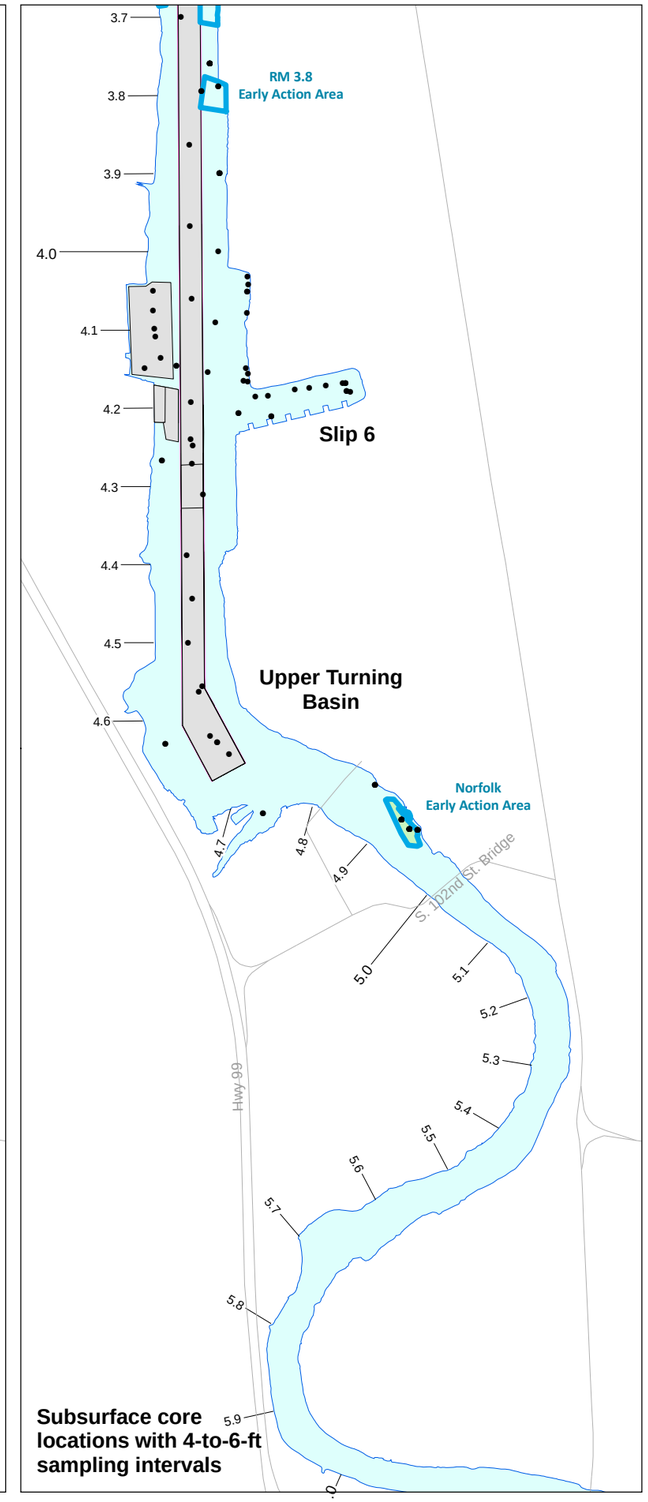
Dredging information provided by AECOM.



Subsurface core locations with 0-to-2-ft sampling intervals



Subsurface core locations with 2-to-4-ft sampling intervals



Subsurface core locations with 4-to-6-ft sampling intervals

Total LPAH concentration (µg/kg dw)[a]

- > 2,300
- > 550 and ≤ 2,300
- > 230 and ≤ 550
- > 84 and ≤ 230
- ≤ 84
- Non-detect

95th percentile = 2,300
75th percentile = 550
50th percentile = 230
25th percentile = 84

Sampling interval

	Left panel	Middle panel	Right panel
	0-to-2-ft[b]	2-to-4-ft[b]	4-to-6-ft[b]
	0-to-1-ft[c]	2-to-3-ft[c]	4-to-5-ft[c]
	1-to-2-ft[c]	3-to-4-ft[c]	5-to-6-ft[c]

- Not analyzed in that sampling interval
- Other subsurface sampling location analyzed for LPAHs, but not in the illustrated sampling intervals
- Early Action Area[d]
- Dredged area[e]
- Dredged and capped area[e]
- Navigation channel
- River mile

[a] In accordance with the Washington State SMS, Total LPAH represents the sum of the concentrations of detected LPAH compounds. Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. For locations with non-detects, one-half the non-detect value was used.

[b] Data from 2-foot sampling intervals; some locations show an average of data from both 1-foot intervals within that 2-foot interval at a given location.

[c] Data from 1-foot sampling intervals are shown if available. If both 1-foot intervals within the 2-foot interval were collected, the average of the two intervals is also shown.

[d] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[e] Subsurface sediment data at locations in dredged areas were collected prior to dredging.

N

0 0.1 0.2 Kilometers

0 0.1 0.2 Miles

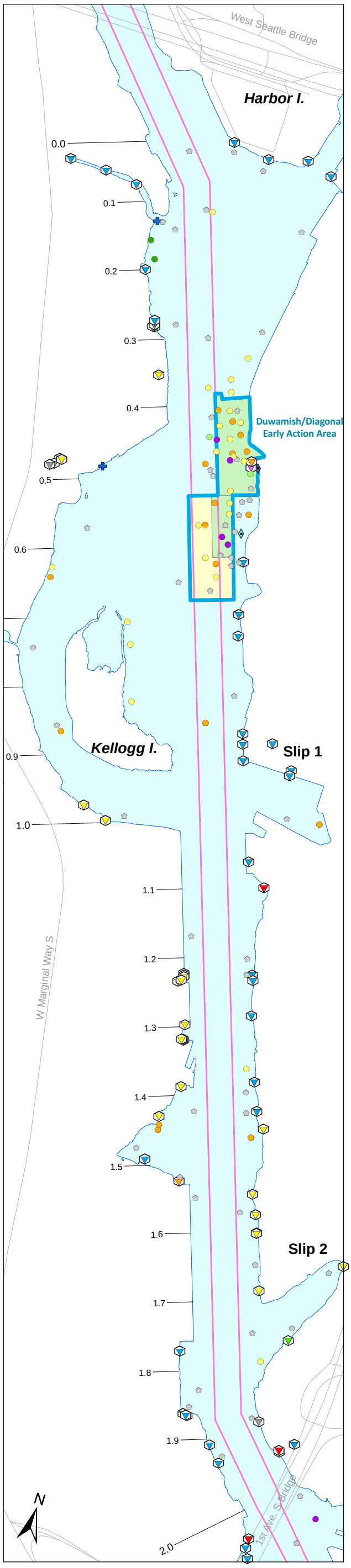
Scale is the same for each map frame

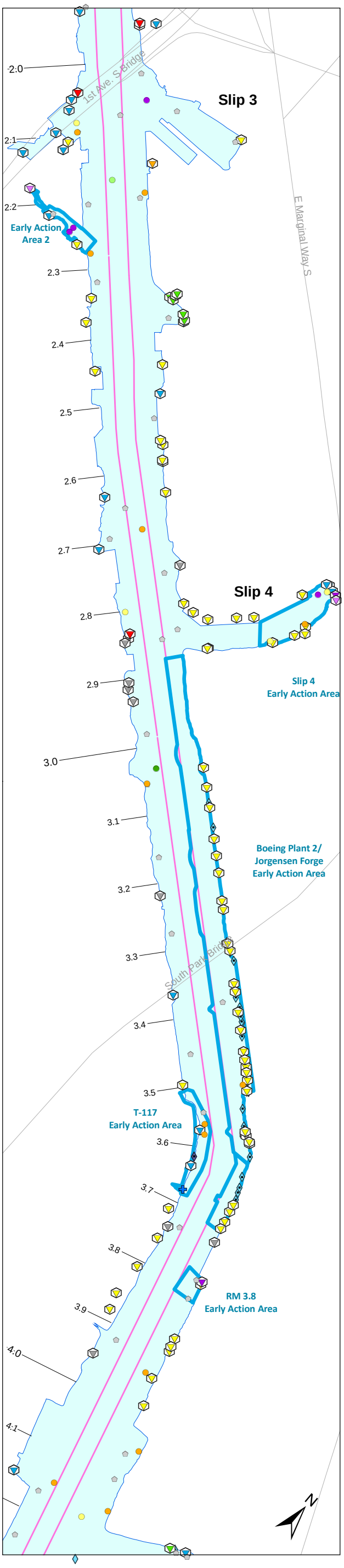
Map 4-67c. Total LPAH concentrations in subsurface sediment within the 0-to-2-ft, 2-to-4-ft, and 4-to-6-ft sampling intervals, RM 3.7 to RM 6.0

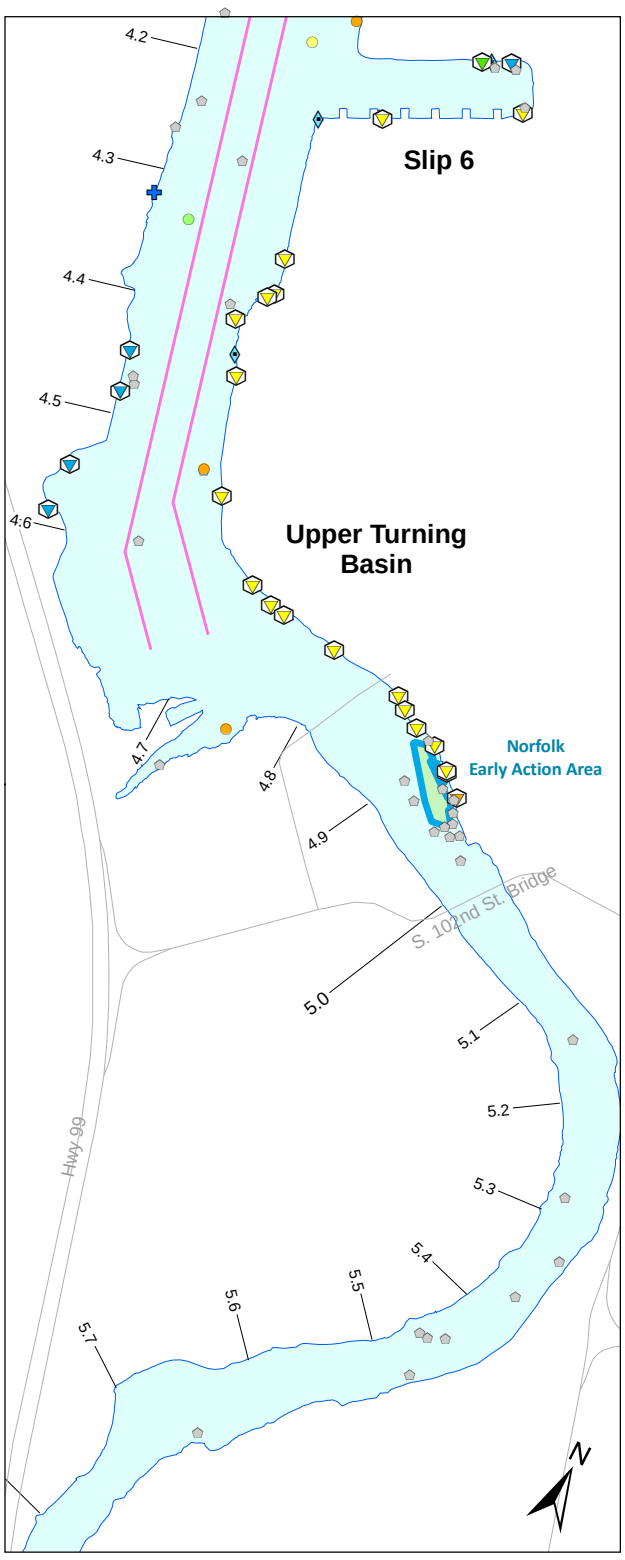
Wind Ward environmental LLC

Prepared by CEH, 07/15/2010, MAP 2834, W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Depth Interval\Other COCs

Dredging information provided by AECOM.







Total DDT concentration (µg/kg dw)[a]

- > 70
- > 7.8 and ≤ 70
- > 2.7 and ≤ 7.8
- > 1.0 and ≤ 2.7
- ≤ 1.0
- Non-detect
- Early Action Area[b]
- Dredged and capped area[c]
- Thin-layer placement[c]
- Road
- Navigation channel
- River mile

95th percentile = 70
75th percentile = 7.8
50th percentile = 2.7
25th percentile = 1.0

Outfall classification[d]

- CSO
- CSO/storm drain
- EOF
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Stream, channel, or swale

[a] Percentiles were calculated on a numerical basis using both detected and non-detected values from the baseline surface sediment dataset. Total DDT values represent the sum of the concentrations of the DDT, DDD, and DDE congeners, using one-half the RL for undetected congeners.

[b] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[c] For the Duwamish/Diagonal early action area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005. For the Norfolk early action area, surface sediment data represent samples collected after dredging and capping at the Norfolk CSO removal area in 1999 and before sediment removal and capping at the Boeing Developmental Center south storm drain in 2003.

[d] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

Windward environmental LLC

0 0.1 0.2 Miles

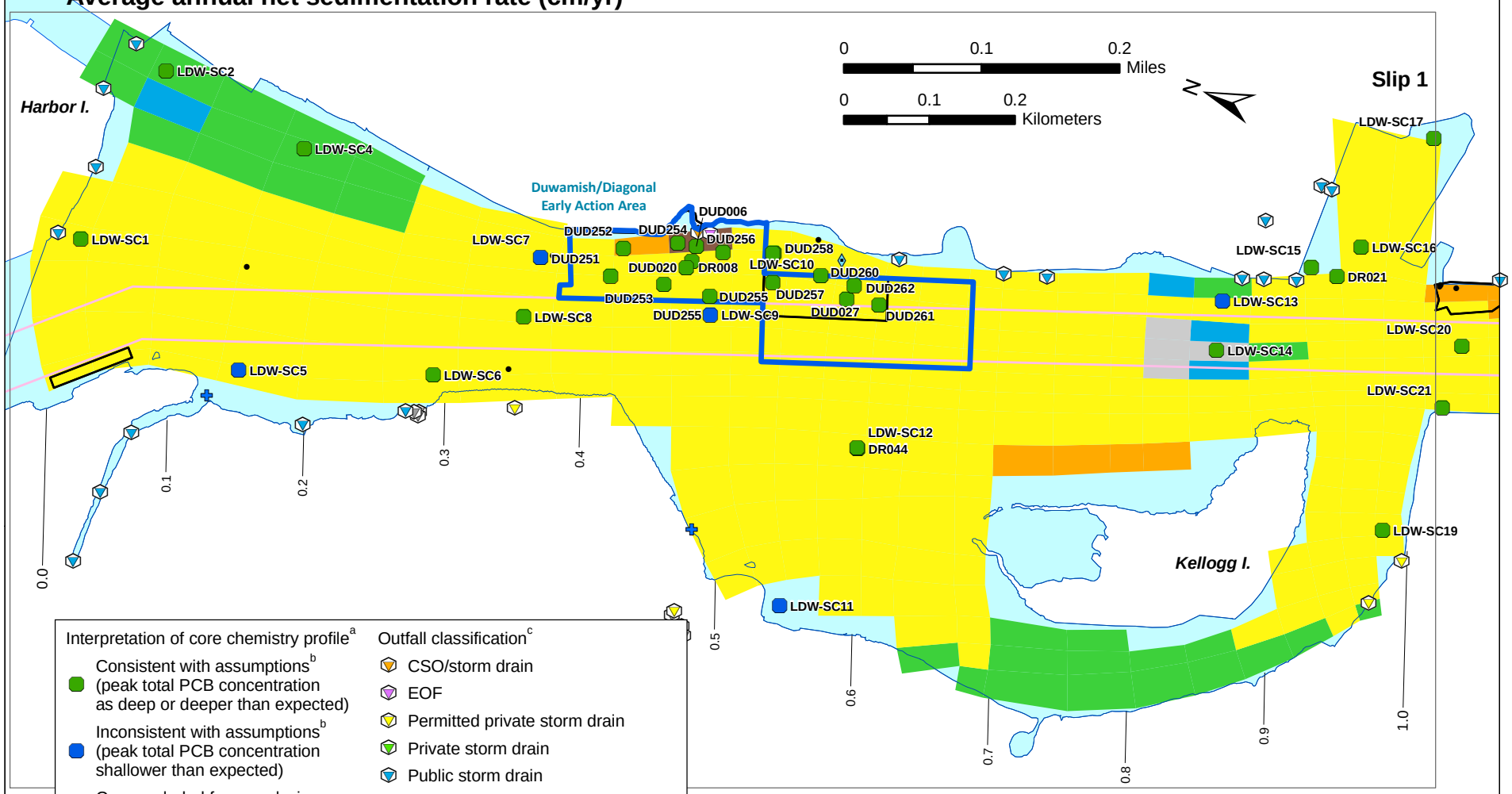
0 0.1 0.2 Kilometers

Scale is the same for each inset map

Map 4-68. Total DDT concentrations in surface sediment

Prepared by CEH, 07/15/2010; MAP 2576; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Surface Sediment\Other COCs

Average annual net sedimentation rate (cm/yr)



Interpretation of core chemistry profile[a]

- Consistent with assumptions[b] (peak total PCB concentration as deep or deeper than expected)
- Inconsistent with assumptions[b] (peak total PCB concentration shallower than expected)
- Core excluded from analysis

Average annual net sedimentation rate from STM (cm/yr)

- Net sediment loss
- 0.1 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- > 3.0
- Outside of STM modeling area

Outfall classification[c]

- CSO/storm drain
- EOF
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Stream, channel, or swale
- Early action area[d]
- Dredged area[e]
- River mile
- Navigation channel

[a] Cores from the RI surface sediment dataset were excluded from this analysis if at least one of the following conditions was met: 1) only one core interval was analyzed for total PCBs, 2) no core interval was analyzed within the depth range of the expected peak, 3) PCBs were not detected, or 4) dredging occurred prior to sampling.

[b] Analysis assumptions
- Annual average net sedimentation rates are from the STM report (QEA 2008)
- Peak usage and release of PCBs assumed to be 1960, 1965, or 1974
- No localized disturbances (e.g., dredging, tug maneuvering)

[c] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

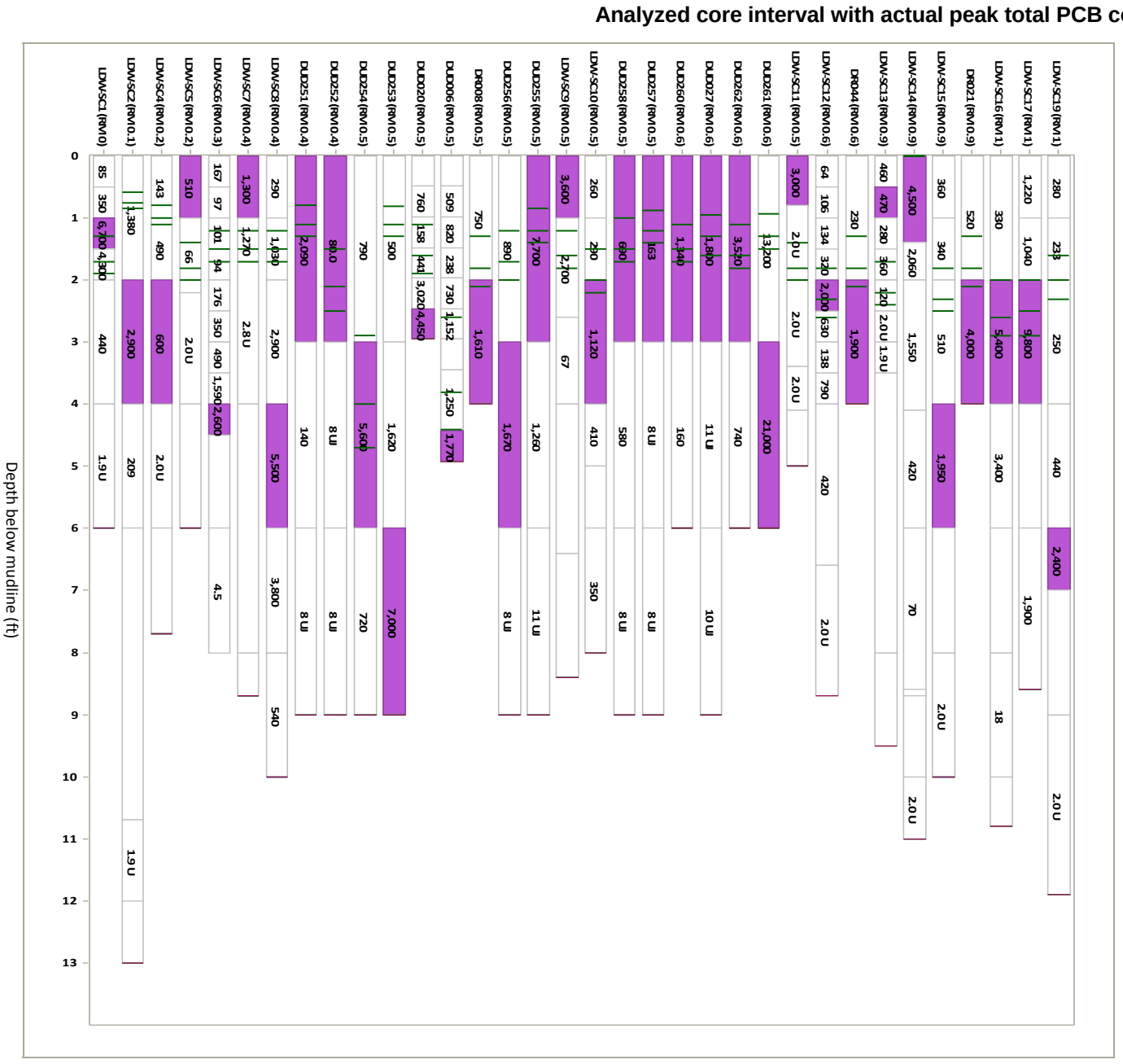
[d] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[e] Cores located within dredged areas were collected prior to dredging.

Peak total PCB concentrations in subsurface cores

Estimated depth of peak total PCB concentration — 1974, 1965, 1960

Analyzed core interval with actual peak total PCB concentration



Prepared by CEH, 07/15/2010; MAP 3068; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Core Analysis

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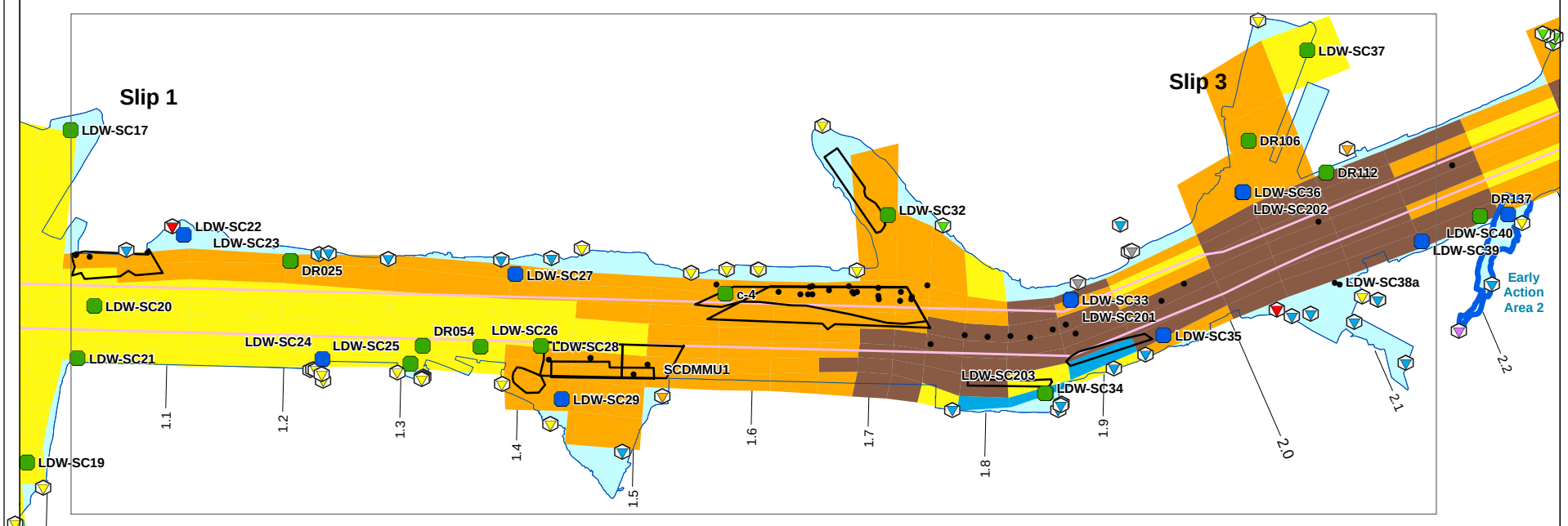
Map 4-69a. Comparison of actual and estimated depths of peak total PCB concentrations in cores based on annual average net sedimentation rates and source assumptions, RM 0.0 to RM 1.0

Average annual net sedimentation rate (cm/yr)



Interpretation of core chemistry profile[a]

- Consistent with assumptions[b] (peak total PCB concentration as deep or deeper than expected)
- Inconsistent with assumptions[b] (peak total PCB concentration shallower than expected)
- Core excluded from analysis

Average annual net sedimentation rate from STM (cm/yr)

- Net sediment loss
- 0.1 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- > 3.0
- Outside of STM modeling area

Outfall classification[c]

- CSO
- CSO/storm drain
- EOF
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Early action area[d]
- Dredged area[e]
- River mile
- Navigation channel

0 0.1 0.2 Miles

0 0.1 0.2 Kilometers

N

[a] Cores from the RI surface sediment dataset were excluded from this analysis if at least one of the following conditions was met: 1) only one core interval was analyzed for total PCBs, 2) no core interval was analyzed within the depth range of the expected peak, 3) PCBs were not detected, or 4) dredging occurred prior to sampling.

[b] Analysis assumptions
- Annual average net sedimentation rates are from the STM report (QEA 2008)
- Peak usage and release of PCBs assumed to be 1960, 1965, or 1974
- No localized disturbances (e.g., dredging, tug maneuvering)

[c] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

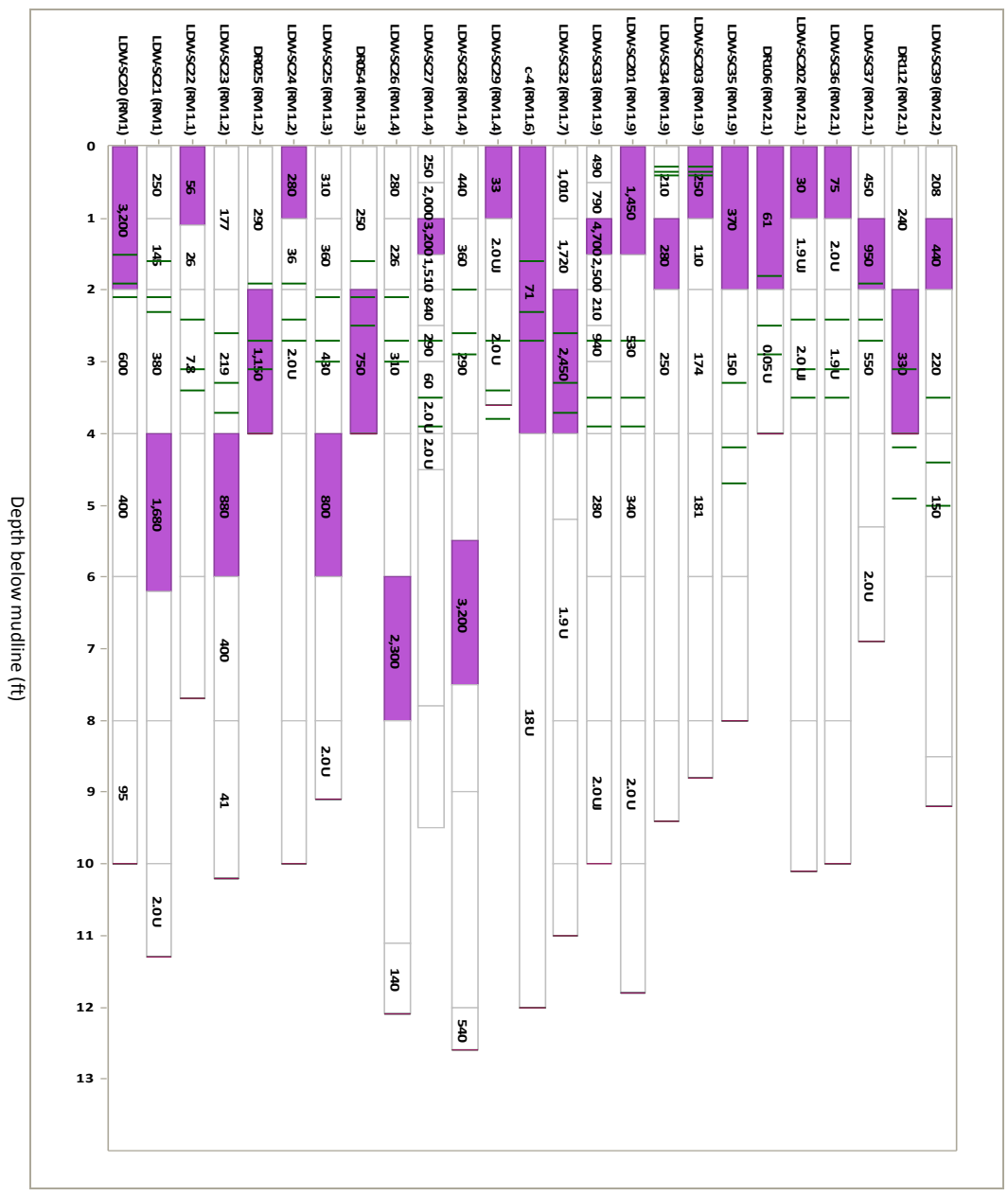
[d] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[e] Cores located within dredged areas were collected prior to dredging.

Peak total PCB concentrations in subsurface cores

Estimated depth of peak total PCB concentration: 1974, 1965, 1960

Analyzed core interval with actual peak total PCB concentration



Prepared by CEH, 07/15/2010; MAP 3088; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Core Analysis

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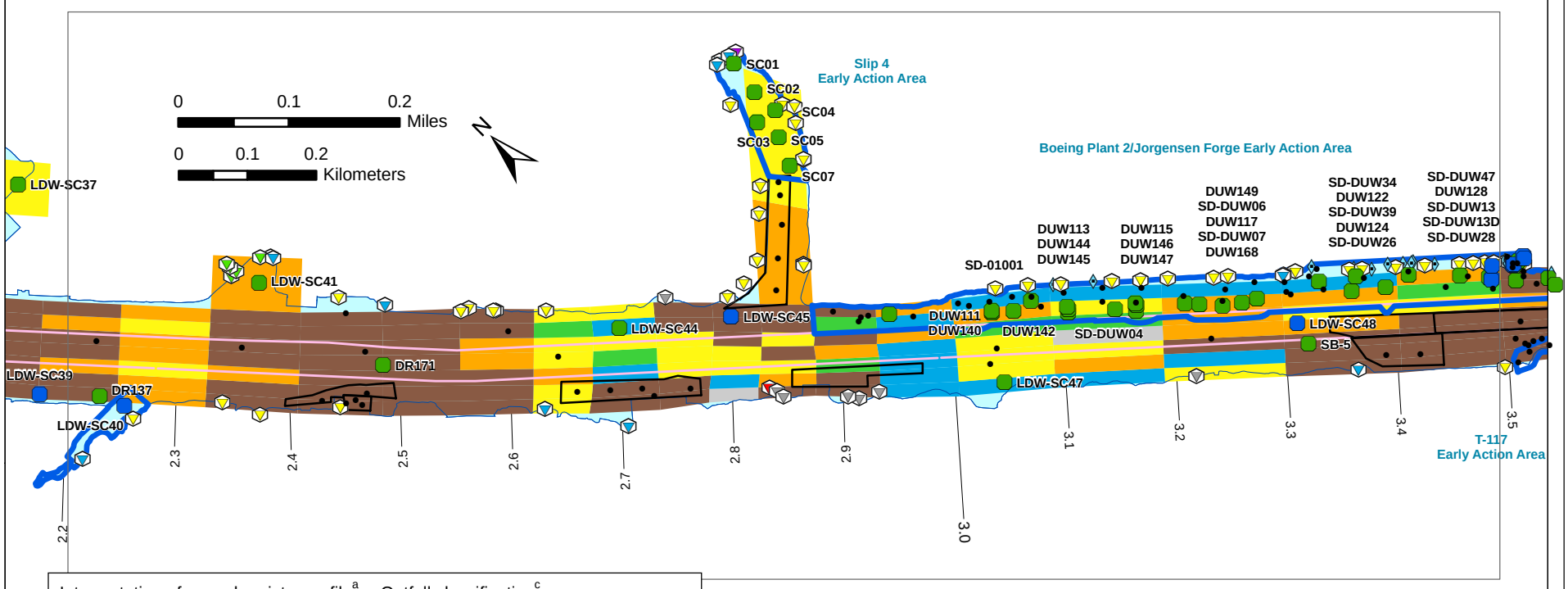
Map 4-69b. Comparison of actual and estimated depths of peak total PCB concentrations in cores based on annual average net sedimentation rates and source assumptions, RM 1.0 to RM 2.2

Average annual net sedimentation rate (cm/yr)



Interpretation of core chemistry profile[a]

- Consistent with assumptions[b] (peak total PCB concentration as deep or deeper than expected)
- Inconsistent with assumptions[b] (peak total PCB concentration shallower than expected)
- Core excluded from analysis

Average annual net sedimentation rate from STM (cm/yr)

- Net sediment loss
- 0.1 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- > 3.0
- Outside of STM modeling area

Outfall classification[c]

- CSO
- EOF/storm drain
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Not an outfall
- Early action area[d]
- Dredged area[e]
- River mile
- Navigation channel

[a] Cores from the RI surface sediment dataset were excluded from this analysis if at least one of the following conditions was met: 1) only one core interval was analyzed for total PCBs, 2) no core interval was analyzed within the depth range of the expected peak, 3) PCBs were not detected, or 4) dredging occurred prior to sampling.

[b] Analysis assumptions
- Annual average net sedimentation rates are from the STM report (QEA 2008)
- Peak usage and release of PCBs assumed to be 1960, 1965, or 1974
- No localized disturbances (e.g., dredging, tug maneuvering)

[c] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

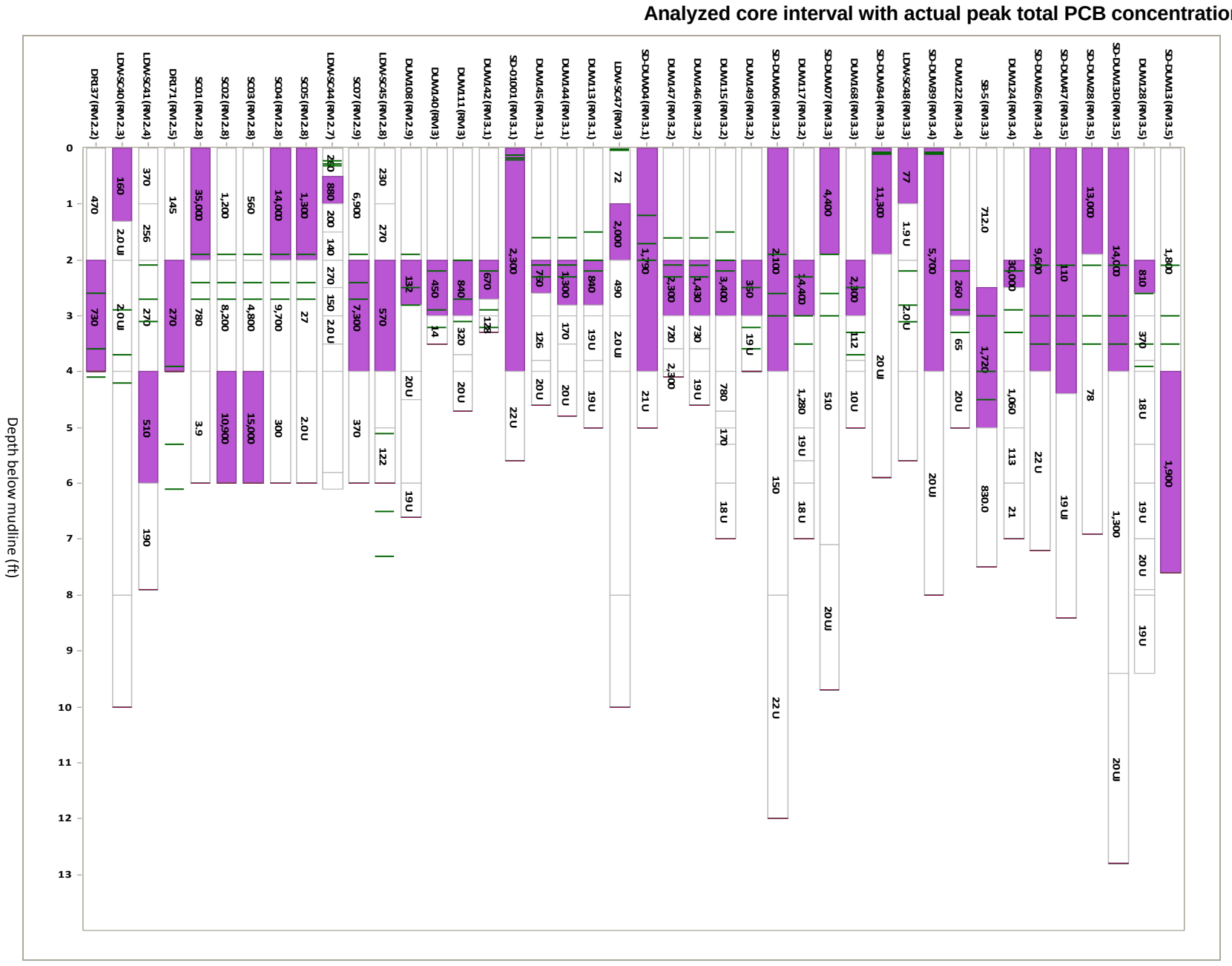
[d] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[e] Cores located within dredged areas were collected prior to dredging.

Peak total PCB concentrations in subsurface cores

Estimated depth of peak total PCB concentration: 1974, 1965, 1960

Analyzed core interval with actual peak total PCB concentration



Map 4-69c. Comparison of actual and estimated depths of peak total PCB concentrations in cores based on annual average net sedimentation rates and source assumptions, RM 2.2 to RM 3.5

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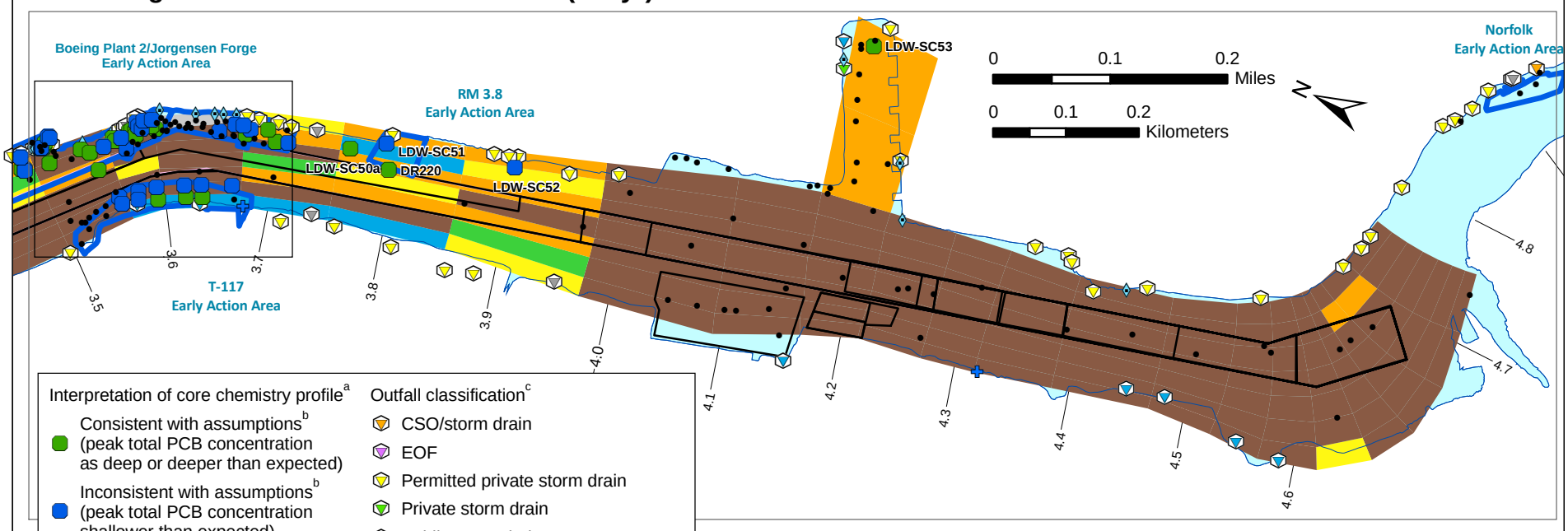
Prepared by CEH, 07/15/2010; MAP 3088; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Core Analysis

Average annual net sedimentation rate (cm/yr)



Interpretation of core chemistry profile[a]

- Consistent with assumptions[b] (peak total PCB concentration as deep or deeper than expected)
- Inconsistent with assumptions[b] (peak total PCB concentration shallower than expected)
- Core excluded from analysis

Average annual net sedimentation rate from STM (cm/yr)

- Net sediment loss
- 0.1 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- > 3.0
- Outside of STM modeling area

Outfall classification[c]

- CSO/storm drain
- EOF
- Permitted private storm drain
- Private storm drain
- Public storm drain
- Pipe of unresolved origin and/or use
- Abandoned
- Stream, channel, or swale
- Early action area[d]
- Dredged area[e]
- River mile
- Navigation channel

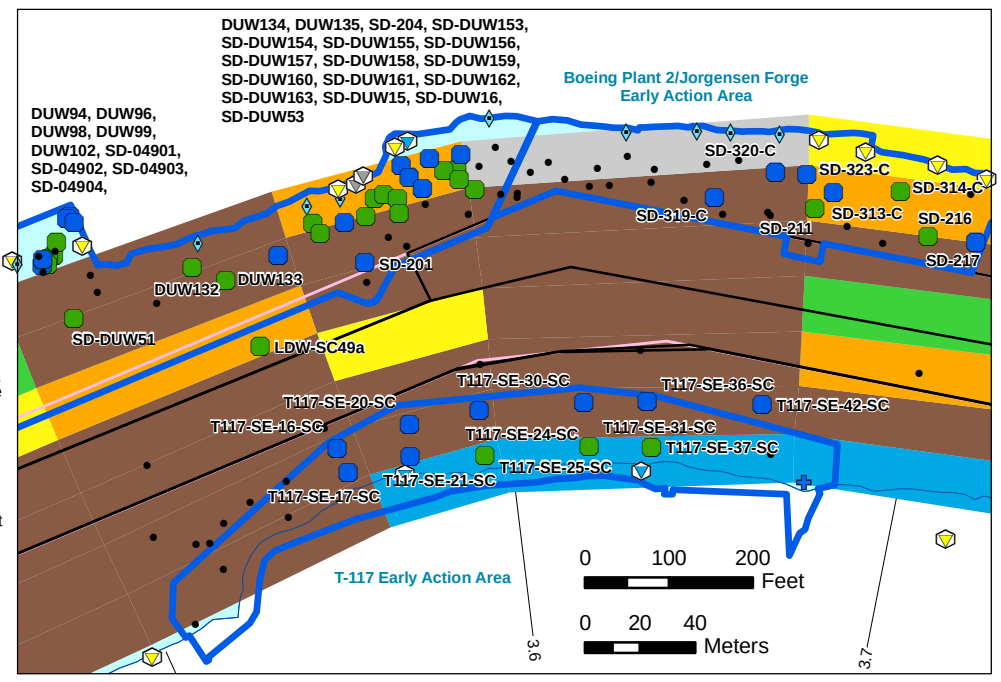
[a] Cores from the RI surface sediment dataset were excluded from this analysis if at least one of the following conditions was met: 1) only one core interval was analyzed for total PCBs, 2) no core interval was analyzed within the depth range of the expected peak, 3) PCBs were not detected, or 4) dredging occurred prior to sampling.

[b] Analysis assumptions
- Annual average net sedimentation rates are from the STM report (QEA 2008)
- Peak usage and release of PCBs assumed to be 1960, 1965, or 1974
- No localized disturbances (e.g., dredging, tug maneuvering)

[c] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and Lower Duwamish Waterway Group (LDWG) personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

[d] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

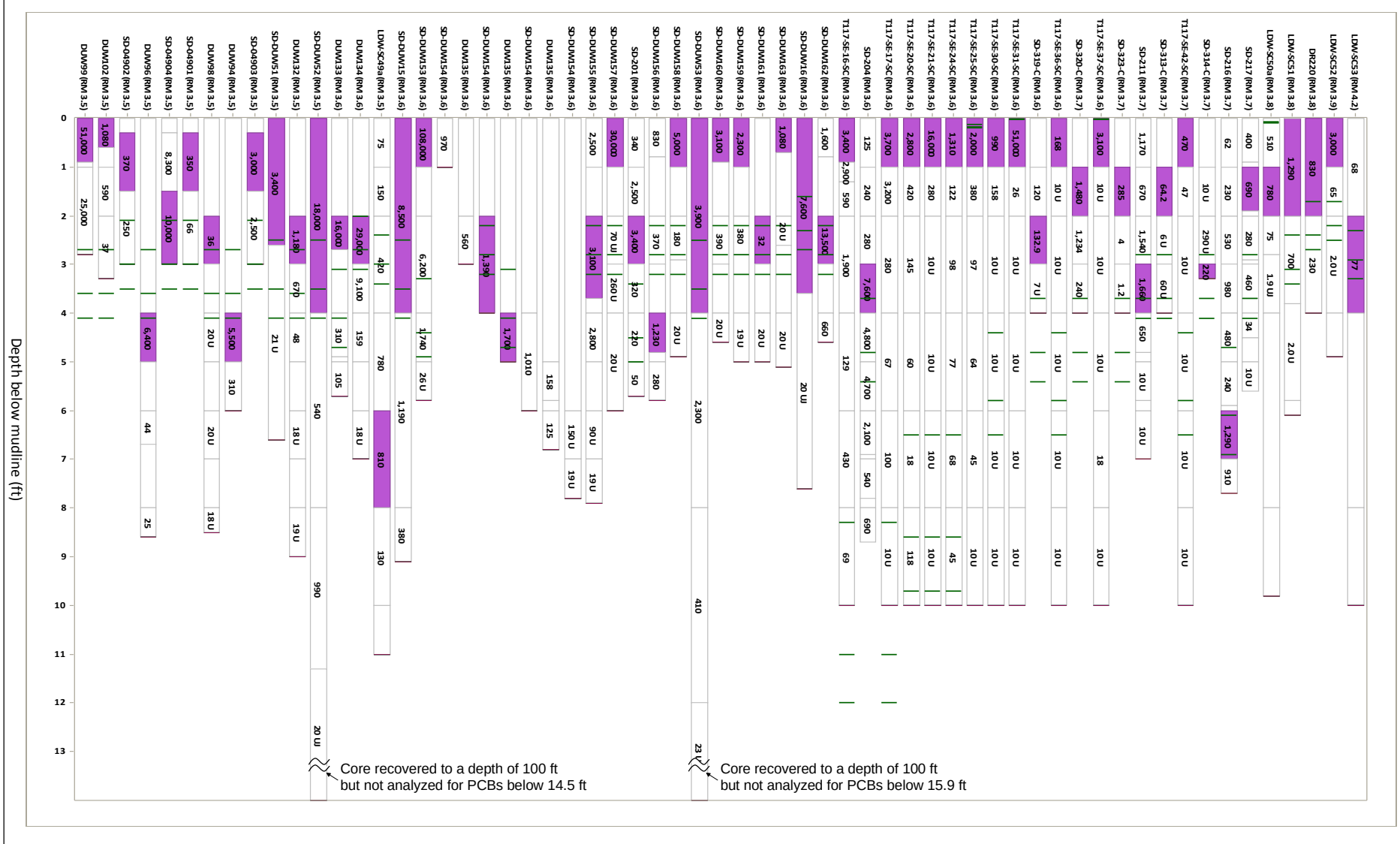
[e] Cores located within dredged areas were collected prior to dredging.



Peak total PCB concentrations in subsurface cores

Estimated depth of peak total PCB concentration: 1974, 1965, 1960

Analyzed core interval with actual peak total PCB concentration



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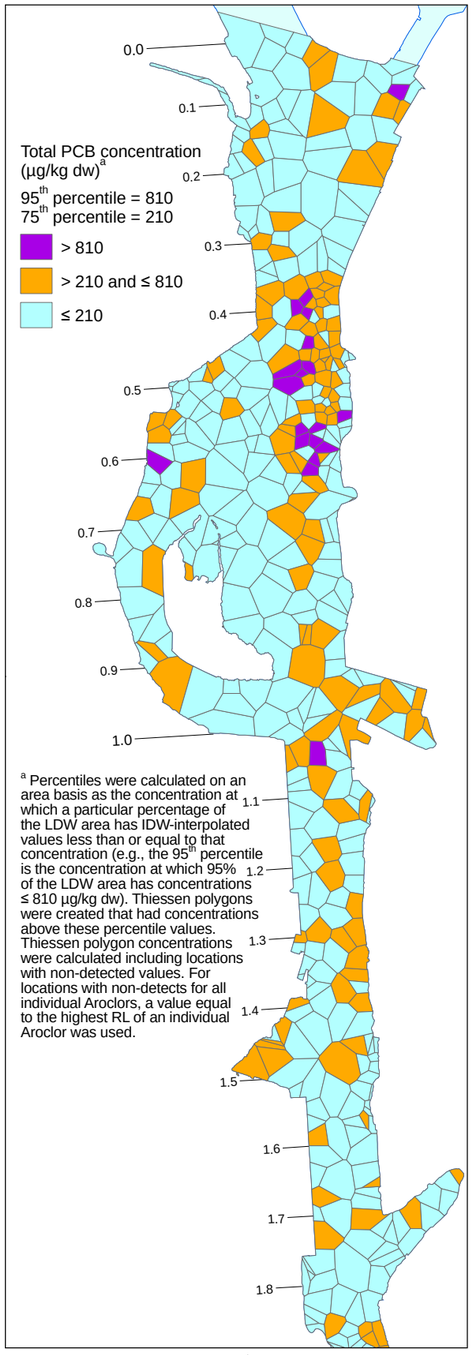
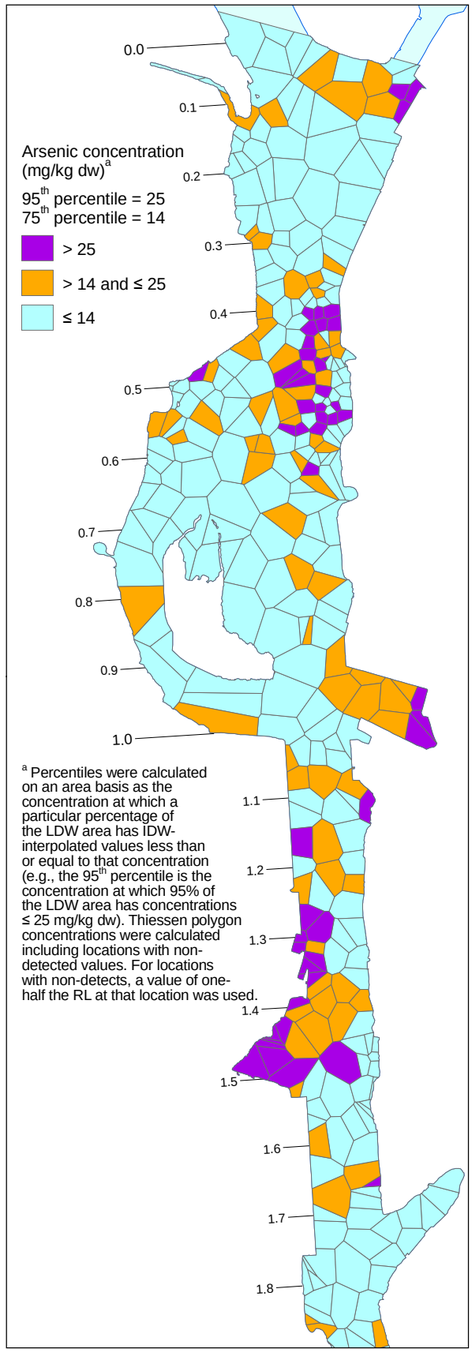
Map 4-69d. Comparison of actual and estimated depths of peak total PCB concentrations in cores based on annual average net sedimentation rates and source assumptions, RM 3.5 to RM 4.8

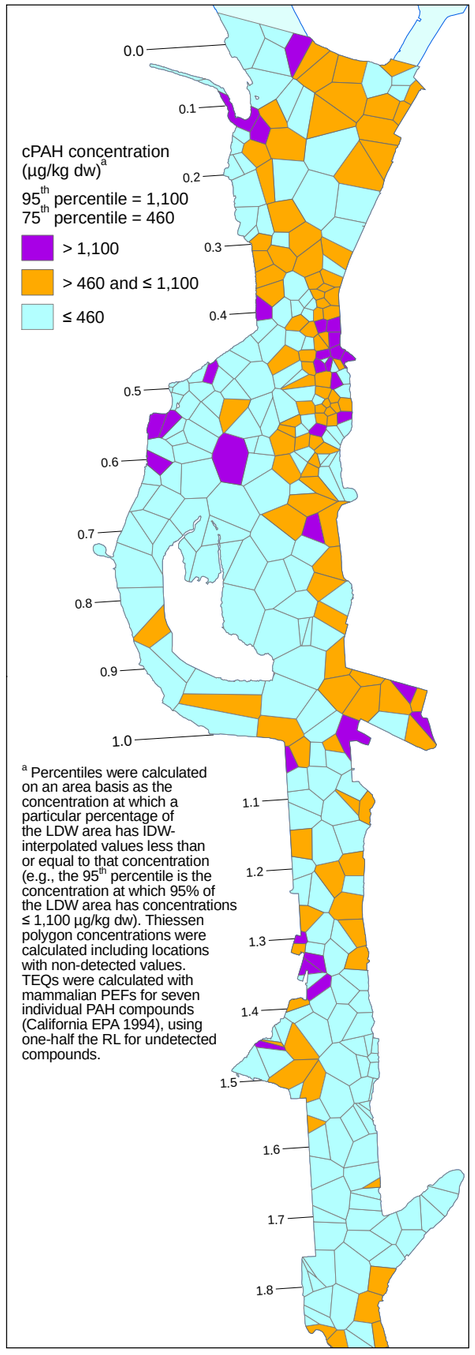
Prepared by CEH, 07/15/2010; MAP 3068; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Nature and Extent\Subsurface\Core Analysis



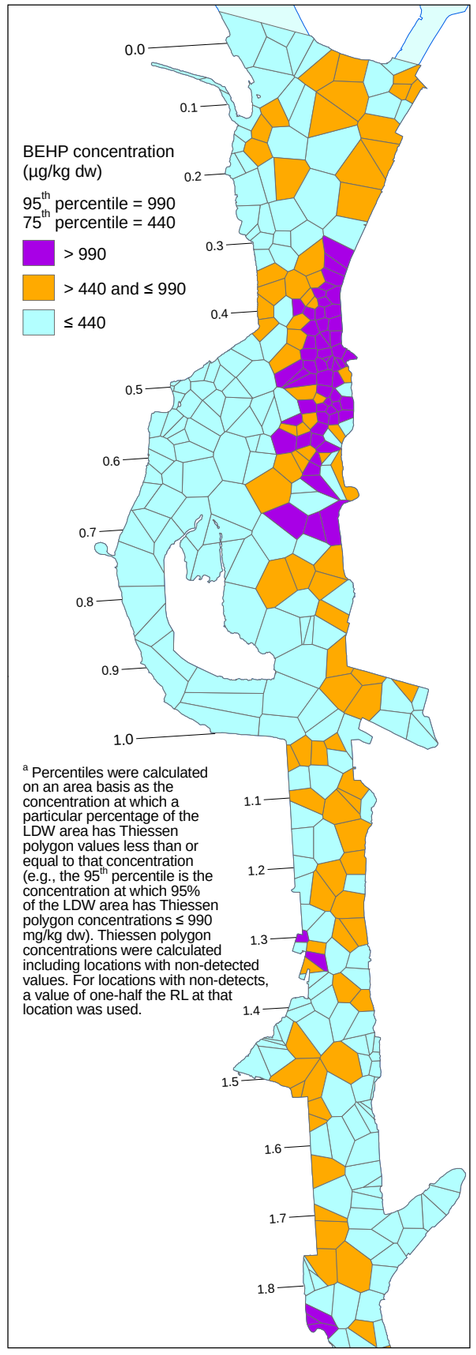
[a] Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has IDW-interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has concentrations ≤ 810 µg/kg dw). Thiessen polygons were created that had concentrations above these percentile values. Thiessen polygon concentrations were calculated including locations with non-detected values. For locations with non-detects for all individual Aroclors, a value equal to the highest RL of an individual Aroclor was used.



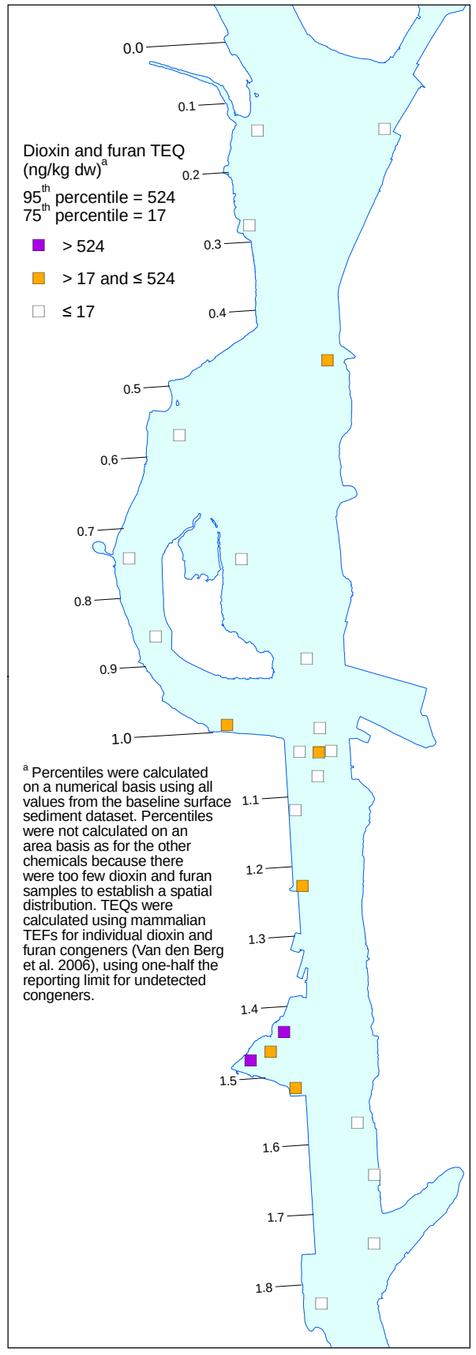
[a] Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has IDW-interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has concentrations ≤ 25 mg/kg dw). Thiessen polygon concentrations were calculated including locations with non-detected values. For locations with non-detects, a value of one-half the RL at that location was used.



[a] Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has IDW-interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has concentrations ≤ 1,100 µg/kg dw). Thiessen polygon concentrations were calculated including locations with non-detected values. TEQs were calculated with mammalian PEFs for seven individual PAH compounds (California EPA 1994), using one-half the RL for undetected compounds.



[a] Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has Thiessen polygon values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has Thiessen polygon concentrations ≤ 990 mg/kg dw). Thiessen polygon concentrations were calculated including locations with non-detected values. For locations with non-detects, a value of one-half the RL at that location was used.



[a] Percentiles were calculated on a numerical basis using all values from the baseline surface sediment dataset. Percentiles were not calculated on an area basis as for the other chemicals because there were too few dioxin and furan samples to establish a spatial distribution. TEQs were calculated using mammalian TEFs for individual dioxin and furan congeners (Van den Berg et al. 2006), using one-half the reporting limit for undetected congeners.

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0 1,000 2,000 Feet

0 250 500 Meters

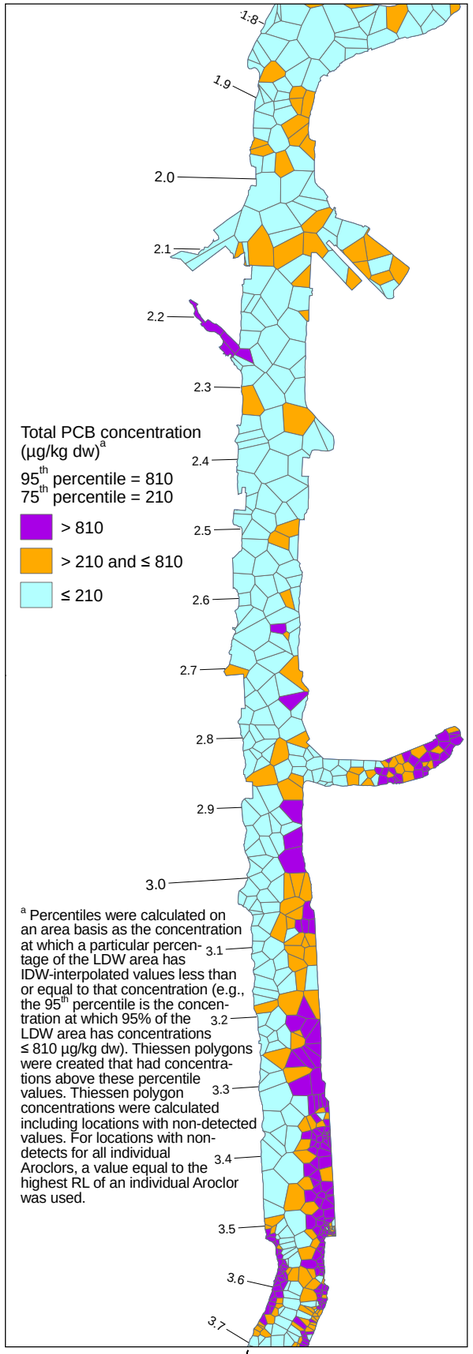
Scale is the same for each inset map

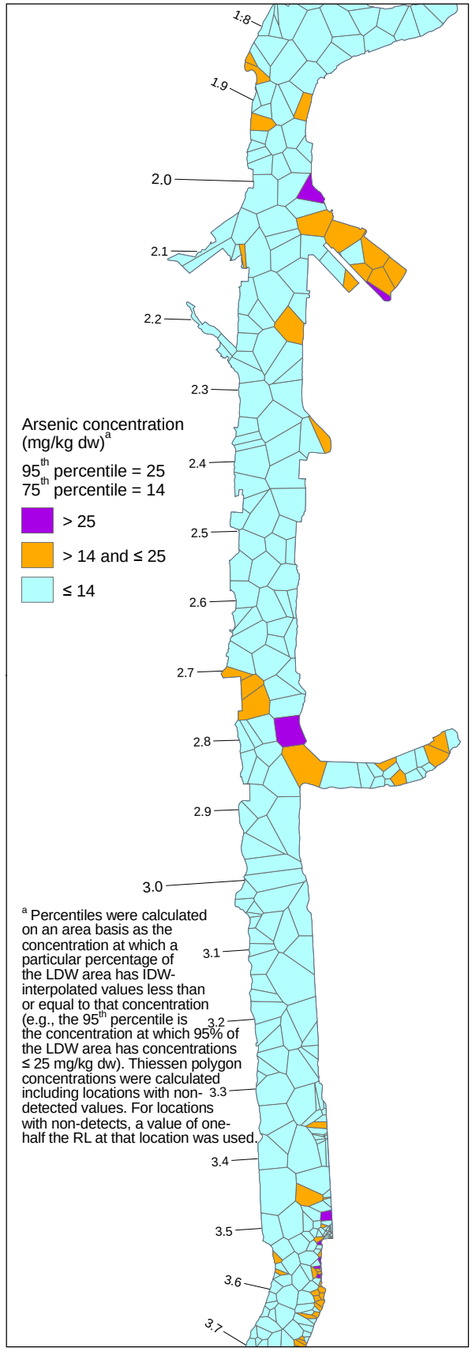
N

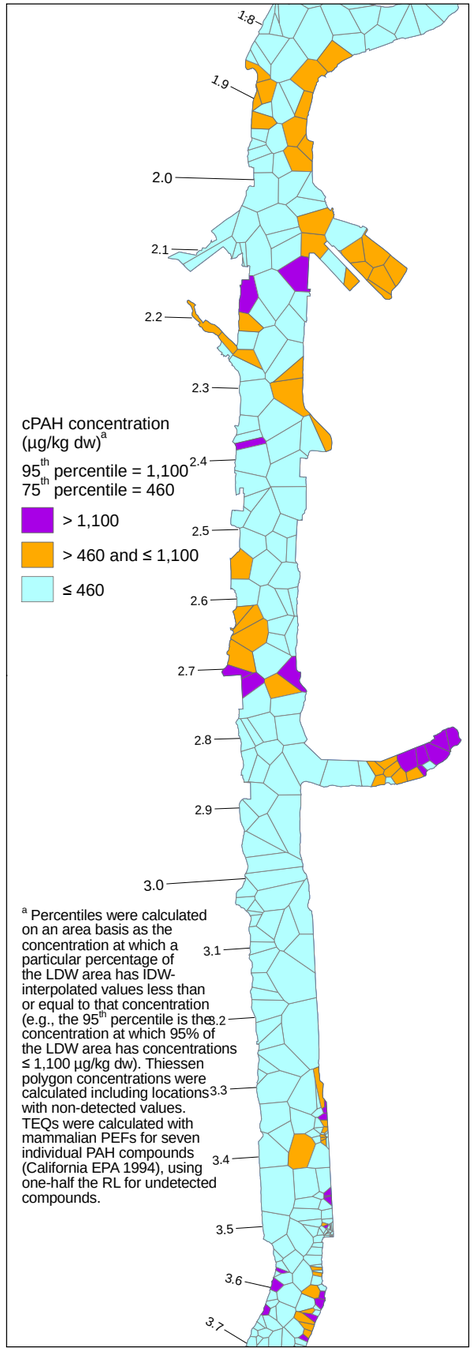
Map 4-70a. 95th and 75th Percentiles of risk driver chemicals, RM 0.0 to RM 1.8

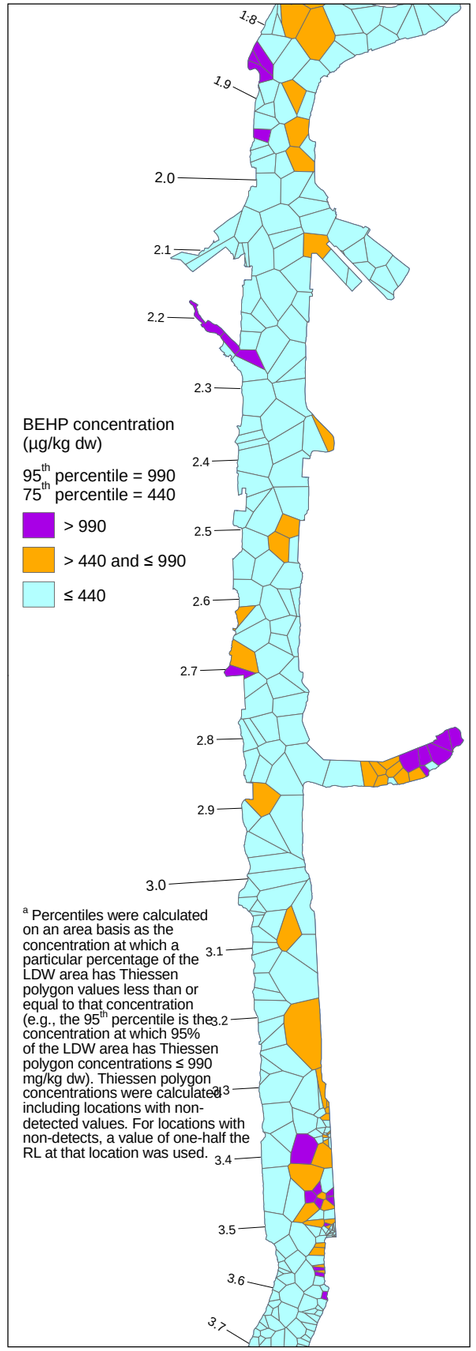
For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 to 2005.

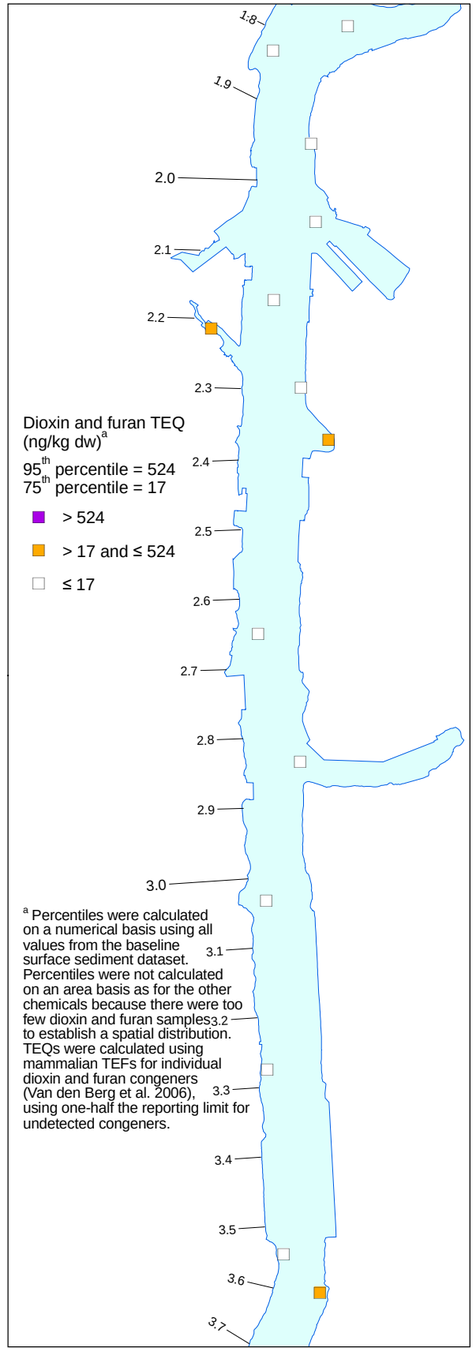
Produced by CEH, 07/15/2010; MAP 3056; W:\Projects\00-08-06_Duwamish_Ph\data\GIS\Phase2 RI\Nature and Extent\Surface Sediment\Baseline Locations











Wind Ward environmental LLC

0 1,000 2,000 Feet

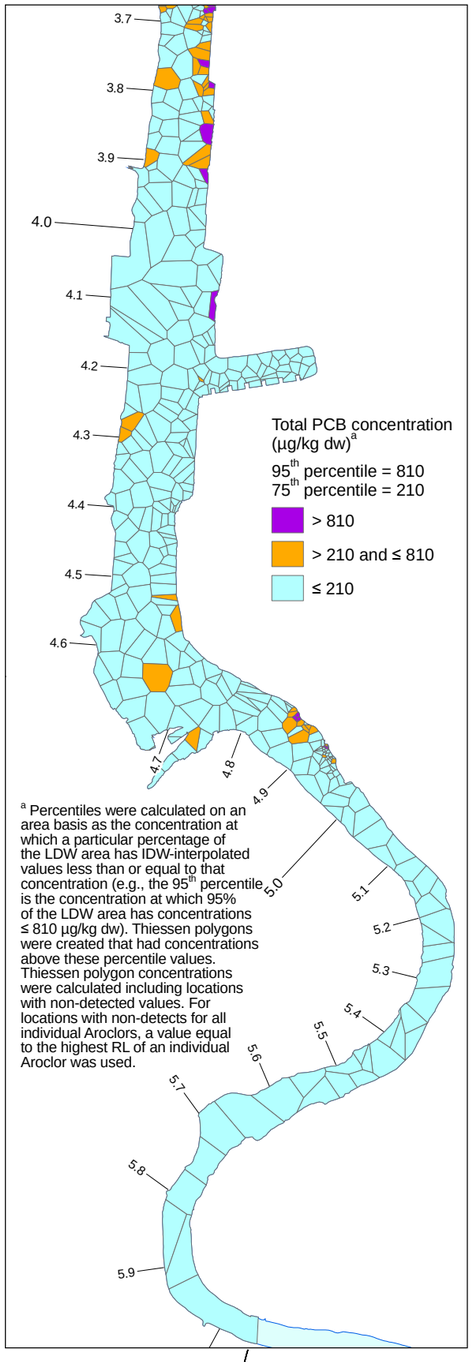
0 250 500 Meters

Scale is the same for each inset map

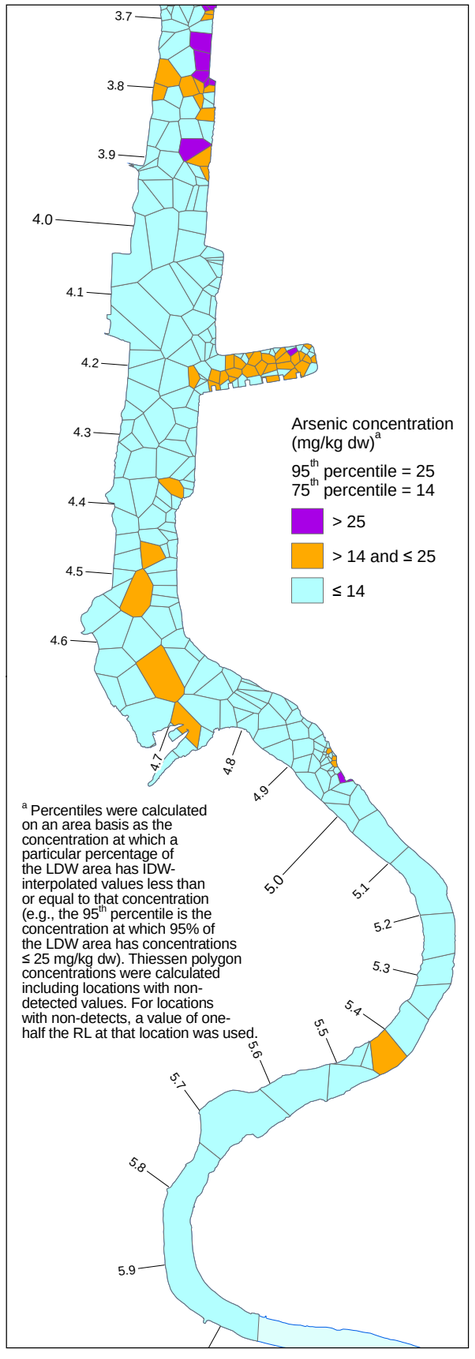
N

Map 4-70b. 95th and 75th Percentiles of risk driver chemicals, RM 1.8 to RM 3.7

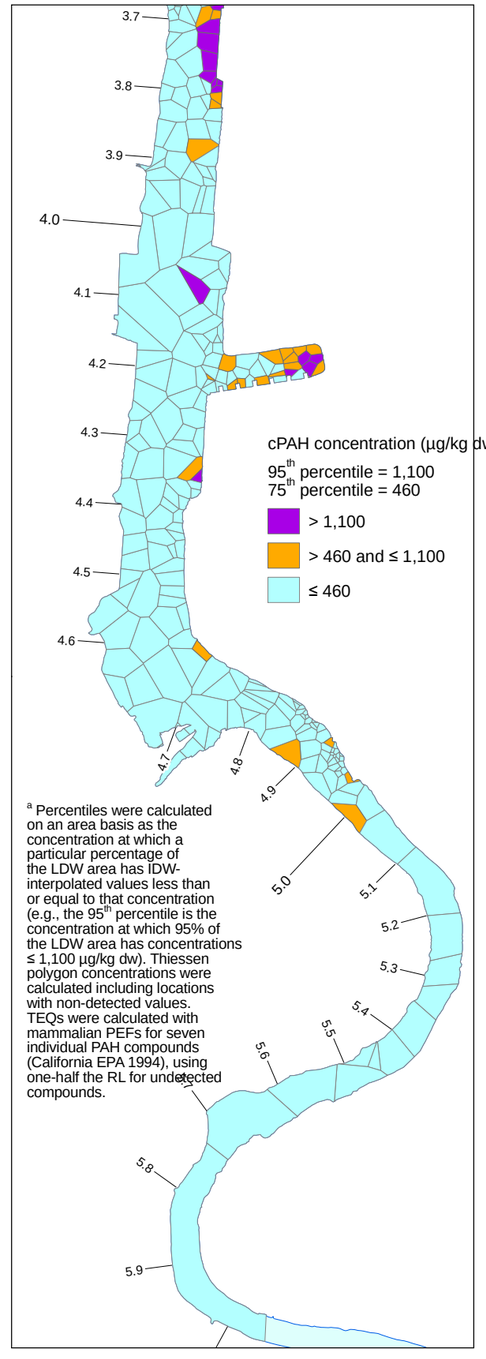
Produced by CEH, 07/15/2010, MAP 3056, W:\Projects\00-08-06_Duwamish_Ridata\GIS\Phase2 RI\Nature and Extent\Surface Sediment\Baseline Locations



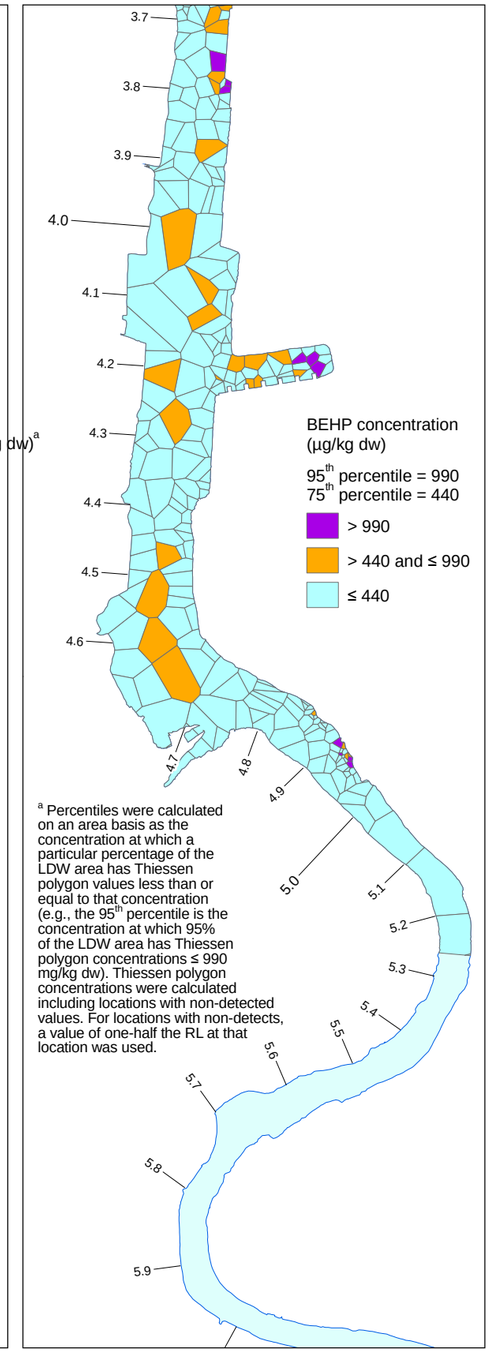
[a] Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has IDW-interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has concentrations ≤ 810 µg/kg dw). Thiessen polygons were created that had concentrations above these percentile values. Thiessen polygon concentrations were calculated including locations with non-detected values. For locations with non-detects for all individual Aroclors, a value equal to the highest RL of an individual Aroclor was used.



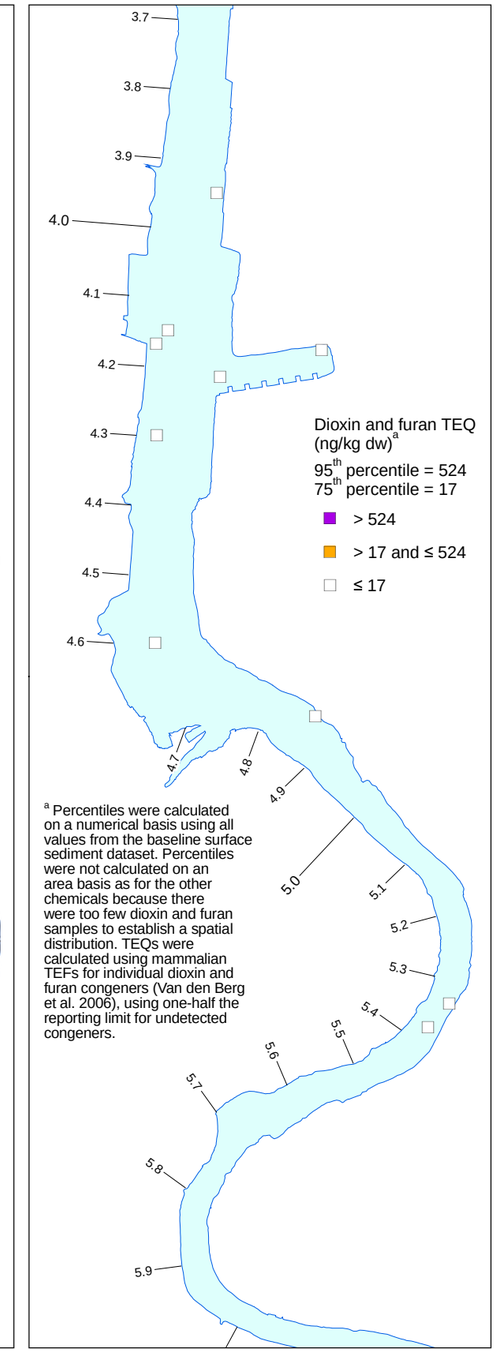
[a] Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has IDW-interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has concentrations ≤ 25 mg/kg dw). Thiessen polygon concentrations were calculated including locations with non-detected values. For locations with non-detects, a value of one-half the RL at that location was used.



[a] Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has IDW-interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has concentrations ≤ 1,100 µg/kg dw). Thiessen polygon concentrations were calculated including locations with non-detected values. TEQs were calculated with mammalian PEFs for seven individual PAH compounds (California EPA 1994), using one-half the RL for undetected compounds.



[a] Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has Thiessen polygon values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has Thiessen polygon concentrations ≤ 990 mg/kg dw). Thiessen polygon concentrations were calculated including locations with non-detected values. For locations with non-detects, a value of one-half the RL at that location was used.



[a] Percentiles were calculated on a numerical basis using all values from the baseline surface sediment dataset. Percentiles were not calculated on an area basis as for the other chemicals because there were too few dioxin and furan samples to establish a spatial distribution. TEQs were calculated using mammalian TEFs for individual dioxin and furan congeners (Van den Berg et al. 2006), using one-half the reporting limit for undetected congeners.

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0 1,000 2,000 Feet

0 250 500 Meters

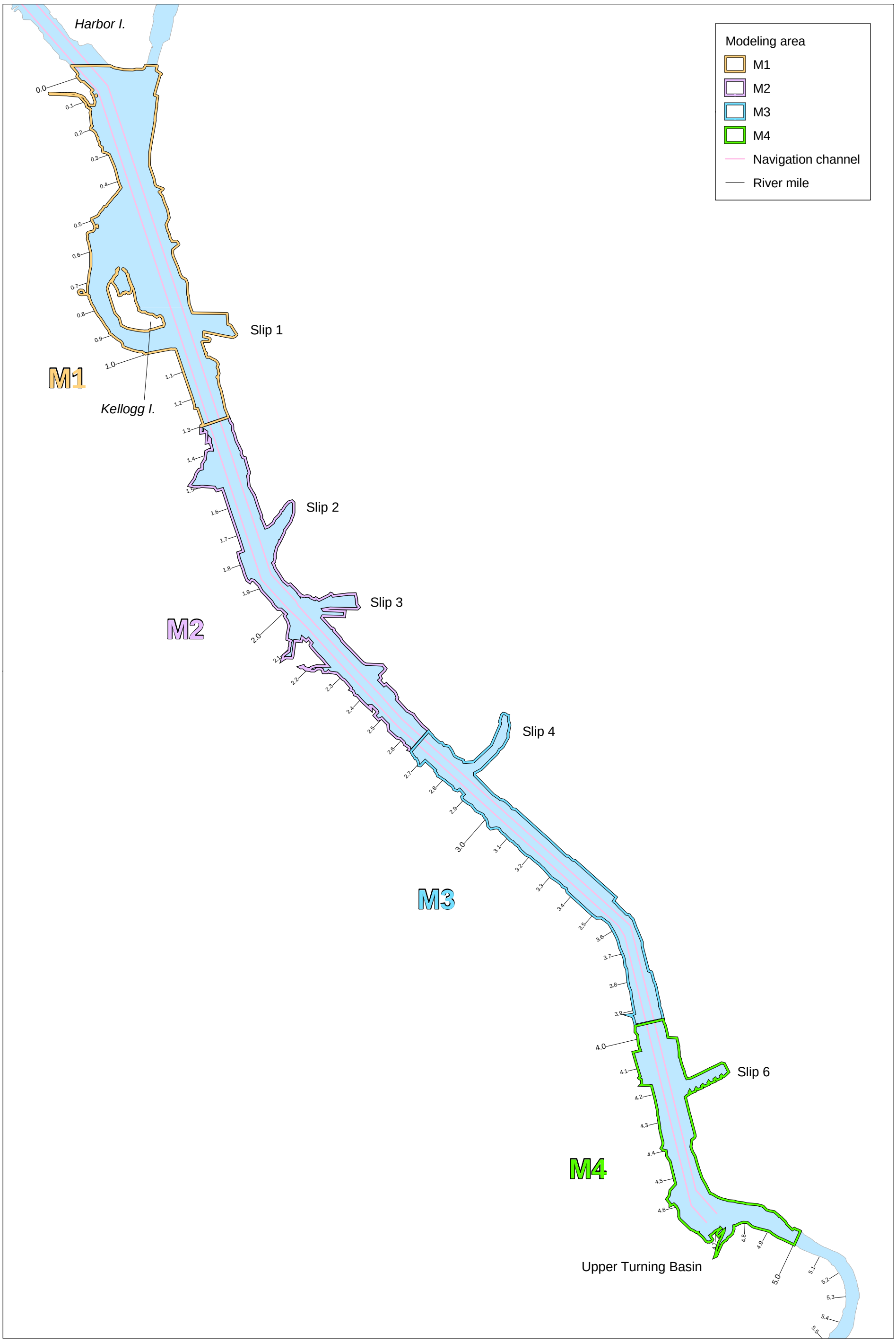
Scale is the same for each inset map

N

Map 4-70c. 95th and 75th Percentiles of risk driver chemicals, RM 3.7 to RM 6.0

For the Norfolk Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging, capping, or thin-layer placement in 2003 and 2004.

Produced by CEH, 07/15/2010, MAP 3056, W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Nature and Extent\Surface Sediment\Baseline Locations



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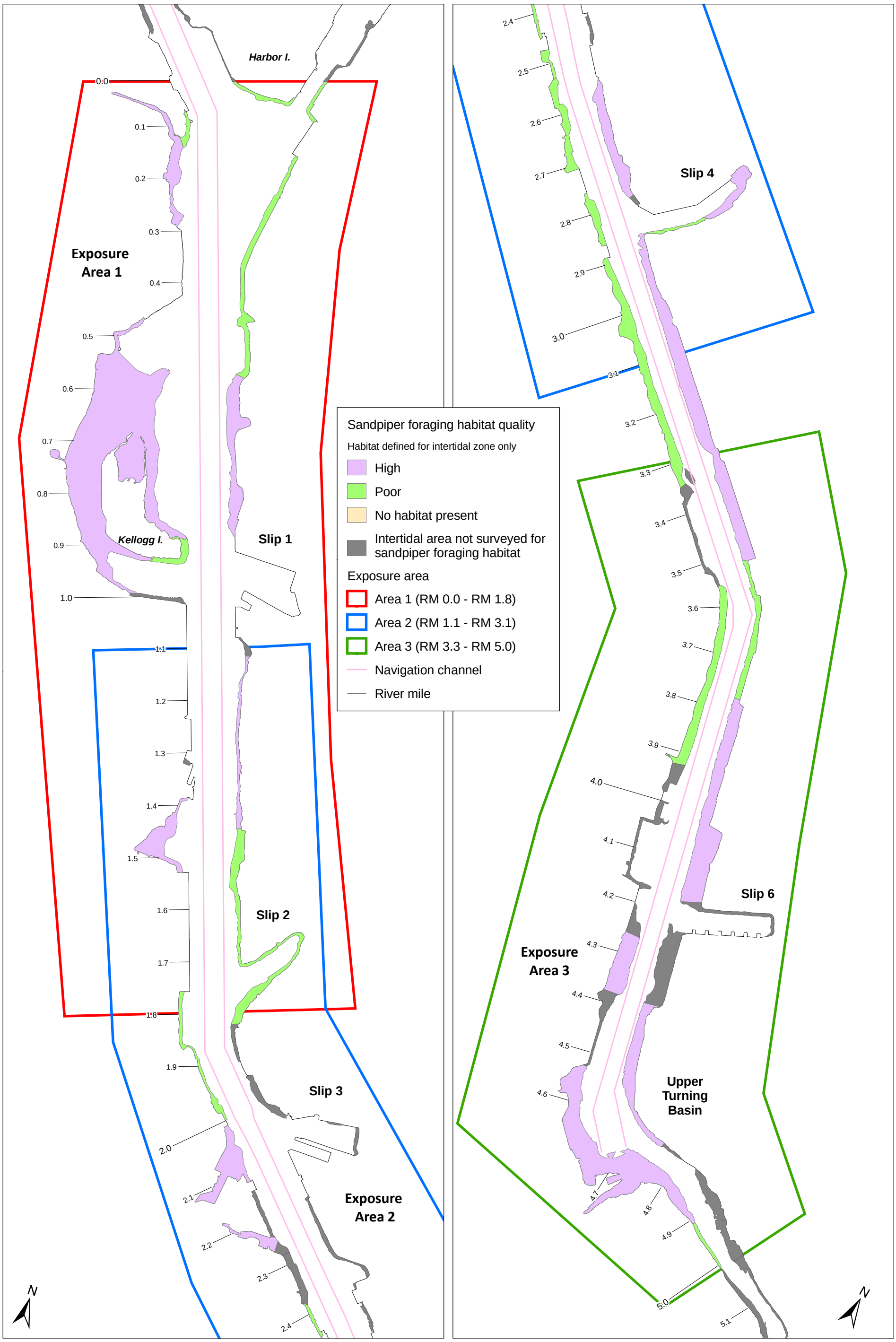
N

0 0.25 0.5 Miles

0 0.25 0.5 Kilometers

Map 5-1. Modeling areas in the LDW used in the fish exposure assessment and the food web model

Prepared by CEH, 07/15/2010; MAP #2379; W:\Projects\03-08-06_Duwamish_Rt\data\gis\Phase2 RI\ERA Summary



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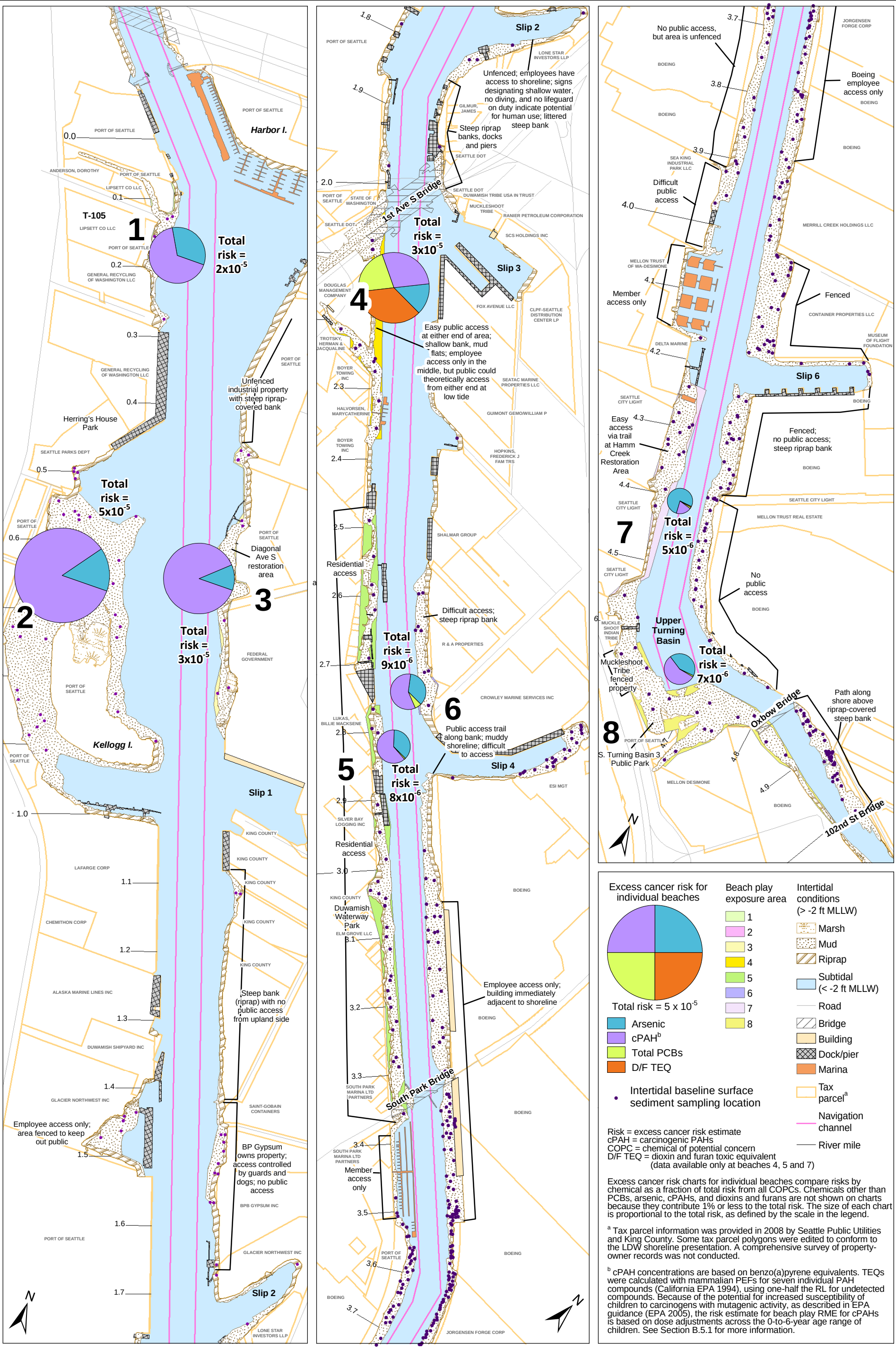
0 1,000 2,000 Feet

0 210 420 Meters

Scale is the same for each inset map

Map 5-2. Spotted sandpiper exposure areas in the LDW

Prepared by CEH, 07/15/2010; Map 2283; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\ERA Summary



Excess cancer risk for individual beaches

Total risk = 5 x 10^{-5}

- Arsenic
- cPAH[b]
- Total PCBs
- D/F TEQ

Intertidal baseline surface sediment sampling location

Beach play exposure area: 1, 2, 3, 4, 5, 6, 7, 8

Intertidal conditions (> -2 ft MLLW): Marsh, Mud, Riprap

Subtidal (< -2 ft MLLW)

Road, Bridge, Building, Dock/pier, Marina, Tax parcel[a], Navigation channel, River mile

Risk = excess cancer risk estimate
cPAH = carcinogenic PAHs
COPC = chemical of potential concern
D/F TEQ = dioxin and furan toxic equivalent (data available only at beaches 4, 5 and 7)

Excess cancer risk charts for individual beaches compare risks by chemical as a fraction of total risk from all COPCs. Chemicals other than PCBs, arsenic, cPAHs, and dioxins and furans are not shown on charts because they contribute 1% or less to the total risk. The size of each chart is proportional to the total risk, as defined by the scale in the legend.

[a] Tax parcel information was provided in 2008 by Seattle Public Utilities and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property-owner records was not conducted.

[b] cPAH concentrations are based on benzo(a)pyrene equivalents. TEQs were calculated with mammalian PEFs for seven individual PAH compounds (California EPA 1994), using one-half the RL for undetected compounds. Because of the potential for increased susceptibility of children to carcinogens with mutagenic activity, as described in EPA guidance (EPA 2005), the risk estimate for beach play RME for cPAHs is based on dose adjustments across the 0-to-6-year age range of children. See Section B.5.1 for more information.

Wind Ward environmental LLC

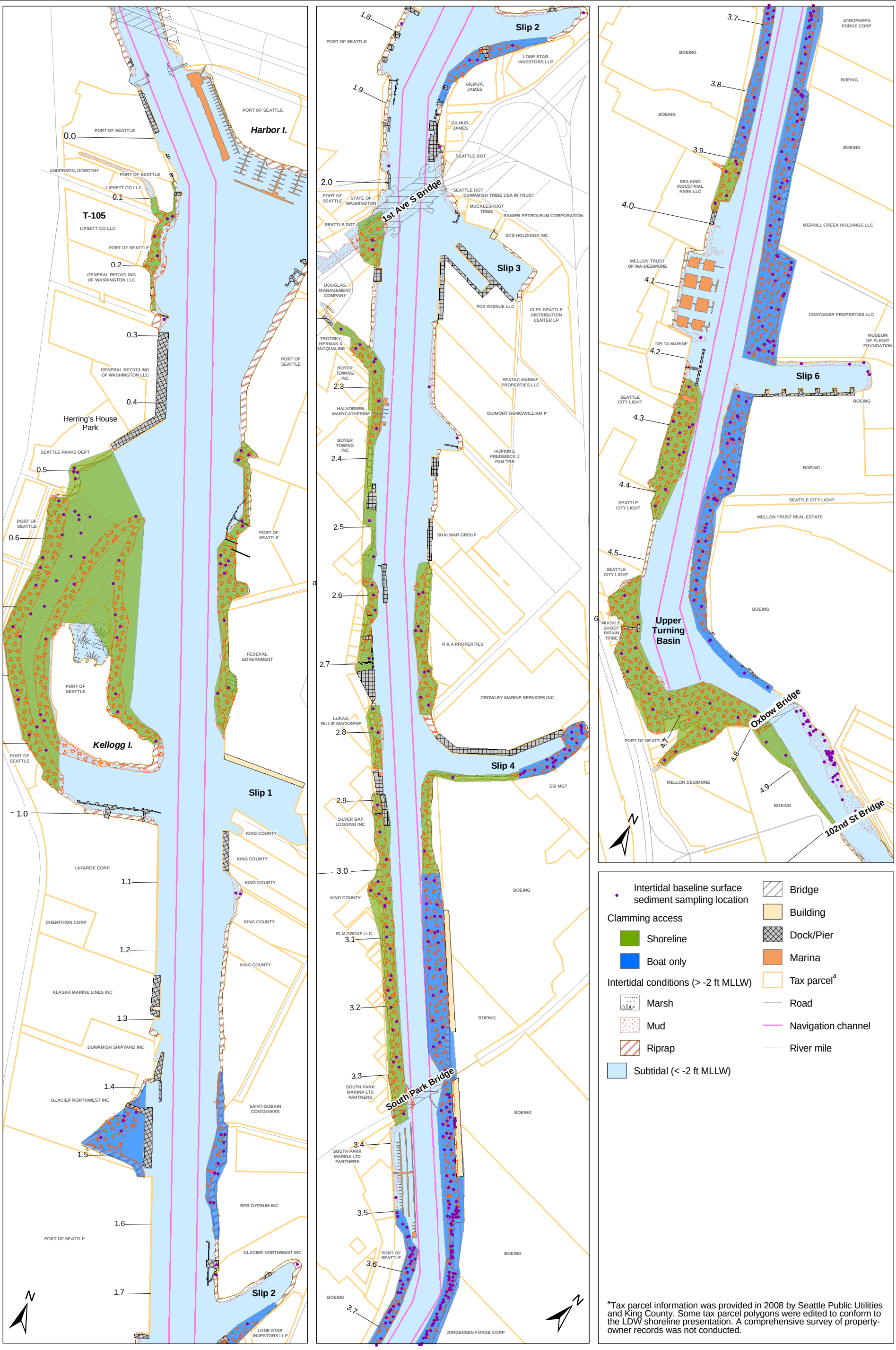
0 0.1 0.2 Miles

0 0.1 0.2 Kilometers

Scale is the same for each inset map

Map 6-1. LDW intertidal areas included in the beach play direct sediment contact exposure scenarios and excess cancer risk estimates

Prepared by CEH, 07/15/2010; Map 2602; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\HHRA Summary



Map 6-2. LDW intertidal areas included in the clam harvesting direct sediment contact exposure scenarios

Prepared by CEH, 07/15/2010; Map 2245; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\HHRA Summary

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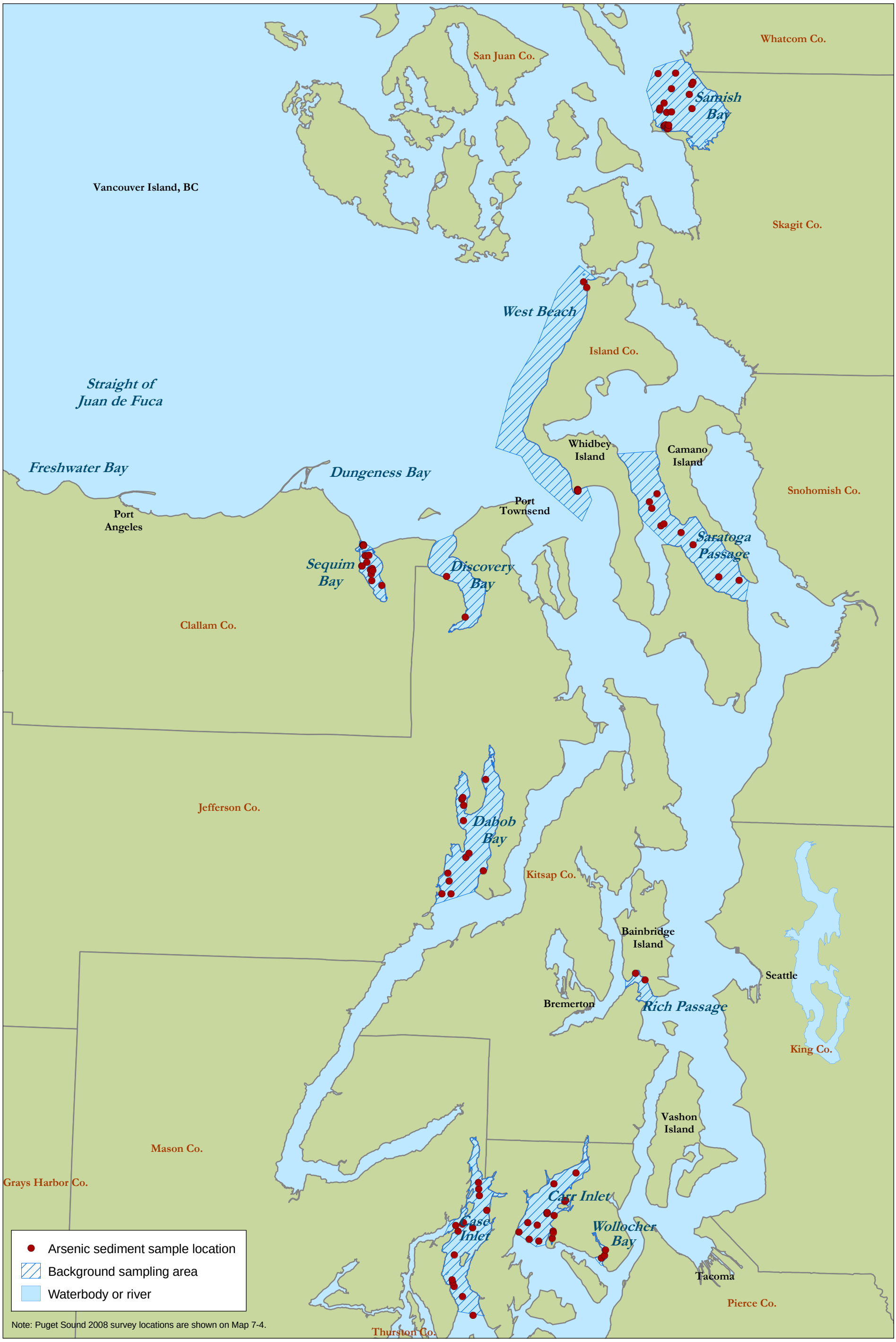
Map 7-1. Locations of surface sediment PCB and dioxin and furan data available for natural background from reference areas prior to 2008

Prepared by CEH, 07/15/2010, Map 3240; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Background



Wind Ward environmental LLC

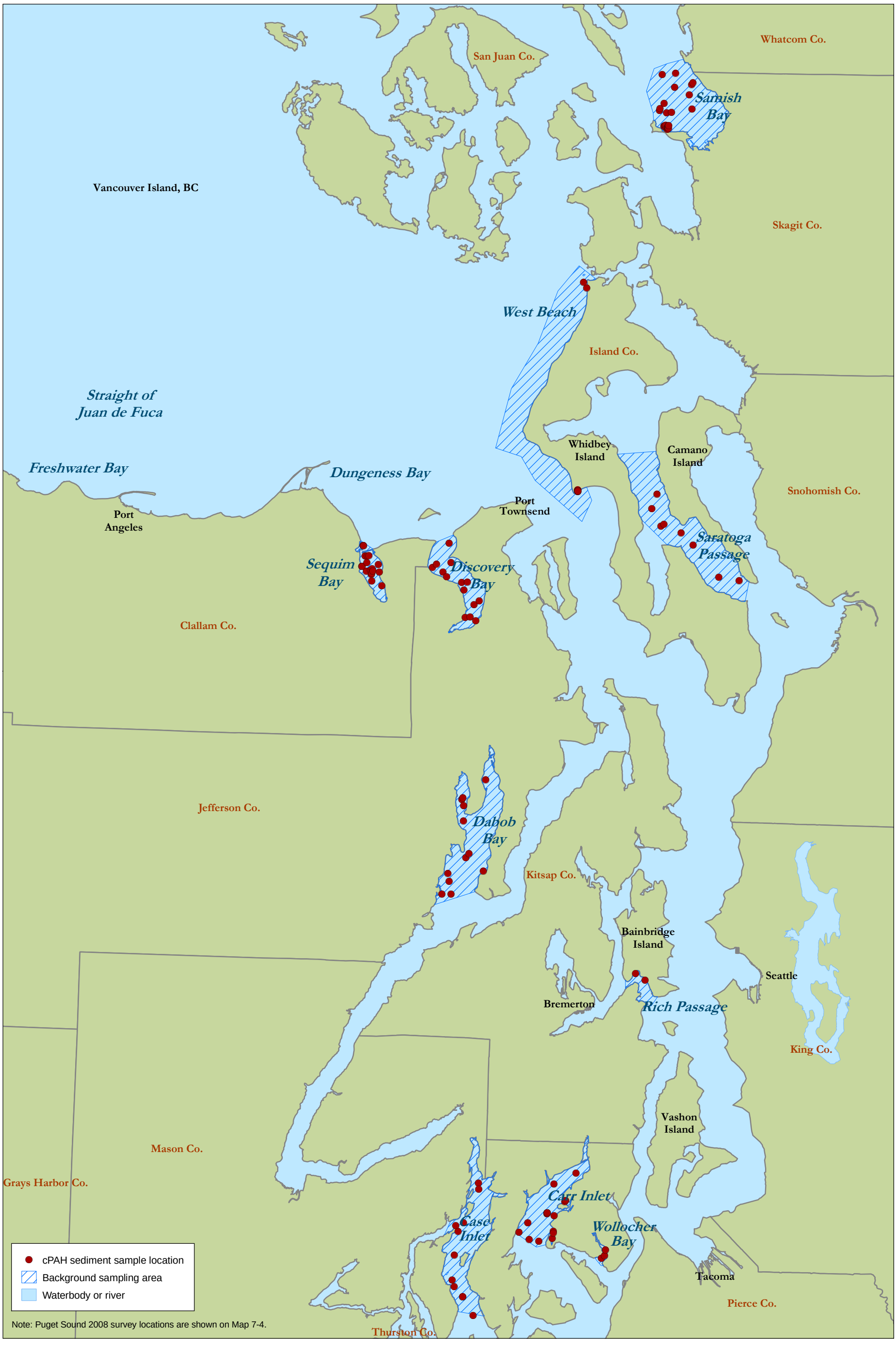
N

0 5 10 Miles

0 5 10 Kilometers

Map 7-2. Locations of surface sediment arsenic data available for natural background from reference areas prior to 2008

Prepared by CEH, 07/15/2010; Map 3242; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Background



Wind Ward LLC environmental

Map 7-3. Locations of surface sediment cPAH data available for natural background from reference areas prior to 2008

Prepared by CEH, 07/15/2010; Map 3241; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Background

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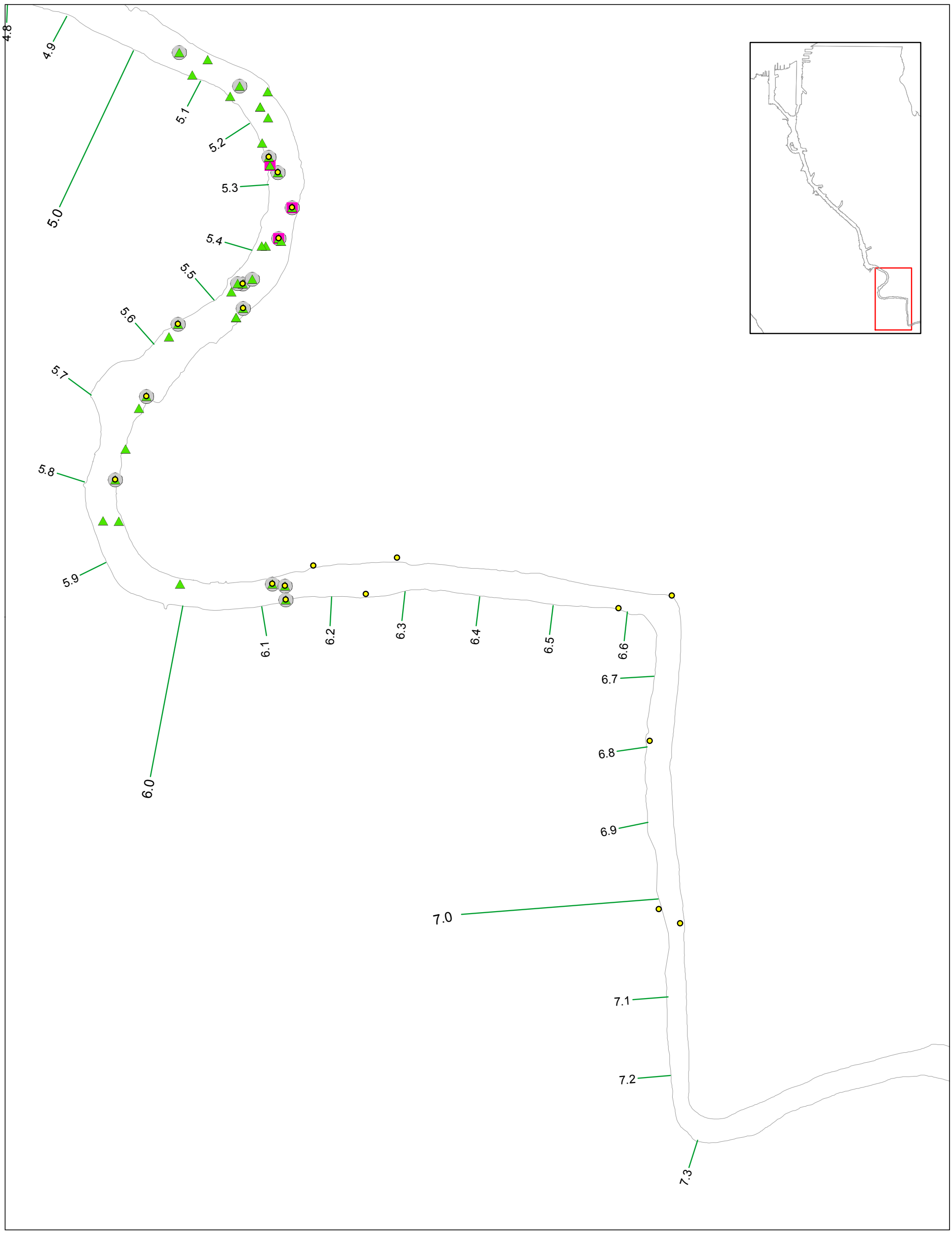
Map 7-4. Locations of surface sediment data available for arsenic, PCBs, cPAHs, and dioxins and furans from the Puget Sound 2008 survey for natural background consideration

Prepared by CEH, 07/15/2010, Map 3786, W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Background



Legend

- Arsenic sample location
- PCB sample location
- cPAH sample location
- Dioxin and furan sample location
- Navigation channel
- River Mile marker

0 250 500 1,000 Feet

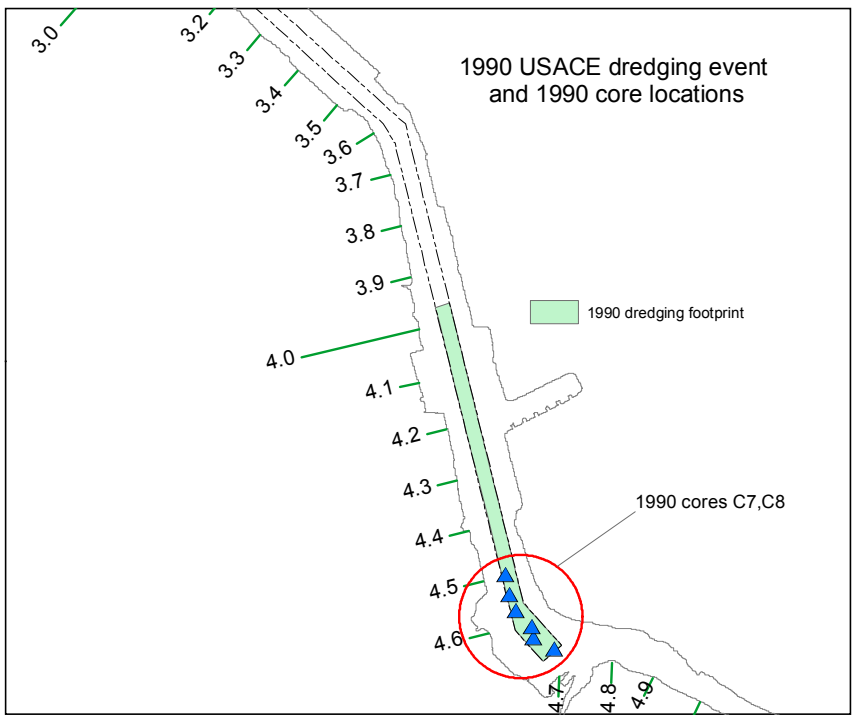
0 50 100 200 Meters

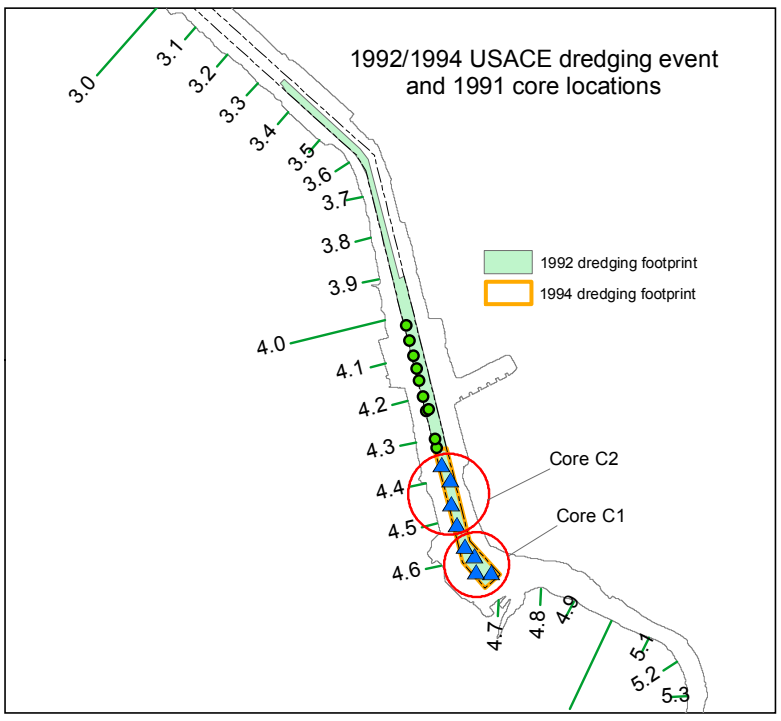
AECOM

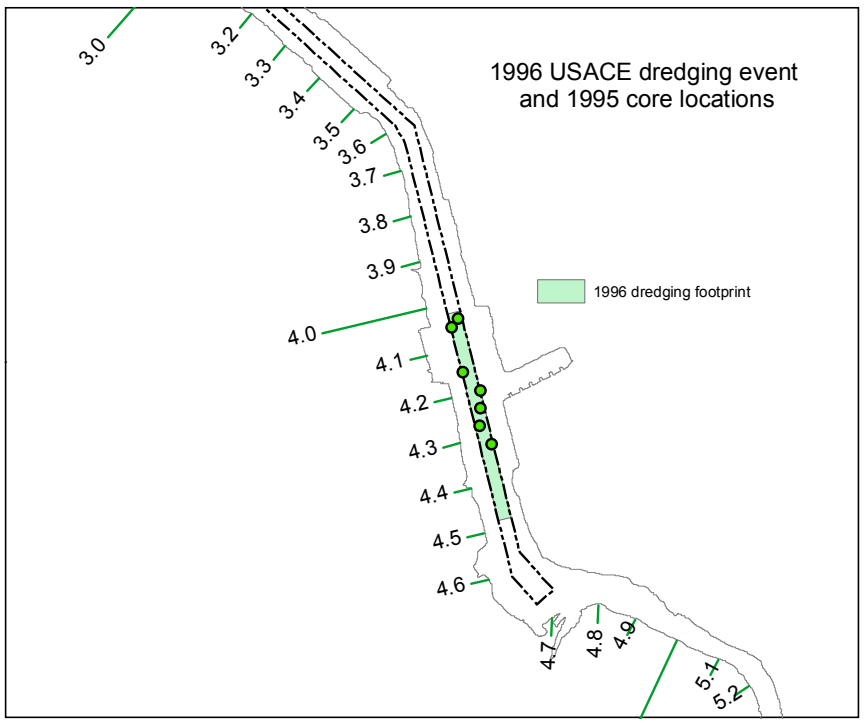
Wind Ward environmental LLC

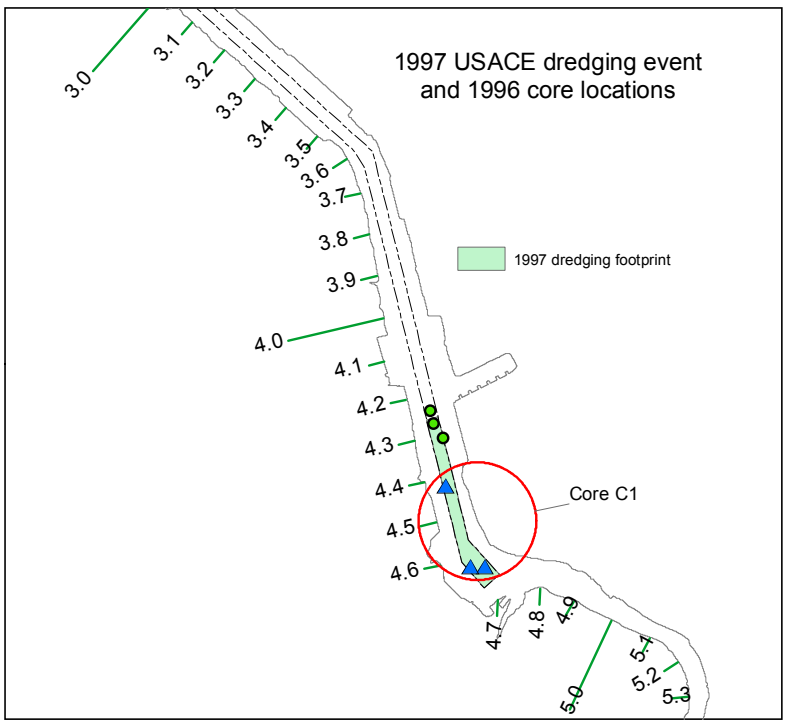
Notes:
1. An additional sample collected from Springbrook Creek (which enters the Duwamish River at RM 10.2) was included in the dioxin and furan dataset for samples from RM 5.0 - 7.0, but is not shown on this map.

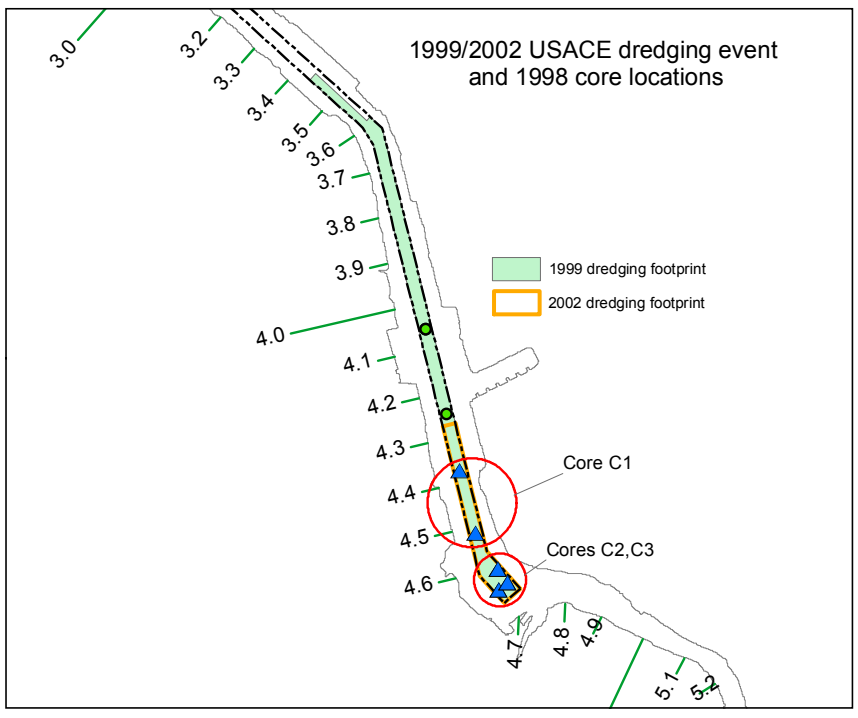
Map 7-5. Surface sediment sampling locations for arsenic, PCBs, cPAHs, or dioxins and furans - RM 5.0 to RM 7.0

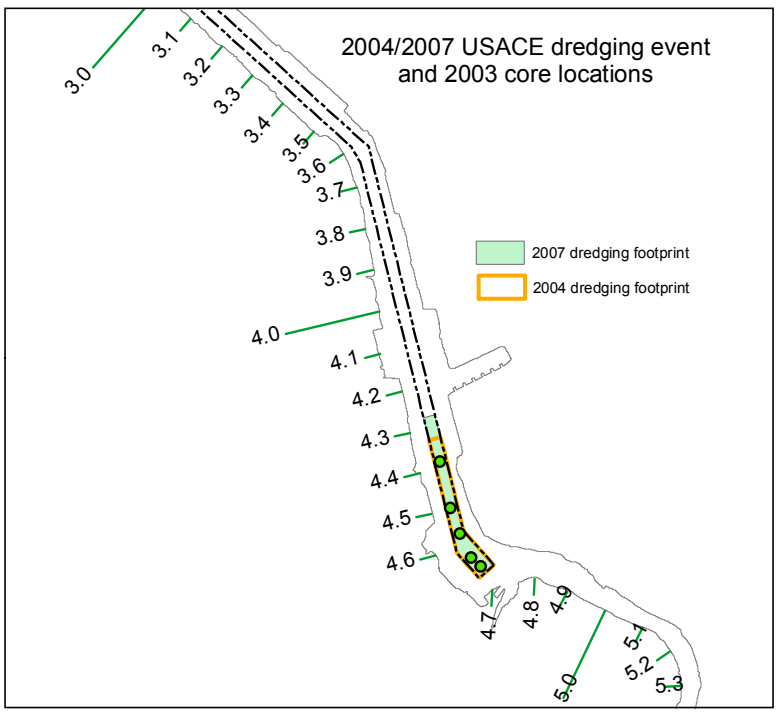












Notes:
1. Sampling data provided by USACE (2007).
2. Dredge footprints from USACE dredge summary and analysis reports.
3. Single sample locations represent stations where a single core was collected (generally from 0 to 4 ft below the mudline), composited over the length of the core, and analyzed. Composite sample locations represent stations where single cores from each of those stations (again, generally from 0 to 4 ft below the mudline) were first composited over the length of the core and then composited with the samples from the cores at other stations prior to analysis.
4. Stations downstream of RM 4.0 not shown.

Legend

- Single core location
- Composite core location
- Navigation channel
- River mile

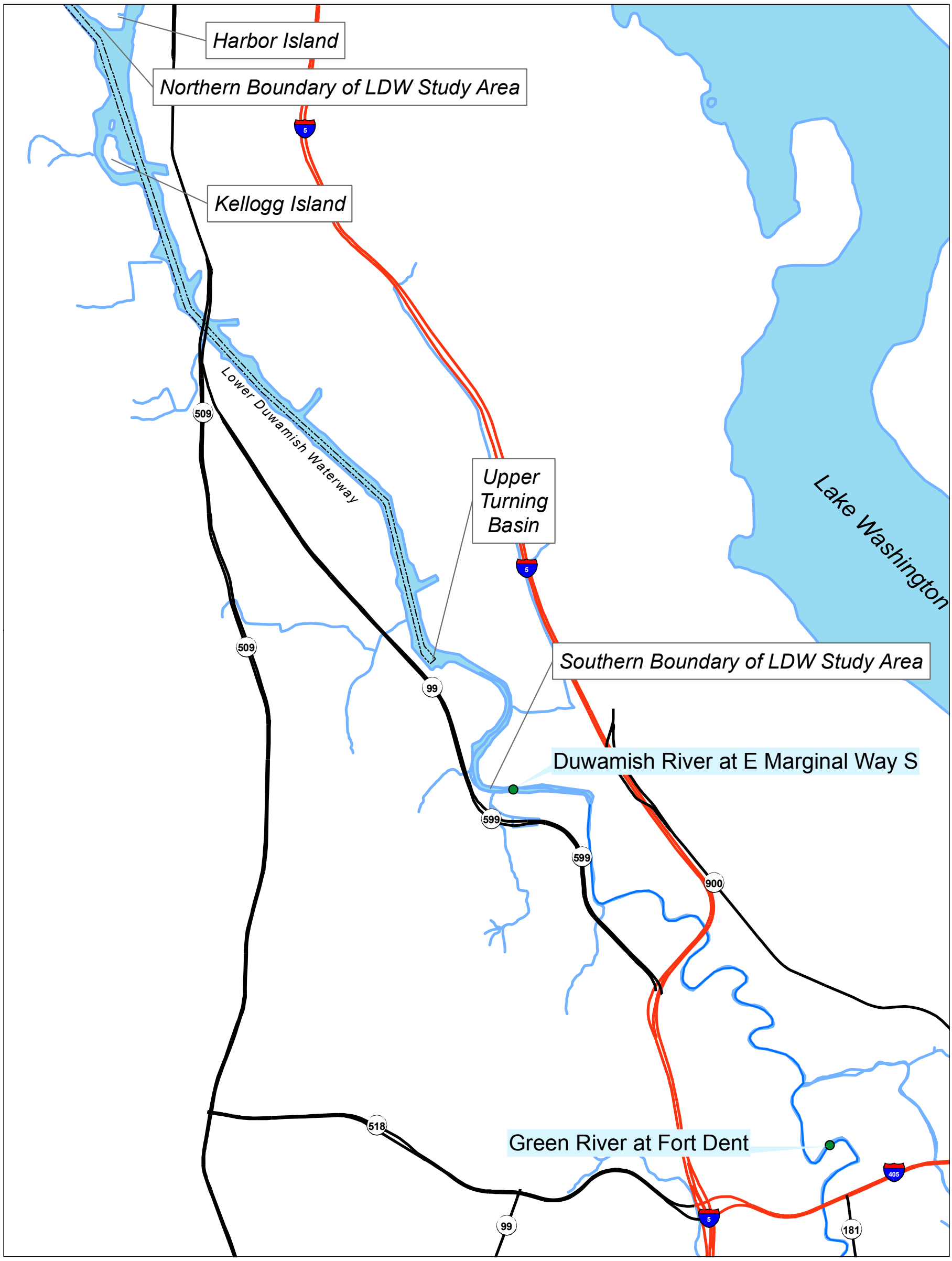
AECOM

Windward environmental LLC

0 250 500 1,000 Meters

N

Map 7-6. Locations of subsurface sediment samples collected as part of the 1990 to 2003 USACE dredged material characterization events



Legend

- King County surface water sampling location
- Navigation channel
- Interstate highway
- State highway

AECOM

Wind Ward environmental LLC

N

0 0.25 0.5 1 Miles

0 0.25 0.5 1 Kilometers

Map 7-7. Upstream surface water sampling locations

Wind Ward LLC environmental

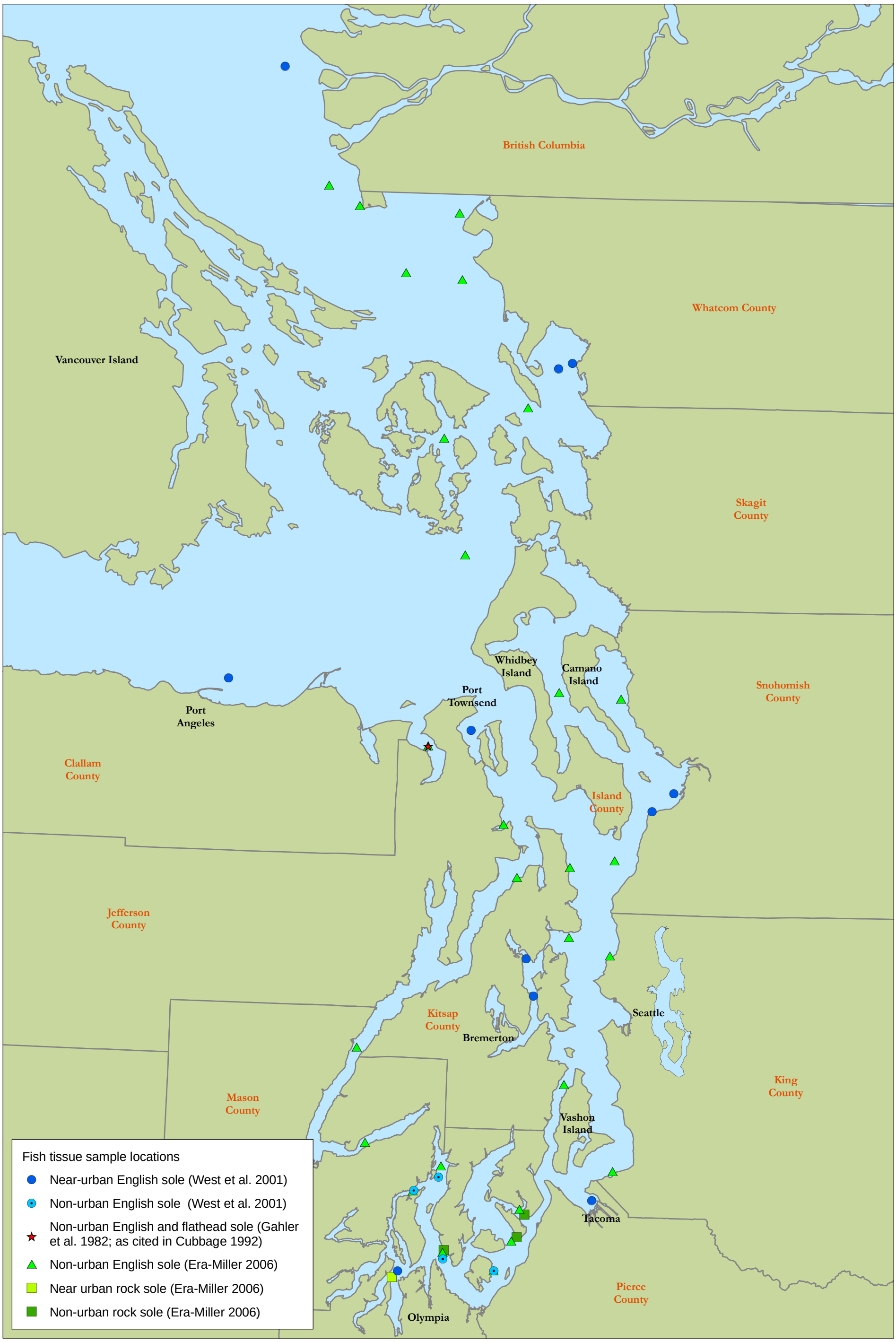
N

0 1.5 3 Miles

0 2.5 5 Kilometers

Map 7-8. Dioxin and furan TEQs in surface sediment samples from the greater Seattle area

Prepared by CEH, 07/15/2010; MAP #2307; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Background



Wind Ward environmental LLC

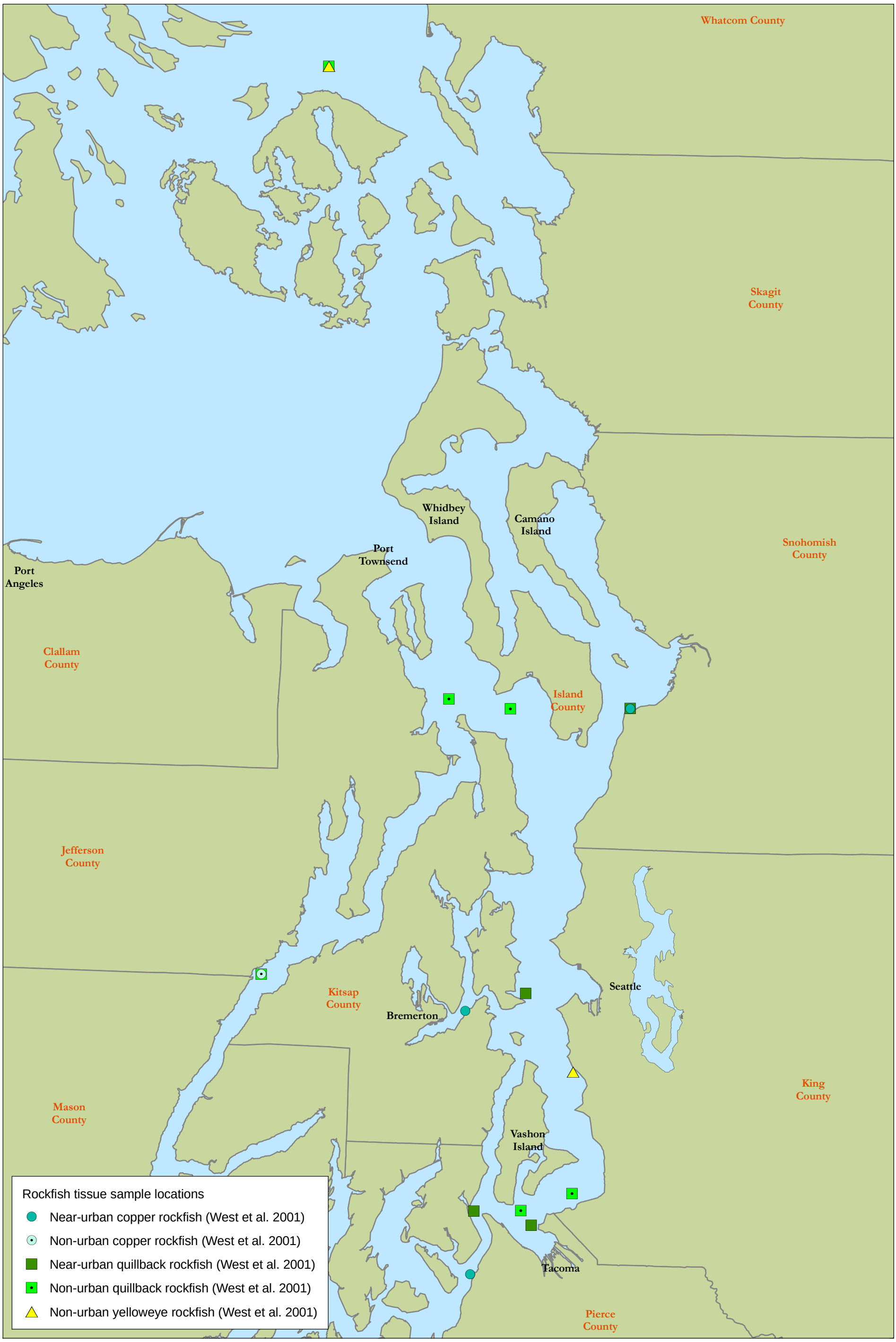
N

0 10 20 Miles

0 10 20 Kilometers

Map 7-9. Greater Puget Sound sampling locations for English, rock, and flathead sole analyzed for PCBs

Prepared by CEH, 07/15/2010; MAP 3034; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Natural background



Wind Ward environmental LLC

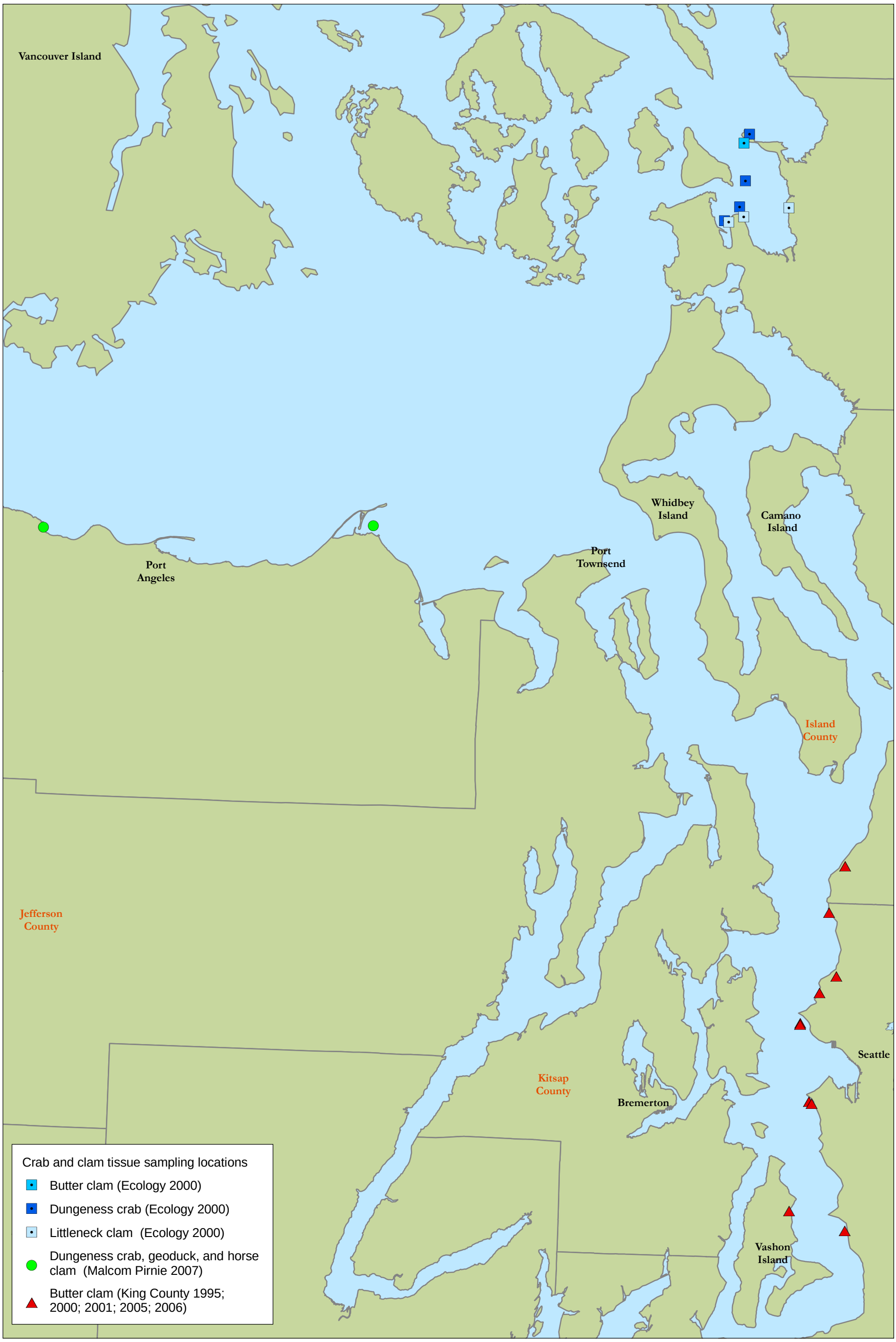
N

0 7.5 15 Miles

0 7.5 15 Kilometers

Map 7-10. Greater Puget Sound sampling locations for rockfish species analyzed for PCBs

Prepared by CEH, 07/15/2010; MAP 3036; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Background



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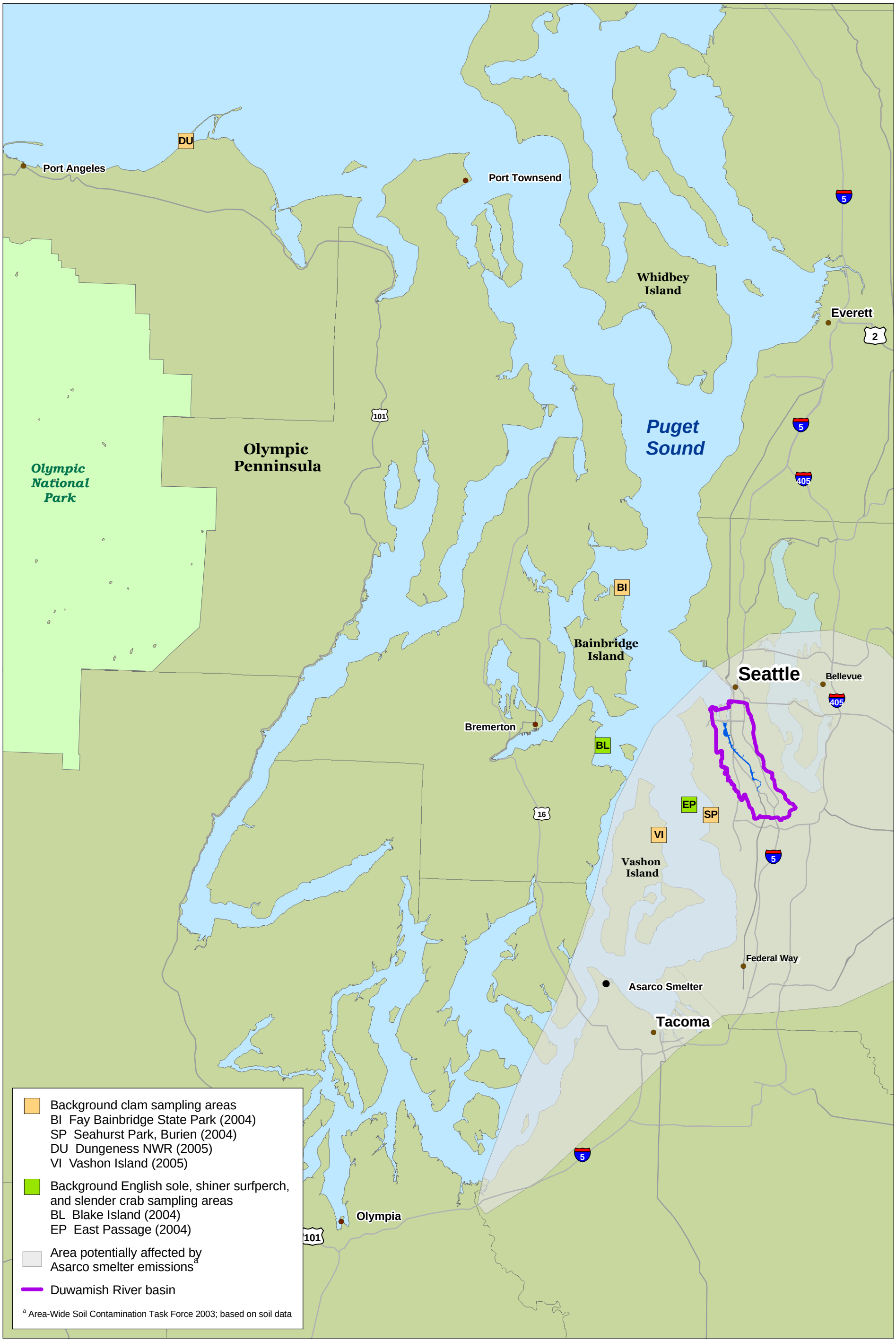
Map 7-11. Greater Puget Sound sampling locations for crab and clam species analyzed for PCBs

Prepared by CEH, 07/15/2010; MAP 3035; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Natural background



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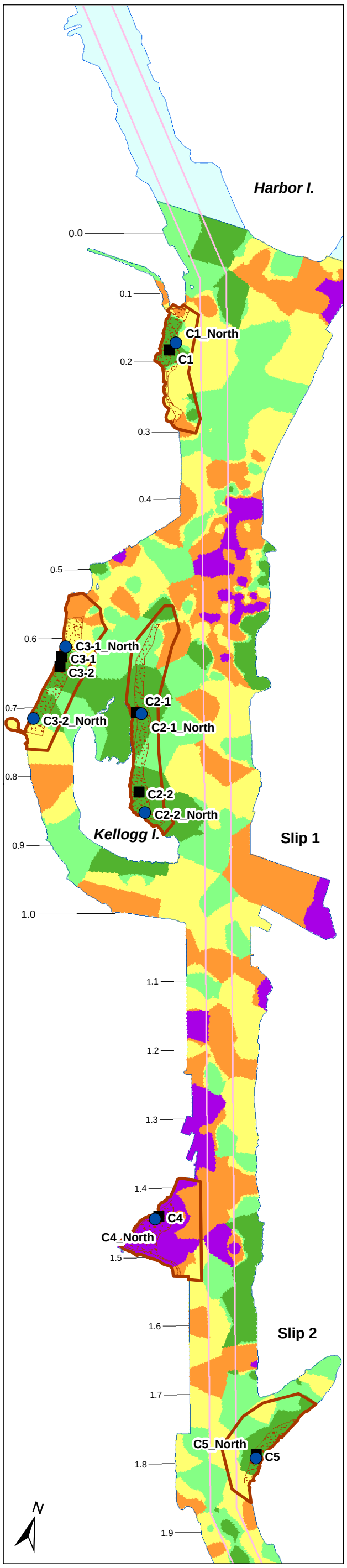
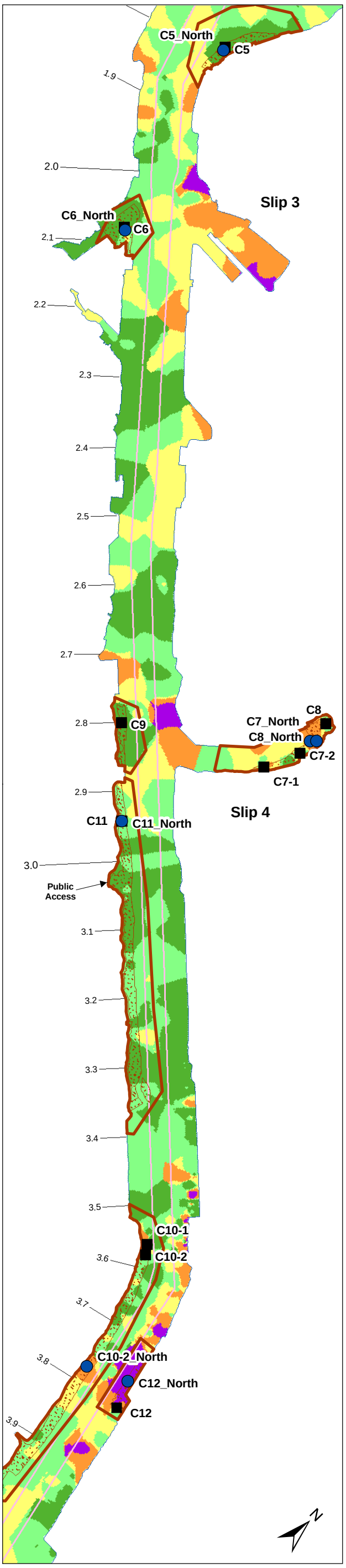
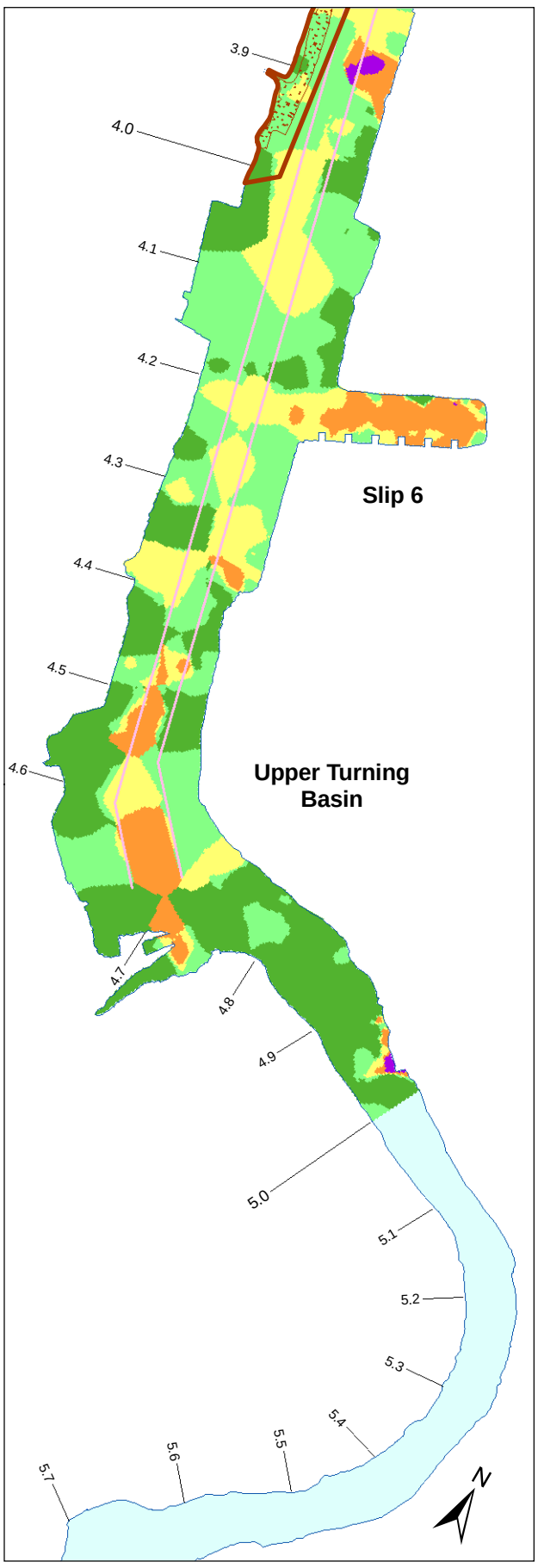
Map 7-12. Background areas where tissue sampling for arsenic was conducted as part of the RI

Prepared by CEH, 07/15/2010; MAP #2282; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Background







- 2004 clam sampling location
- 2007 clam sampling location[a]
- Intertidal clam area[b]
- Intertidal clam area plus buffer area[b]

Interpolated arsenic concentration in surface sediment (mg/kg dw)[c]

- > 25
- > 14 and ≤ 25
- > 11 and ≤ 14
- > 8.6 and ≤ 11
- ≤ 8.6
- Outside the LDW study area
- River mile
- Navigation channel

95th percentile = 25
75th percentile = 14
50th percentile = 11
25th percentile = 8.6

[a] The coordinates for locations C9_North and C10-1_North were not correctly recorded because of a malfunctioning GPS, and do not appear on this map.

[b] Areas used to estimate the sediment SWAC in clam/tissue sediment regressions.

[c] Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 25 mg/kg dw). Interpolated concentrations were calculated including locations with non-detected values. For locations with non-detects, a value of one-half the RL at that location was used.

Wind Ward environmental LLC

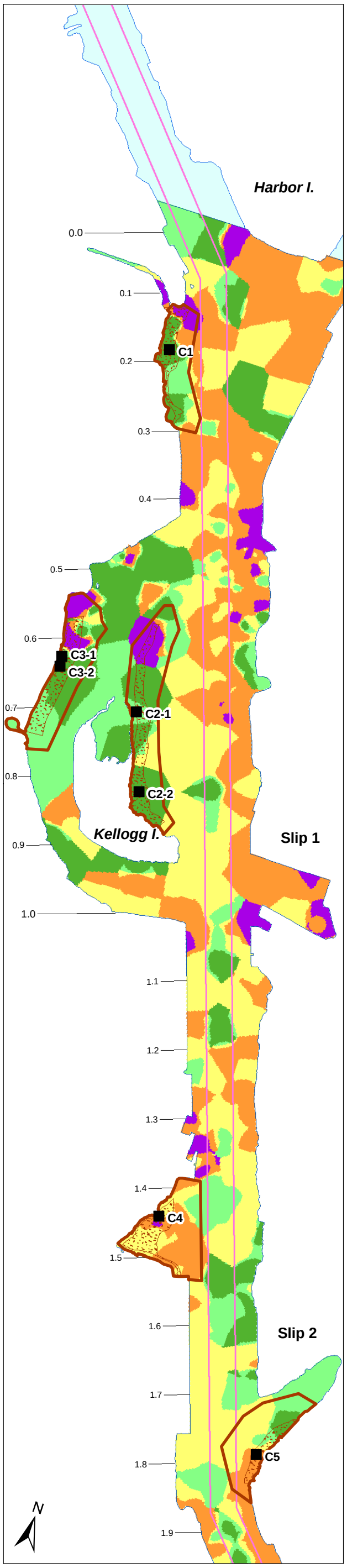
0 0.1 0.2 Miles

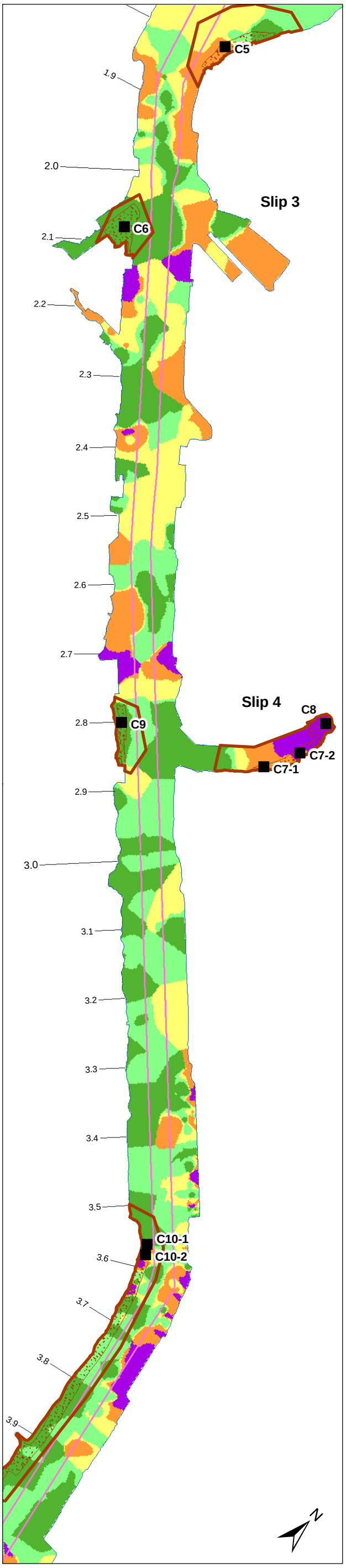
0 0.1 0.2 Kilometers

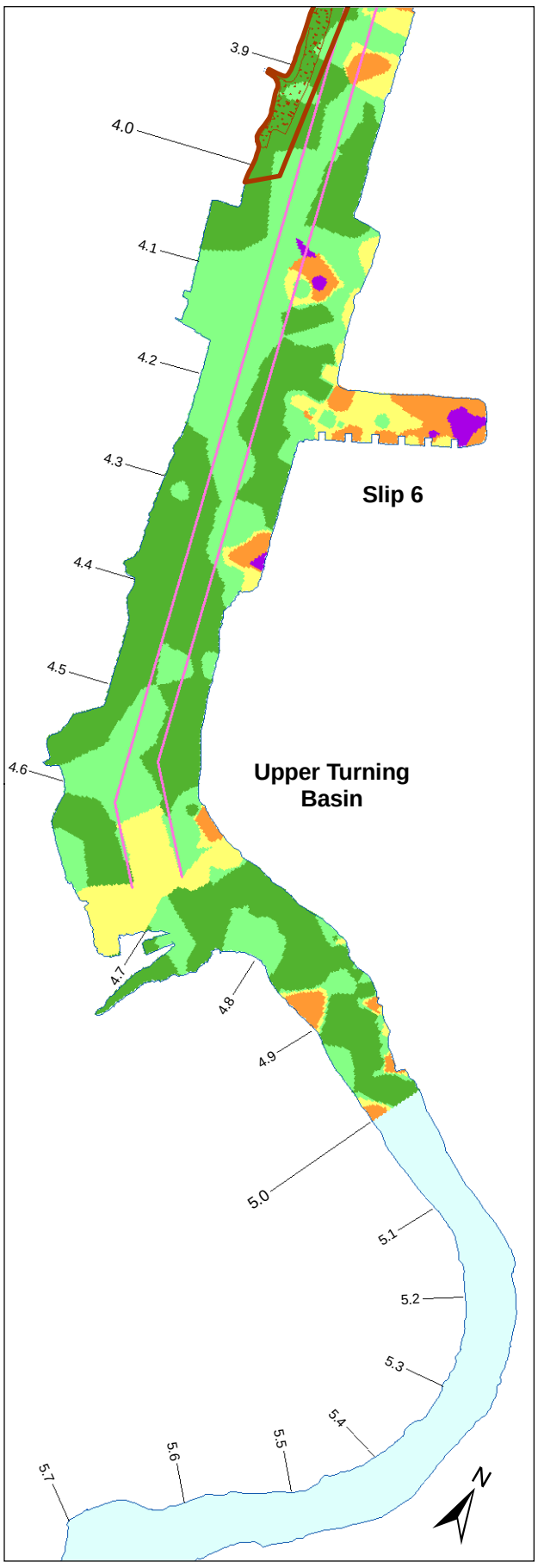
Scale is the same for each inset map

Map 8-1. Clam sampling locations and habitat relative to IDW interpolation of arsenic concentrations in surface sediment

Prepared by CEH, 07/15/2010; MAP #2573; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\COC_RBTC Exploration







- ■ 2004 clam sampling location[a]
- Intertidal clam area[b]
- Intertidal clam area plus buffer area[b]

Interpolated cPAH concentration in surface sediment (µg/kg dw)[c]

- > 1,100
- > 460 and ≤ 1,100
- > 260 and ≤ 460
- > 130 and ≤ 260
- ≤ 130

95th percentile = 1,100
75th percentile = 460
50th percentile = 260
25th percentile = 130

- Outside the LDW study area
- River mile
- Navigation channel

[a] Clams were collected in 2007 but were not analyzed for cPAHs.

[b] Areas used to estimate the sediment SWAC in clam tissue/sediment regressions.

[c] Percentiles were calculated on an area basis as the concentration at which a particular percentage of the LDW area has interpolated values less than or equal to that concentration (e.g., the 95th percentile is the concentration at which 95% of the LDW area has interpolated concentrations ≤ 1,100 µg/kg dw). Interpolated concentrations were calculated including locations with non-detected values. cPAH concentrations are based on benzo(a)pyrene equivalents. TEQs were calculated with mammalian PEFs for seven individual PAH compounds (California EPA 1994), using one-half the RL for undetected compounds.

Wind Ward environmental LLC

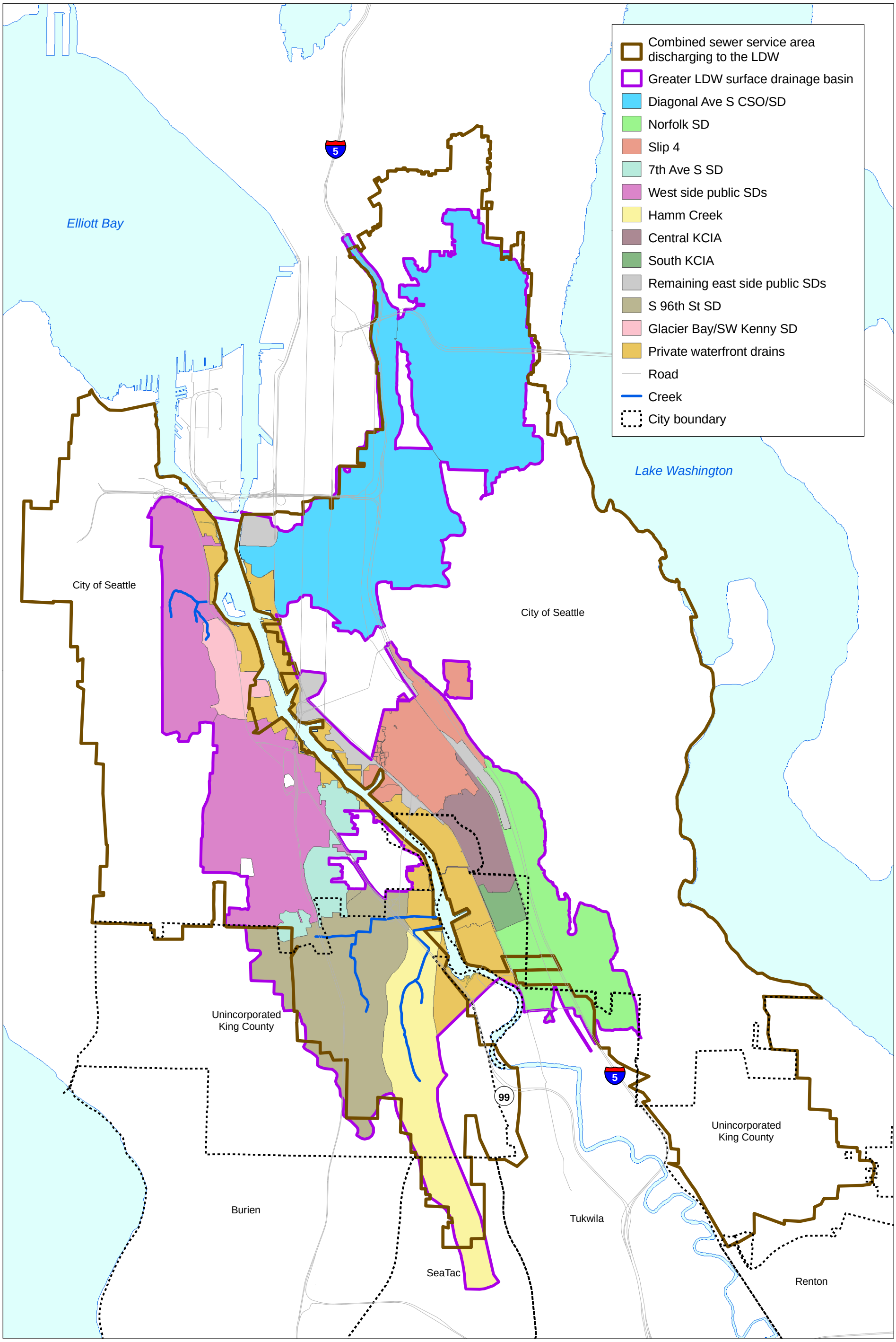
0 0.1 0.2 Miles

0 0.1 0.2 Kilometers

Scale is the same for each inset map

Map 8-2. Clam sampling locations and habitat relative to IDW interpolation of cPAH concentrations in surface sediment

Prepared by CEH, 07/15/2010; MAP #3379; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\COC_RBTC Exploration



Wind Ward environmental LLC

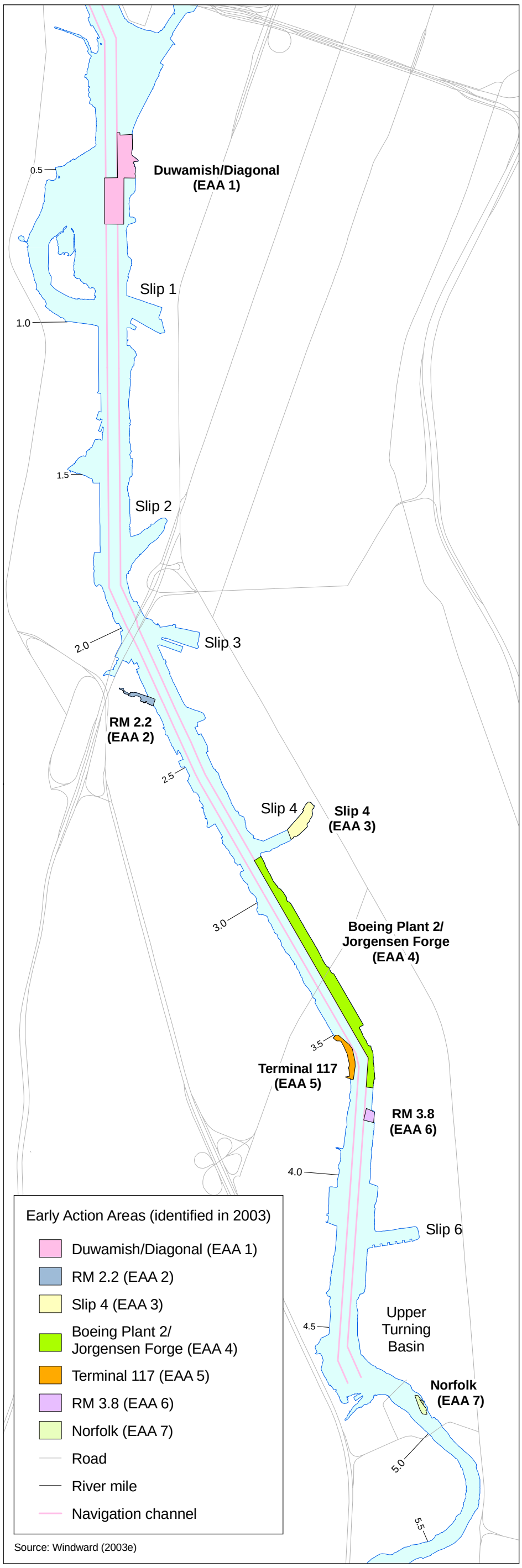
N

0 0.5 1 Miles

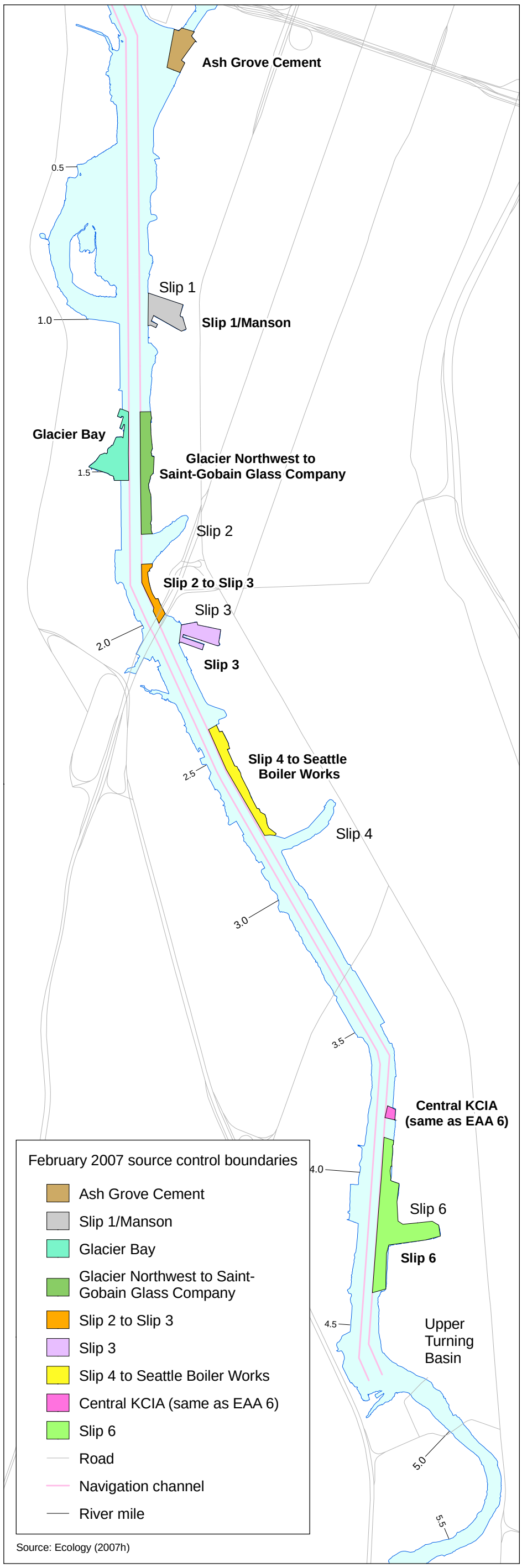
0 0.5 1 Kilometers

Map 9-1. Greater LDW drainage basins

Prepared by CEH, 07/15/2010, MAP 2847: W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Source Control\Section 9



Source: Windward (2003e)



Source: Ecology (2007h)

Windward environmental LLC

N

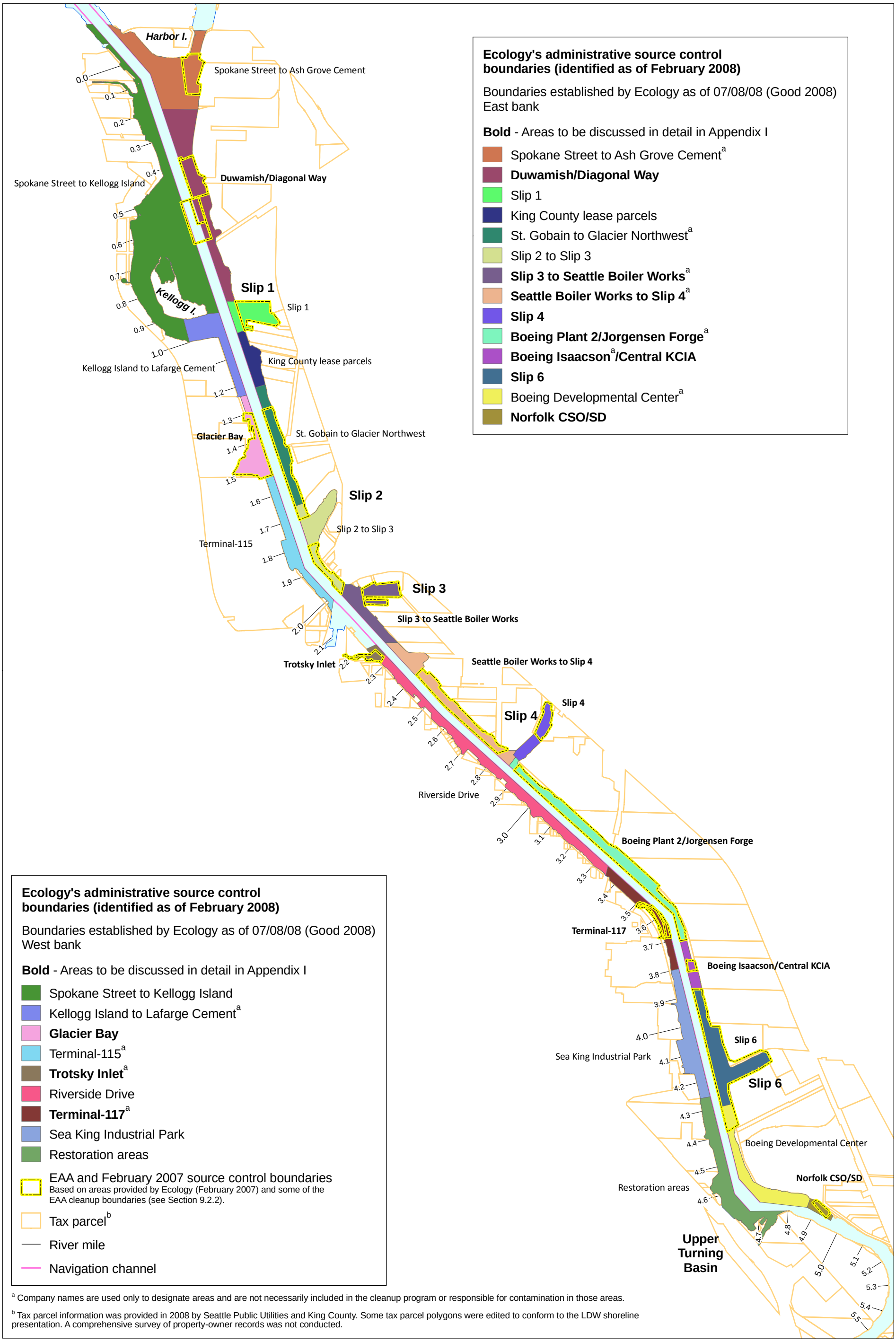
0 0.25 0.5 Miles

0 0.4 0.8 Kilometers

Scale is the same for each inset map

Map 9-2. Early Action Areas (identified in 2003) and Ecology's February 2007 source control boundaries

Prepared by CEH, 07/15/2010; Map 2849; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Source Control\Section 9



Ecology's administrative source control boundaries (identified as of February 2008)

Boundaries established by Ecology as of 07/08/08 (Good 2008)
East bank

Bold - Areas to be discussed in detail in Appendix I

- Spokane Street to Ash Grove Cement[a]
- **Duwamish/Diagonal Way**
- Slip 1
- King County lease parcels
- St. Gobain to Glacier Northwest[a]
- Slip 2 to Slip 3
- **Slip 3 to Seattle Boiler Works[a]**
- **Seattle Boiler Works to Slip 4[a]**
- **Slip 4**
- **Boeing Plant 2/Jorgensen Forge[a]**
- **Boeing Isaacson[a]/Central KCIA**
- **Slip 6**
- Boeing Developmental Center[a]
- **Norfolk CSO/SD**

Ecology's administrative source control boundaries (identified as of February 2008)

Boundaries established by Ecology as of 07/08/08 (Good 2008)
West bank

Bold - Areas to be discussed in detail in Appendix I

- Spokane Street to Kellogg Island
- Kellogg Island to Lafarge Cement[a]
- **Glacier Bay**
- Terminal-115[a]
- **Trotsky Inlet[a]**
- Riverside Drive
- **Terminal-117[a]**
- Sea King Industrial Park
- Restoration areas
- EAA and February 2007 source control boundaries
  Based on areas provided by Ecology (February 2007) and some of the EAA cleanup boundaries (see Section 9.2.2).
- Tax parcel[b]
- River mile
- Navigation channel

[a] Company names are used only to designate areas and are not necessarily included in the cleanup program or responsible for contamination in those areas.

[b] Tax parcel information was provided in 2008 by Seattle Public Utilities and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property-owner records was not conducted.

Wind Ward environmental LLC

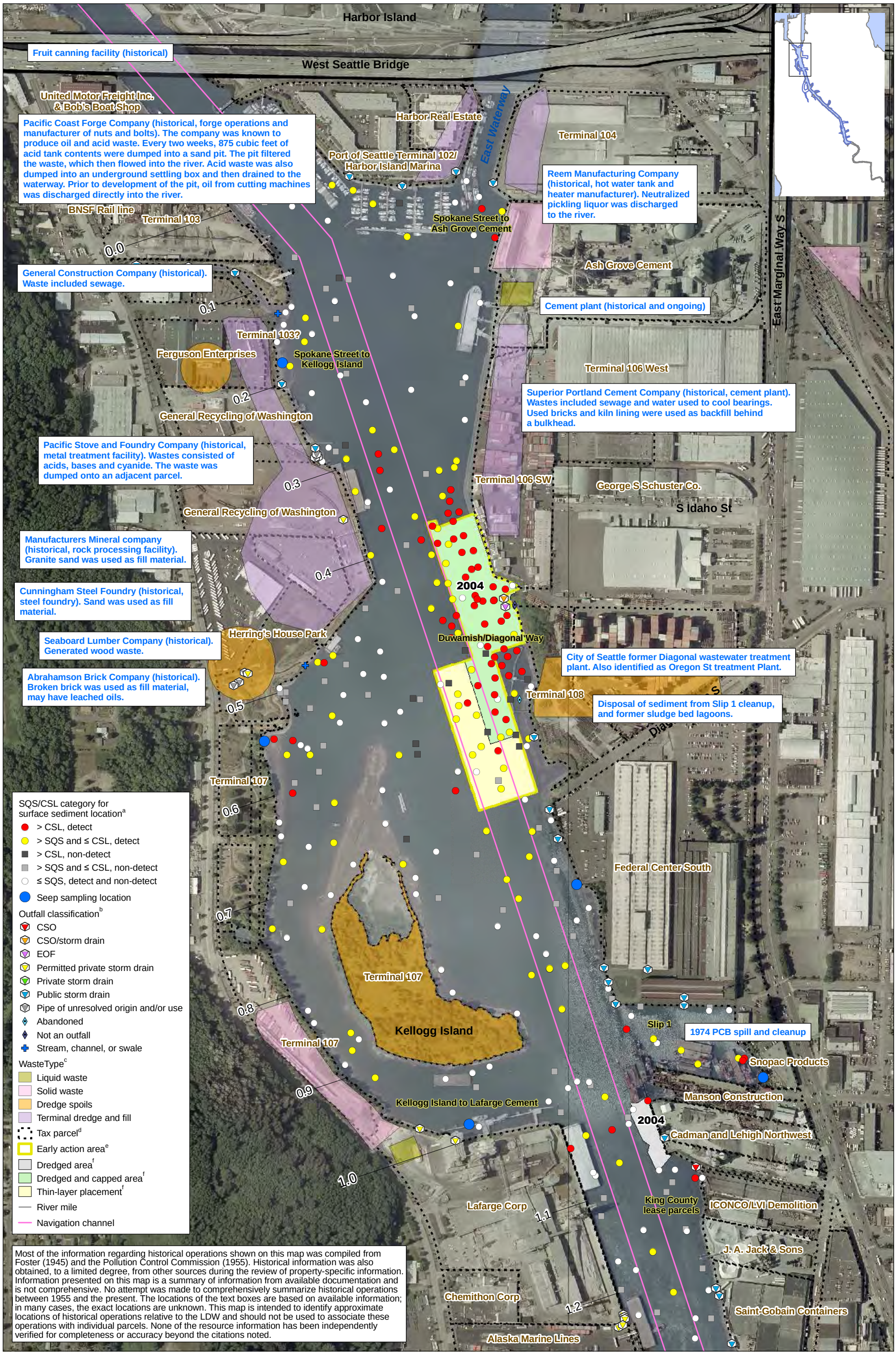
N

0 0.25 0.5 Miles

0 0.25 0.5 Kilometers

Map 9-3. Ecology's administrative source control boundaries (identified as of February 2008)

Prepared by CEH, 07/15/2010; MAP #3245; W:\Projects\00-08-06_Duwamish_Rl\data\gis\Phase2 RI\Source Control\Section 9



Wind Ward environmental LLC

N

0 150 300 600 Feet

0 50 100 200 Meters

Map 9-4a. Selected historical operations near the LDW, RM 0.0 to RM 1.2

Photo source: "USGS High Resolution Orthoimage, Seattle/Tacoma, WA", United States Geological Survey, 2003. Distributed by King County GIS. Photo date 06/11/2002.

Prepared by CEH, 07/15/2010; MAP 3077; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Source Control\Section 9

[a] When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations are compared instead to the LAET and 2LAET.

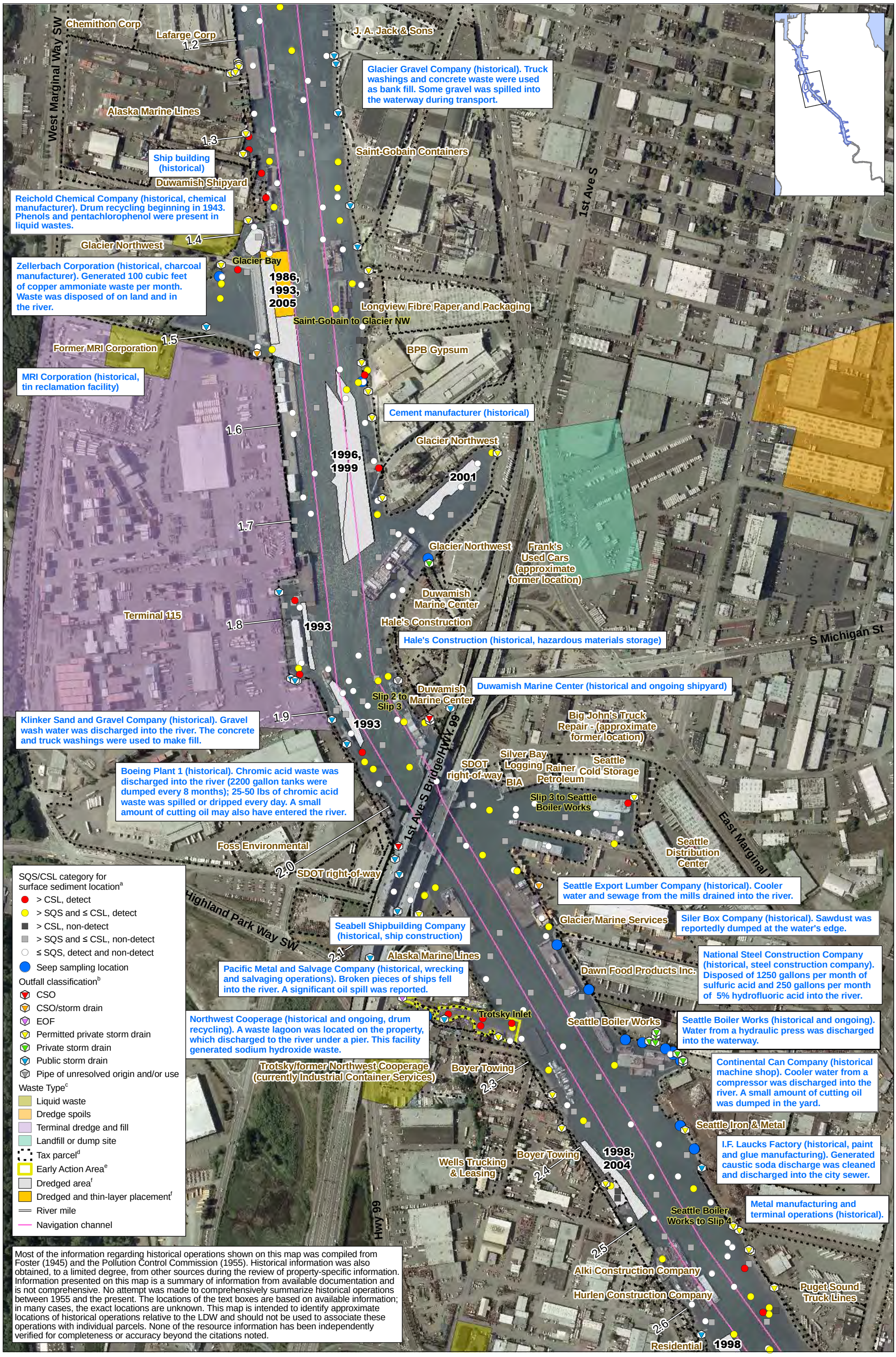
[b] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

[c] Sweet Edwards 1985. Duwamish groundwater study. Prepared for Municipality of Metropolitan Seattle. Sweet, Edwards and Associates, Inc. and Harper-Owes Company, Seattle, WA

[d] Tax parcel information was provided in 2008 by Seattle Public Utilities and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property-owner records was not conducted. Names represent tenant/operator or owner.

[e] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.

[f] For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging/capping in 2003/2004, or thin-layer placement in 2005. For other dredged areas, surface sediment data were collected after dredging. Subsurface sediment data in dredged areas were collected prior to dredging. Dredging information provided by AECOM. Year shown represents dredge year.



Wind Ward environmental LLC

N

0 150 300 600 Feet

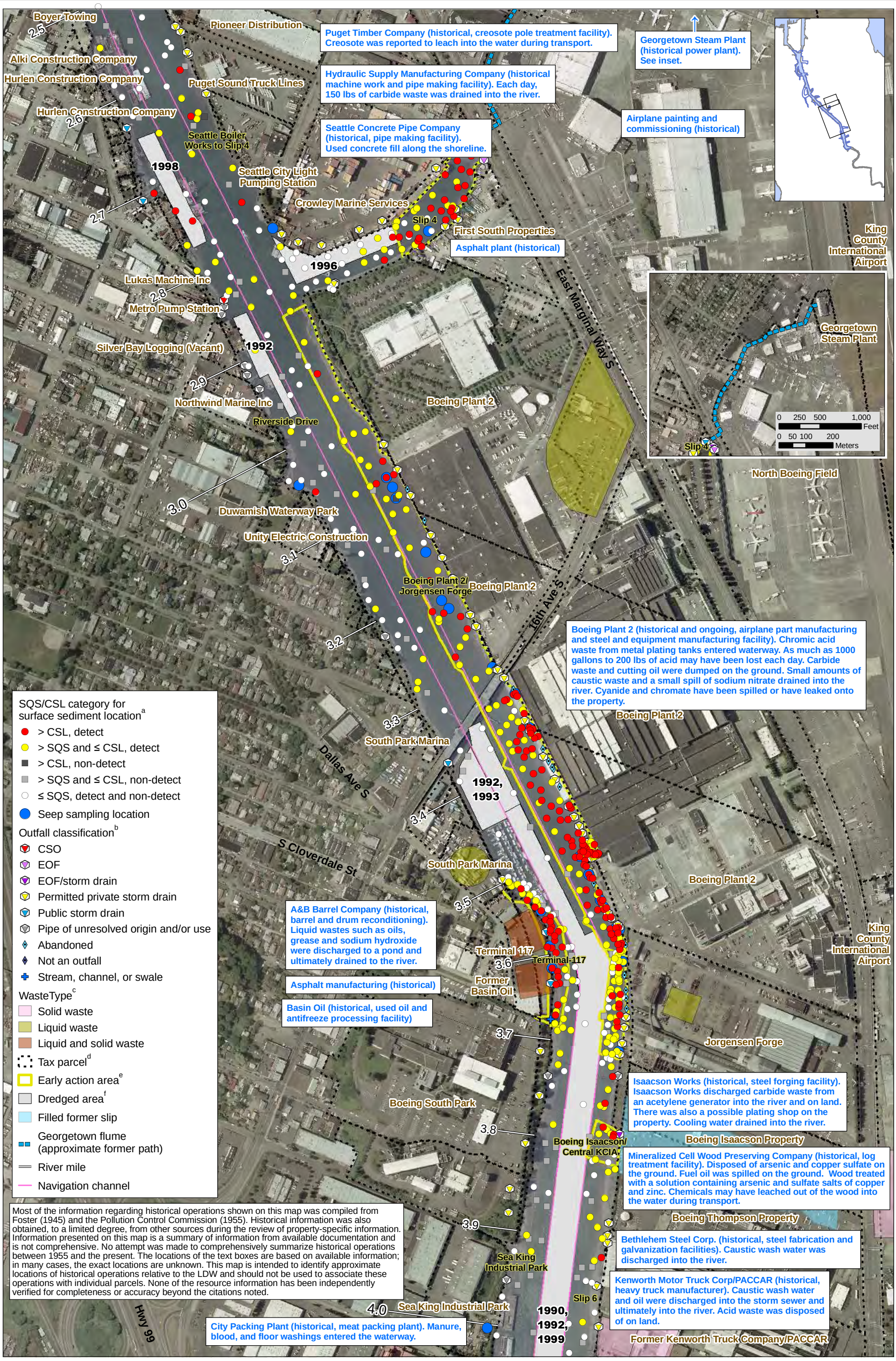
0 50 100 200 Meters

Map 9-4b. Selected historical operations near the LDW, RM 1.2 to RM 2.6

Photo source: "USGS High Resolution Orthoimage, Seattle/Tacoma, WA", United States Geological Survey, 2003. Distributed by King County GIS. Photo date 06/11/2002.

[a] When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations are compared instead to the LAET and 2LAET.
[b] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.
[c] Sweet Edwards 1985. Duwamish groundwater study. Prepared for Municipality of Metropolitan Seattle. Sweet, Edwards and Associates, Inc. and Harper-Owes Company, Seattle, WA
[d] Tax parcel information was provided in 2008 by Seattle Public Utilities and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property-owner records was not conducted. Names represent tenant/operator or owner.
[e] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.
[f] For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging/capping in 2003/2004, or thin-layer placement in 2005. For other dredged areas, surface sediment data were collected after dredging. Subsurface sediment data in dredged areas were collected prior to dredging. Dredging information provided by AECOM. Year shown represents dredge year.

Prepared by CEH, 07/15/2010; MAP 3077; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Source Control\Section 9



Wind Ward environmental LLC

N

0 150 300 600 Feet

0 50 100 200 Meters

Map 9-4c. Selected historical operations near the LDW, RM 2.6 to RM 4.1

Photo source: "USGS High Resolution Orthoimage, Seattle/Tacoma, WA", United States Geological Survey, 2003. Distributed by King County GIS. Photo date 06/11/2002.

[a] When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations are compared instead to the LAET and 2LAET.
[b] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.
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[d] Tax parcel information was provided in 2008 by Seattle Public Utilities and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property-owner records was not conducted. Names represent tenant/operator or owner.
[e] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.
[f] For the Duwamish/Diagonal Early Action Area, surface sediment data in the baseline dataset represent samples collected before dredging/capping in 2003/2004, or thin-layer placement in 2005. For other dredged areas, surface sediment data were collected after dredging. Subsurface sediment data in dredged areas were collected prior to dredging. Dredging information provided by AECOM. Year shown represents dredge year.

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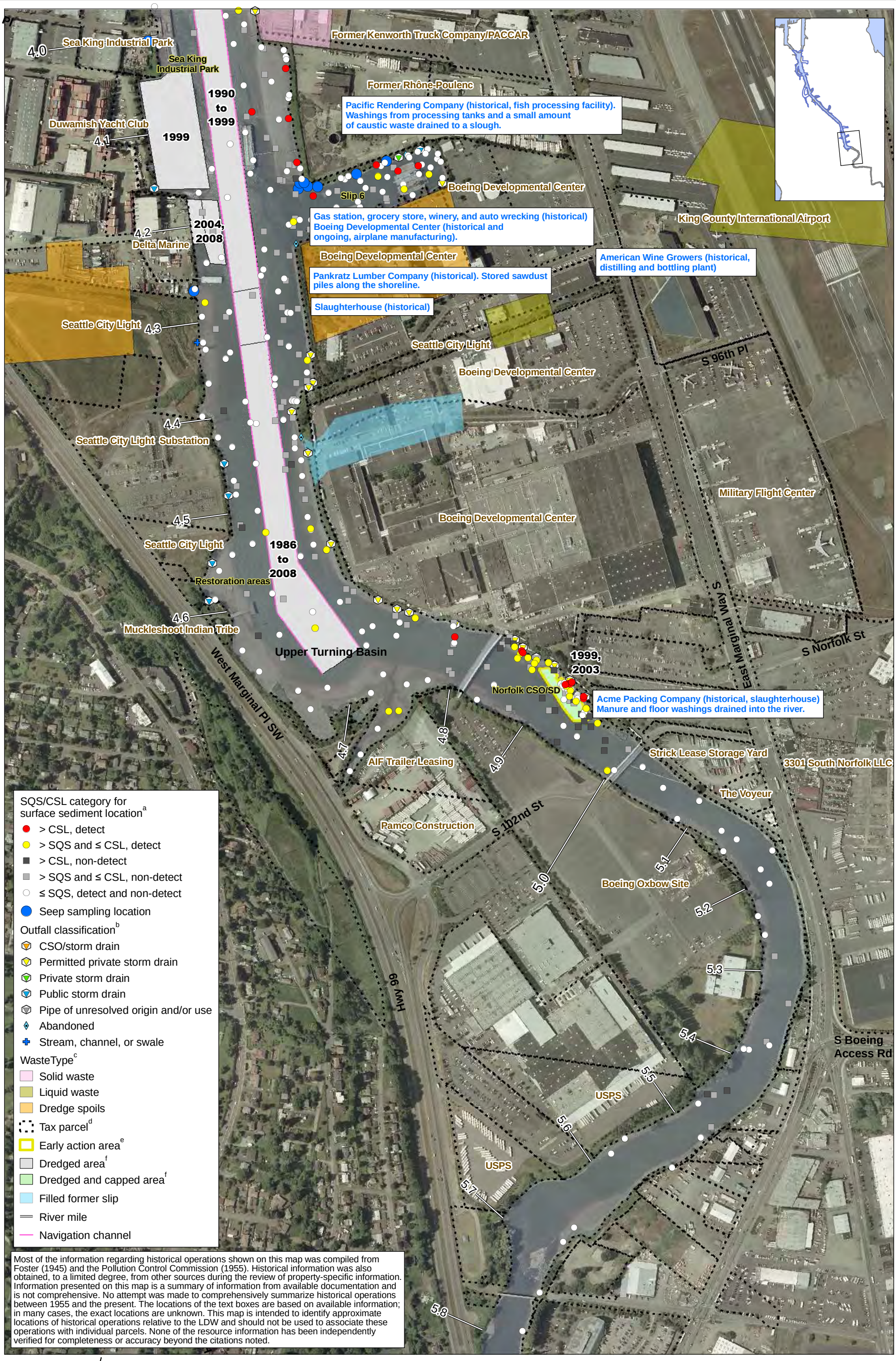

Wind Ward LLC environmental

N

0 150 300 600 Feet

0 50 100 200 Meters

Map 9-4d. Selected historical operations near the LDW, RM 4.1 to RM 5.8

Photo source: "USGS High Resolution Orthoimage, Seattle/Tacoma, WA", United States Geological Survey, 2003. Distributed by King County GIS. Photo date 06/11/2002.

[a] When OC-normalization was not appropriate because TOC content was < 0.5% or > 4.0%, dry weight concentrations for these locations are compared instead to the LAET and 2LAET.
[b] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.
[c] Sweet Edwards 1985. Duwamish groundwater study. Prepared for Municipality of Metropolitan Seattle. Sweet, Edwards and Associates, Inc. and Harper-Owes Company, Seattle, WA
[d] Tax parcel information was provided in 2008 by Seattle Public Utilities and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property-owner records was not conducted. Names represent tenant/operator or owner.
[e] Several of the EAA boundaries are approximate and have not been finalized by EPA/Ecology; a description of each EAA boundary is presented in Section 9.2.2.
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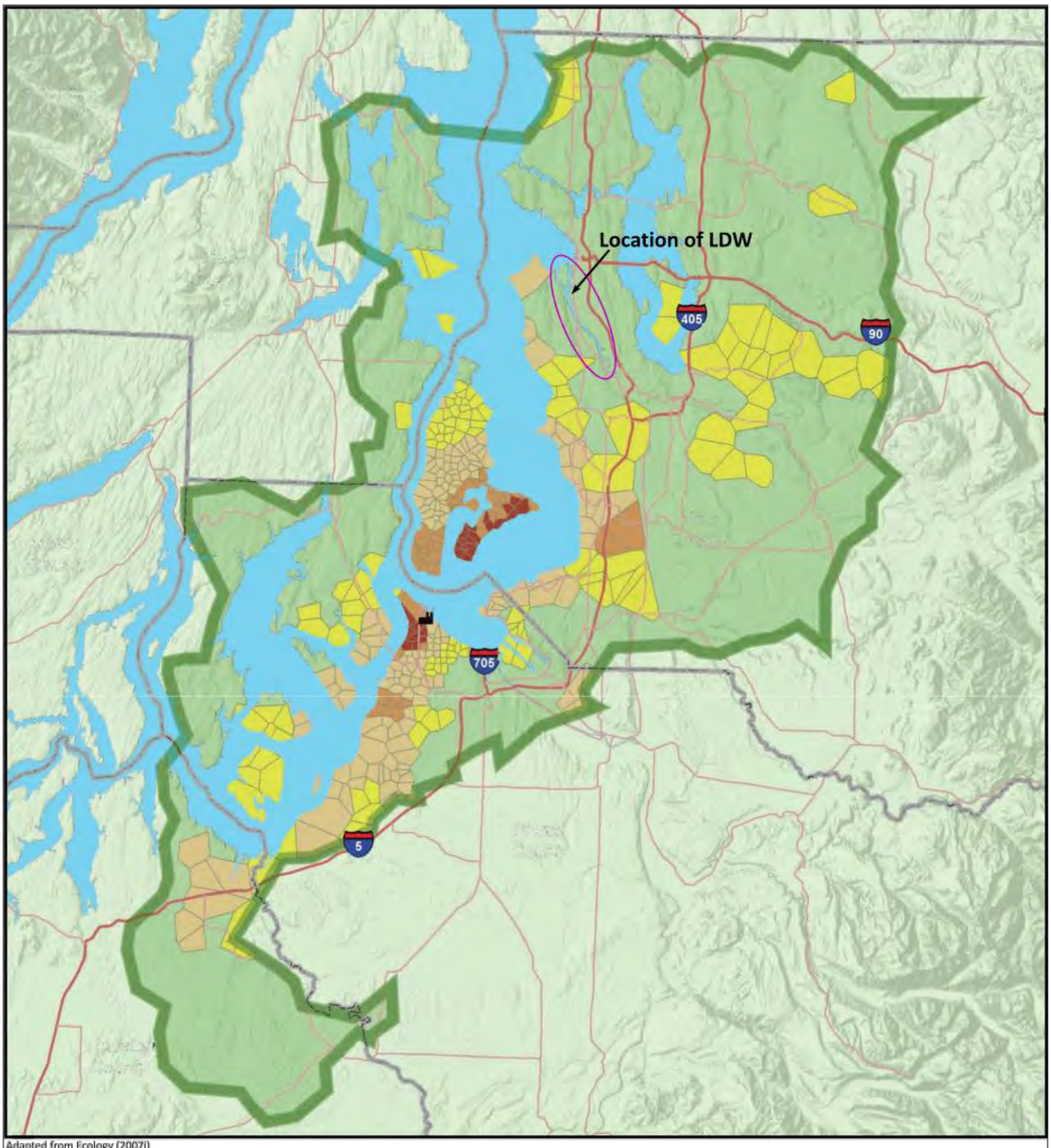


Adapted from Ecology (2007l)

Legend

Arsenic concentrations in soil, 0 to 6 in. (mg/kg dw)

- 20.1 to 40.0
- 40.1 to 100.0
- 100.1 to 200.0
- > 200

- Toxic smelter plume study area
- Stack
- County boundary
- Interstate highway
- Highway

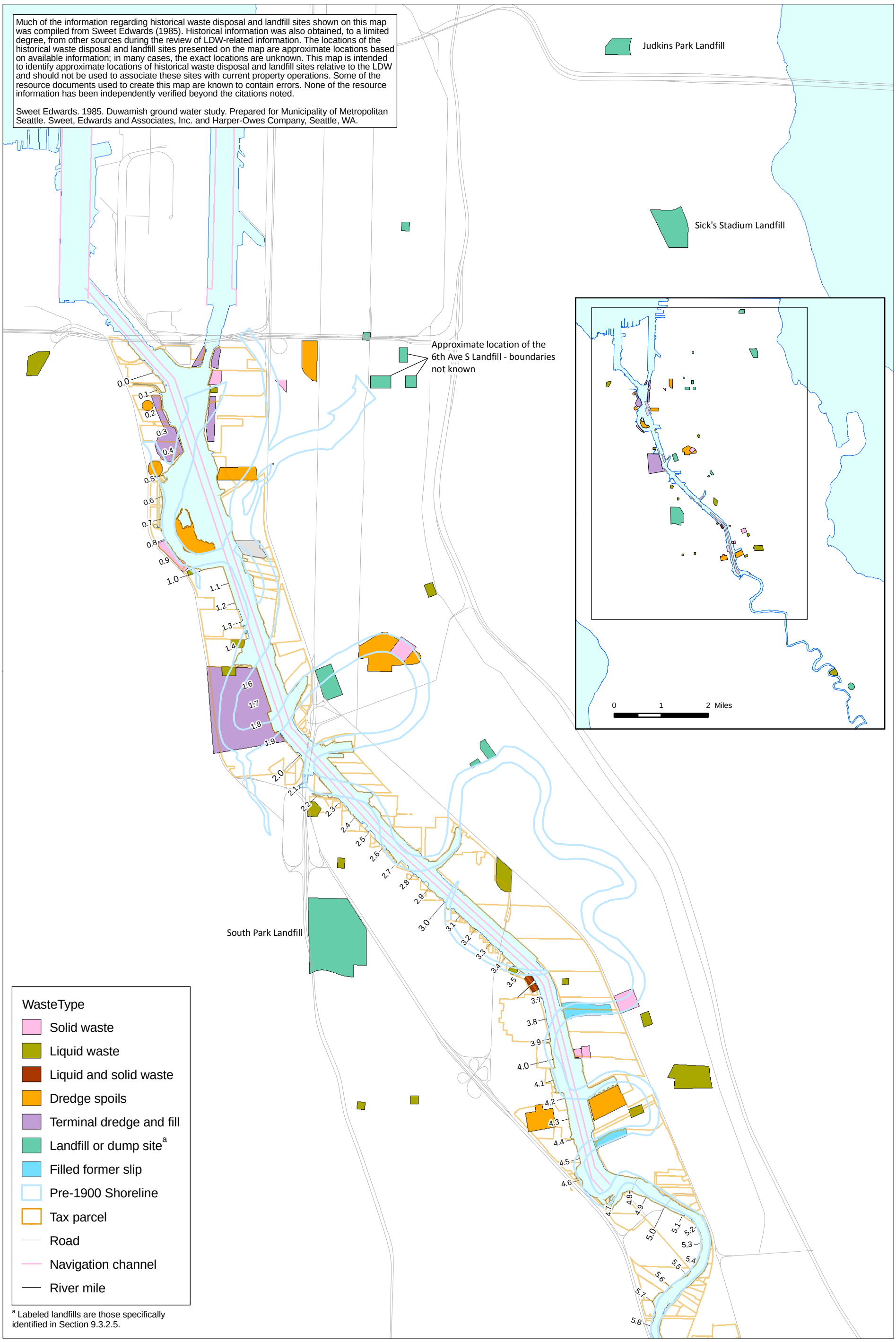
Wind Ward environmental LLC

0 2 4 6 8 10
Miles

Map 9-5. Aerial footprint of Asarco smelter plume

Much of the information regarding historical waste disposal and landfill sites shown on this map was compiled from Sweet Edwards (1985). Historical information was also obtained, to a limited degree, from other sources during the review of LDW-related information. The locations of the historical waste disposal and landfill sites presented on the map are approximate locations based on available information; in many cases, the exact locations are unknown. This map is intended to identify approximate locations of historical waste disposal and landfill sites relative to the LDW and should not be used to associate these sites with current property operations. Some of the resource documents used to create this map are known to contain errors. None of the resource information has been independently verified beyond the citations noted.

Sweet Edwards. 1985. Duwamish ground water study. Prepared for Municipality of Metropolitan Seattle. Sweet, Edwards and Associates, Inc. and Harper-Owes Company, Seattle, WA.



[a] Labeled landfills are those specifically identified in Section 9.3.2.5.

N

0 0.25 0.5 Miles

0 0.5 1 Kilometers

Map 9-6. Historical waste disposal sites and landfills within the LDW summation area as identified by Sweet Edwards (1985)

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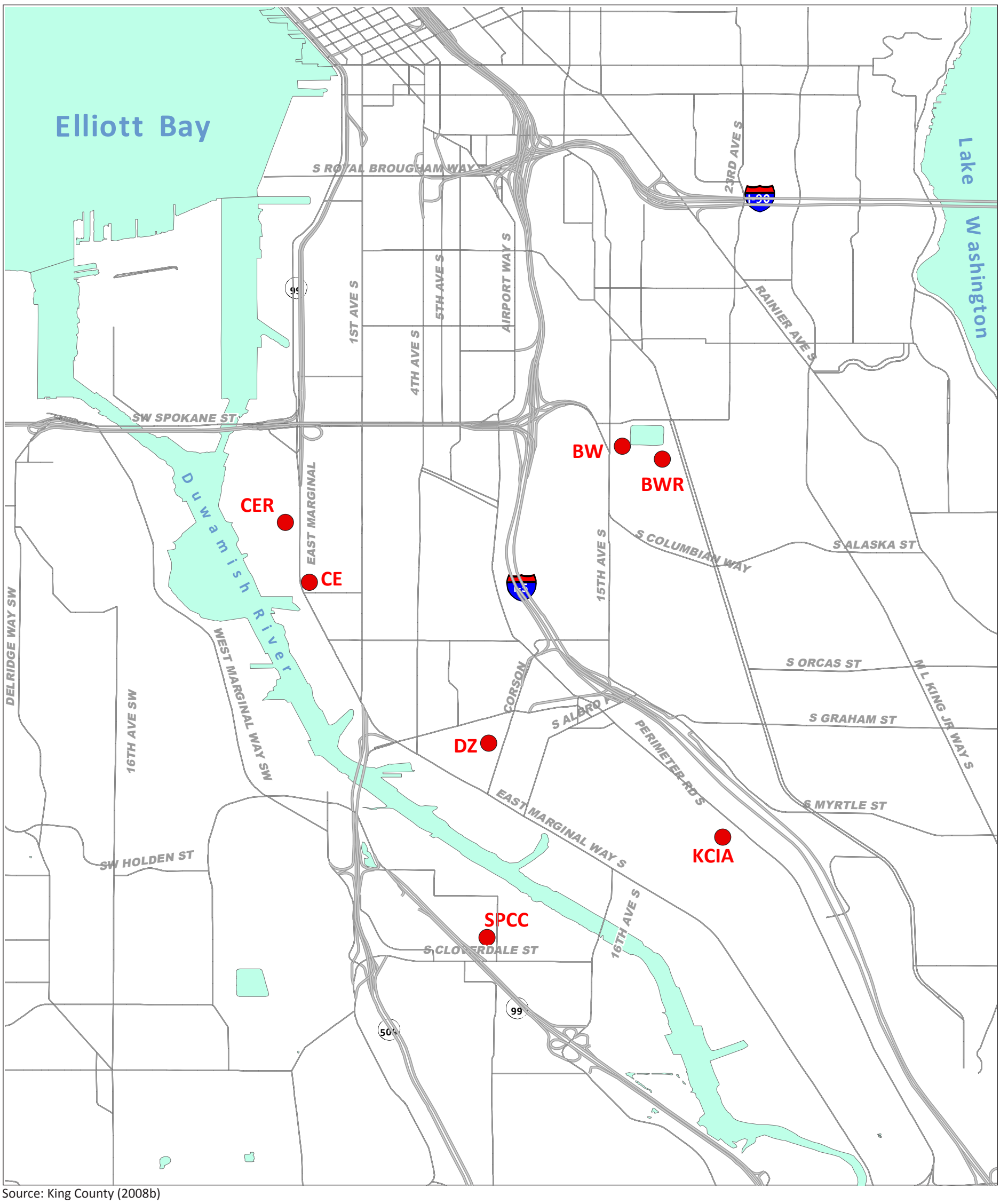

Source: King County (2008b)

Legend

- Atmospheric deposition monitoring station

BW - Beacon Hill
BWR - Relocated Beacon Hill
CE - Duwamish Valley/E Marginal Way S
CER - Relocated Duwamish Valley/E Marginal Way S
DZ - Georgetown
KCIA - King County International Airport
SPCC - South Park Community Center

The information included on this map has been compiled from a variety of sources and is subject to change without notice. King County makes no representations or warranties, express or implied, as to accuracy, completeness, timeliness, or rights to the use of such information. King County shall not be liable for any general, special, indirect, incidenital, or consequential damages including, but not limited to, lost revenues or lost profits resulting from the use or misuse of the information contained on this map. Any sale of this map or information on this map is prohibited except by written permission of King County.

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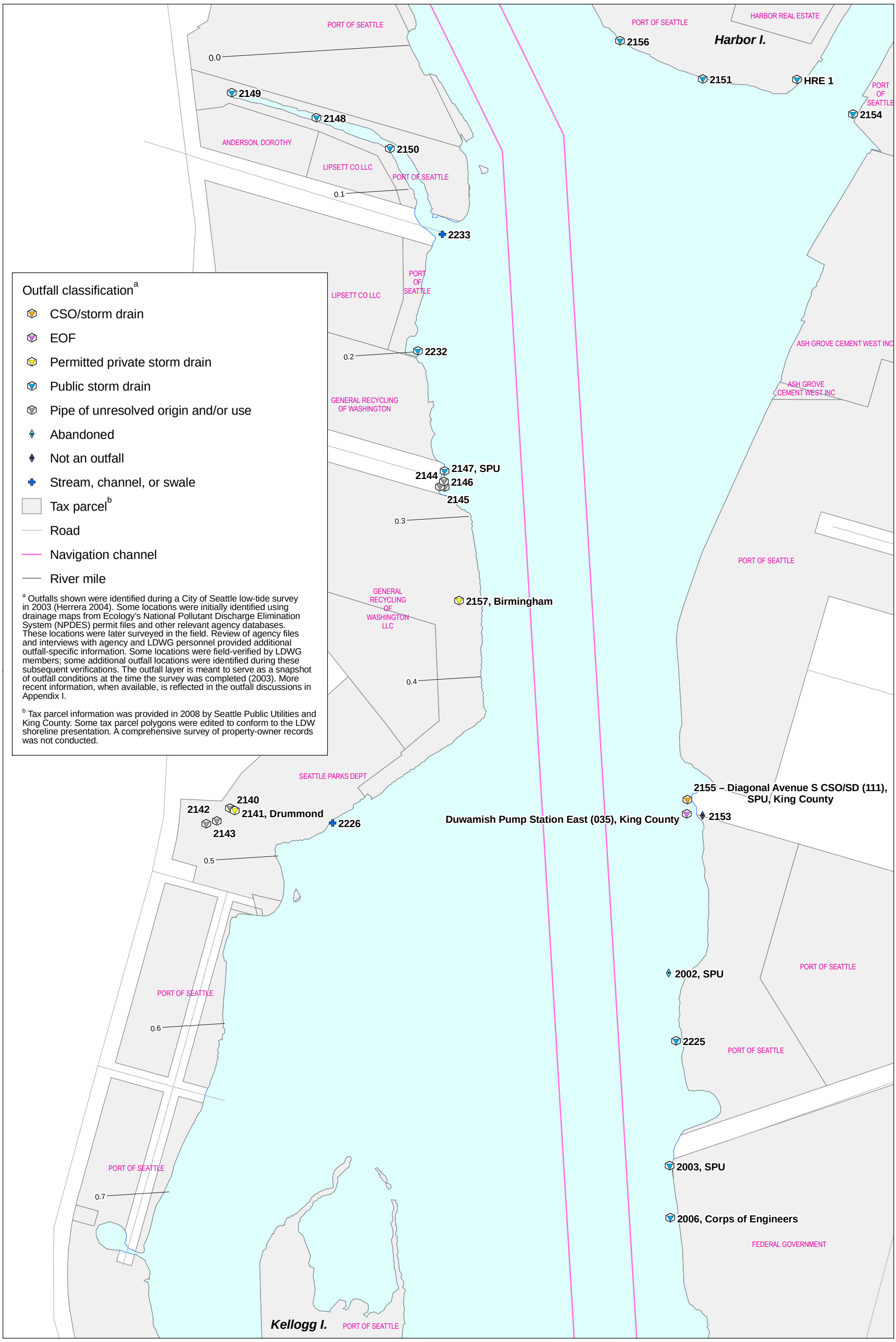
N

0 1,500 3,000 6,000 Feet

April 2007

Map 9-7. King County atmospheric deposition monitoring stations



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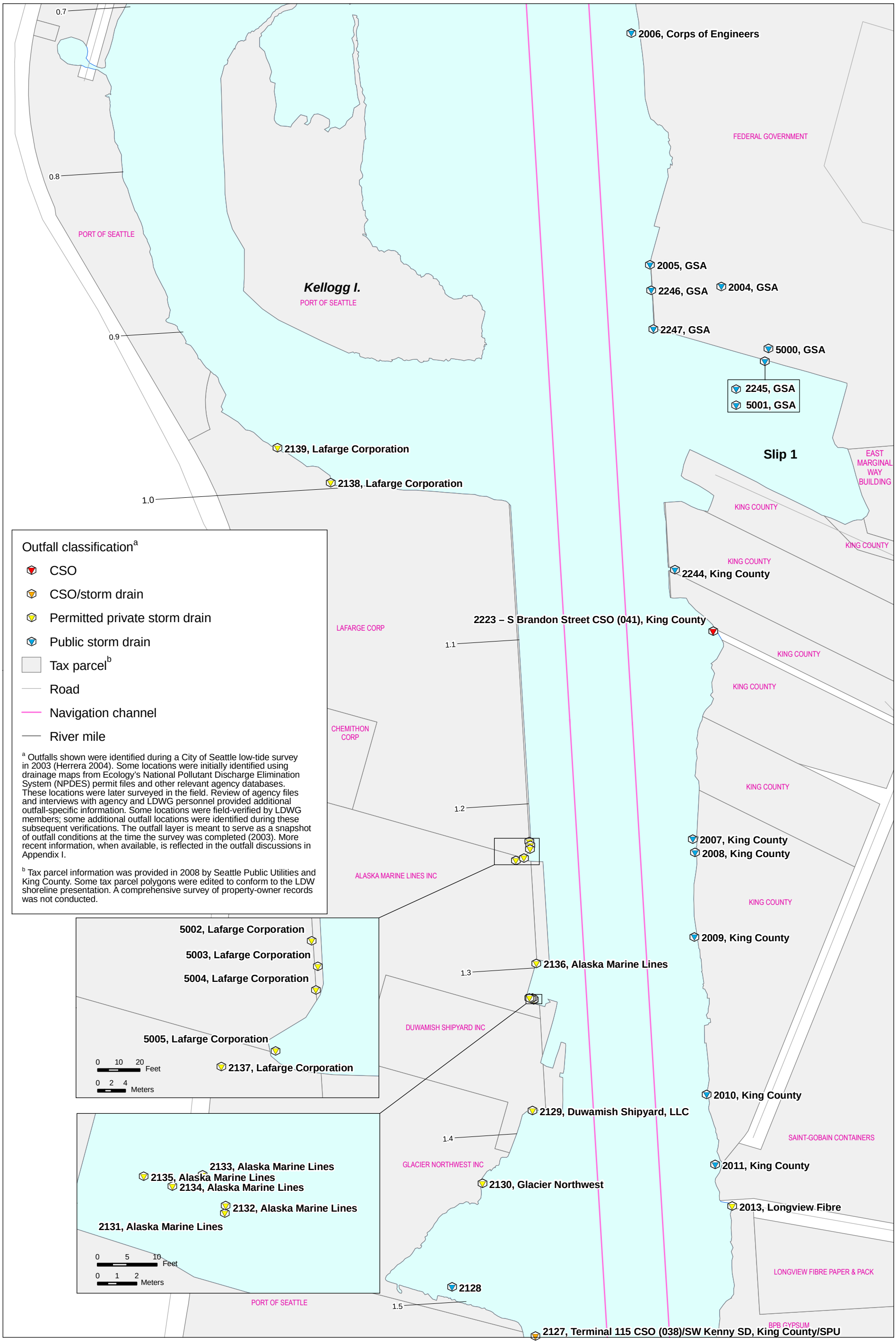
N

0 200 400 Feet

0 50 100 Meters

Map 9-8a. Outfall locations and ownership, RM 0.0 to RM 0.7

Prepared by CEH, 07/15/2010; MAP 2720; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Source Control\Section 9



Wind Ward environmental LLC

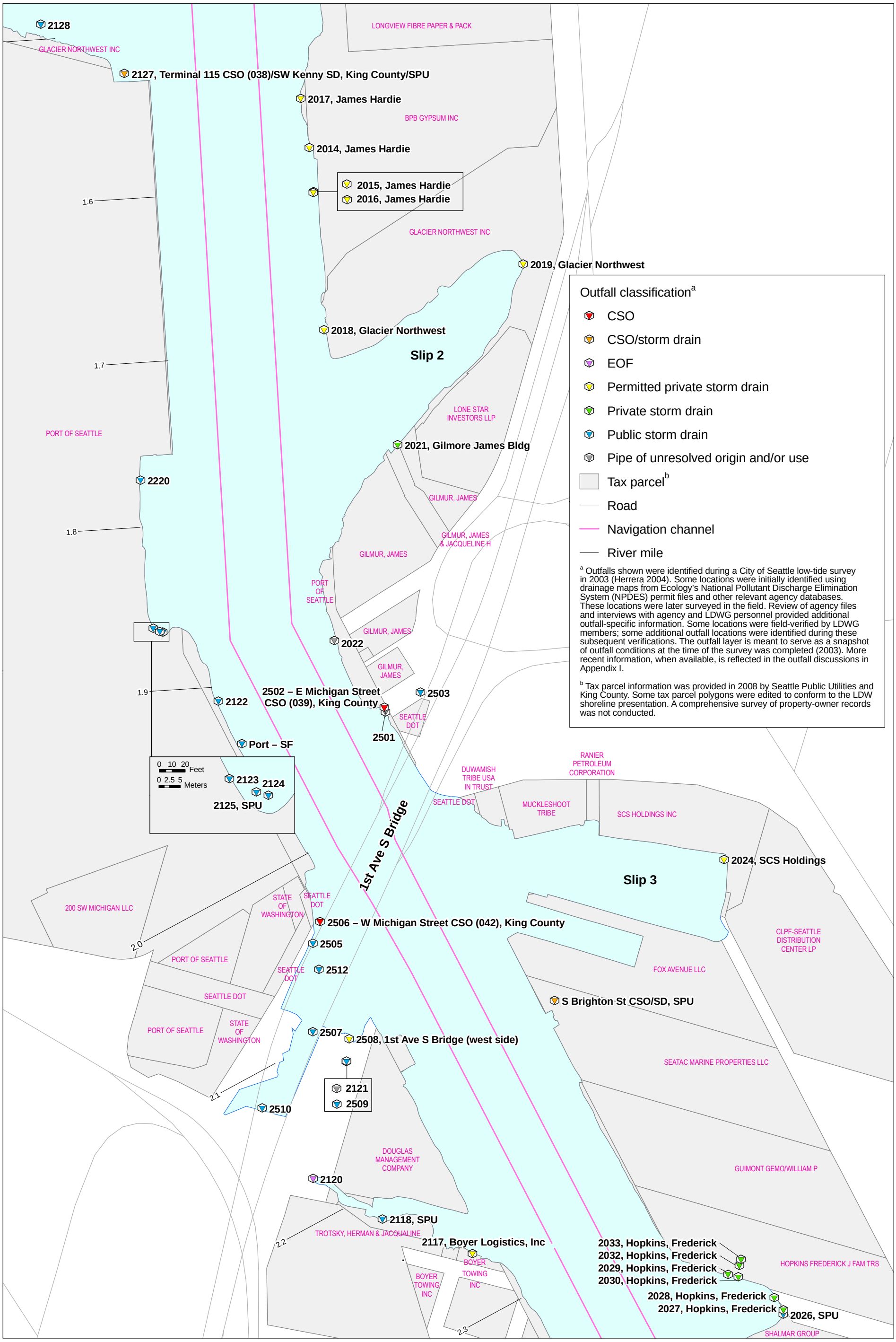
N

0 200 400 Feet

0 50 100 Meters

Map 9-8b. Outfall locations and ownership, RM 0.7 to RM 1.5

Prepared by CEH, 07/15/2010, MAP 2720: W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Source Control\Section 9



Wind Ward environmental LLC

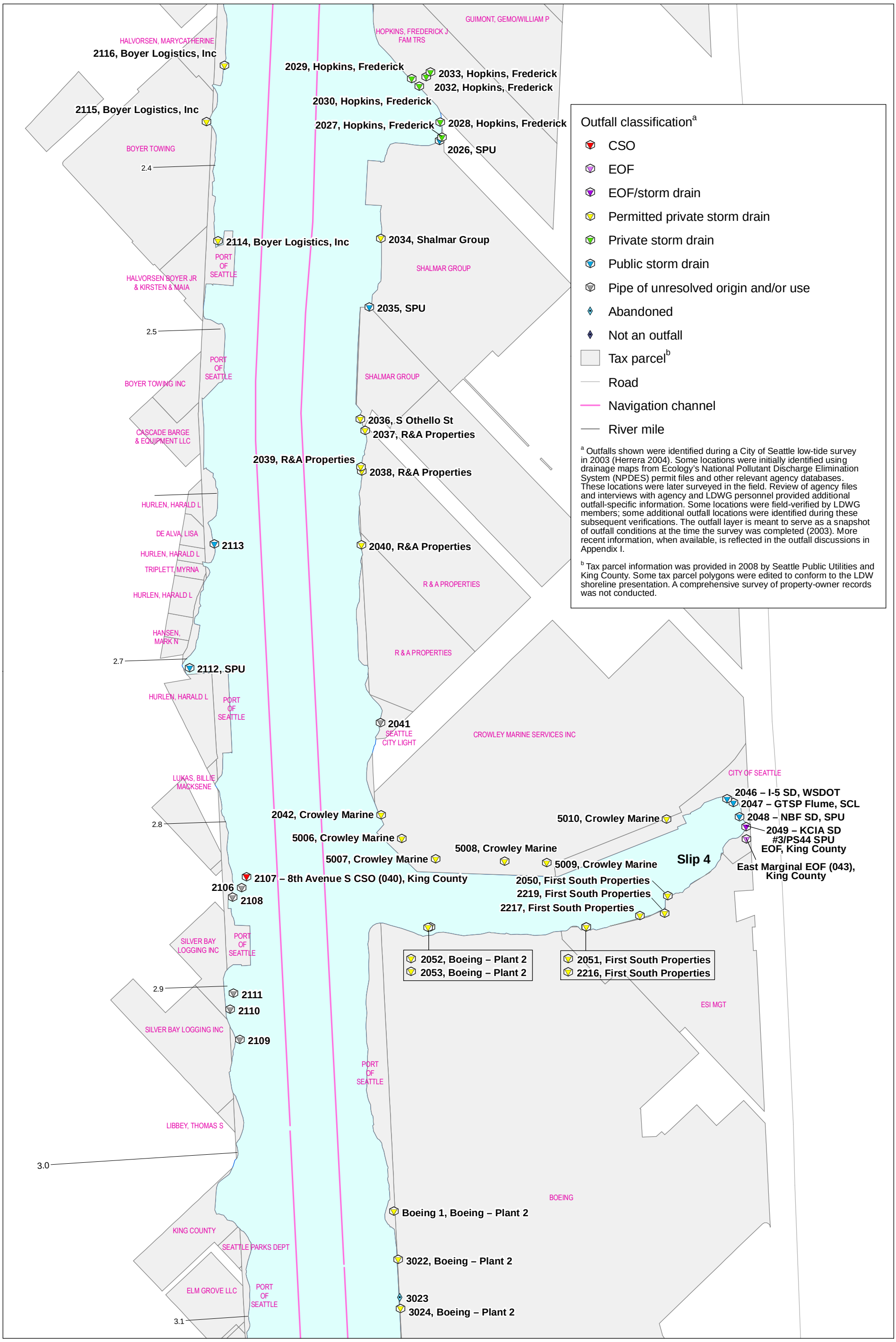
N

0 200 400 Feet

0 50 100 Meters

Map 9-8c. Outfall locations and ownership, RM 1.5 to RM 2.3

Prepared by CEH, 07/15/2010; MAP 2720; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Source Control\Section 9



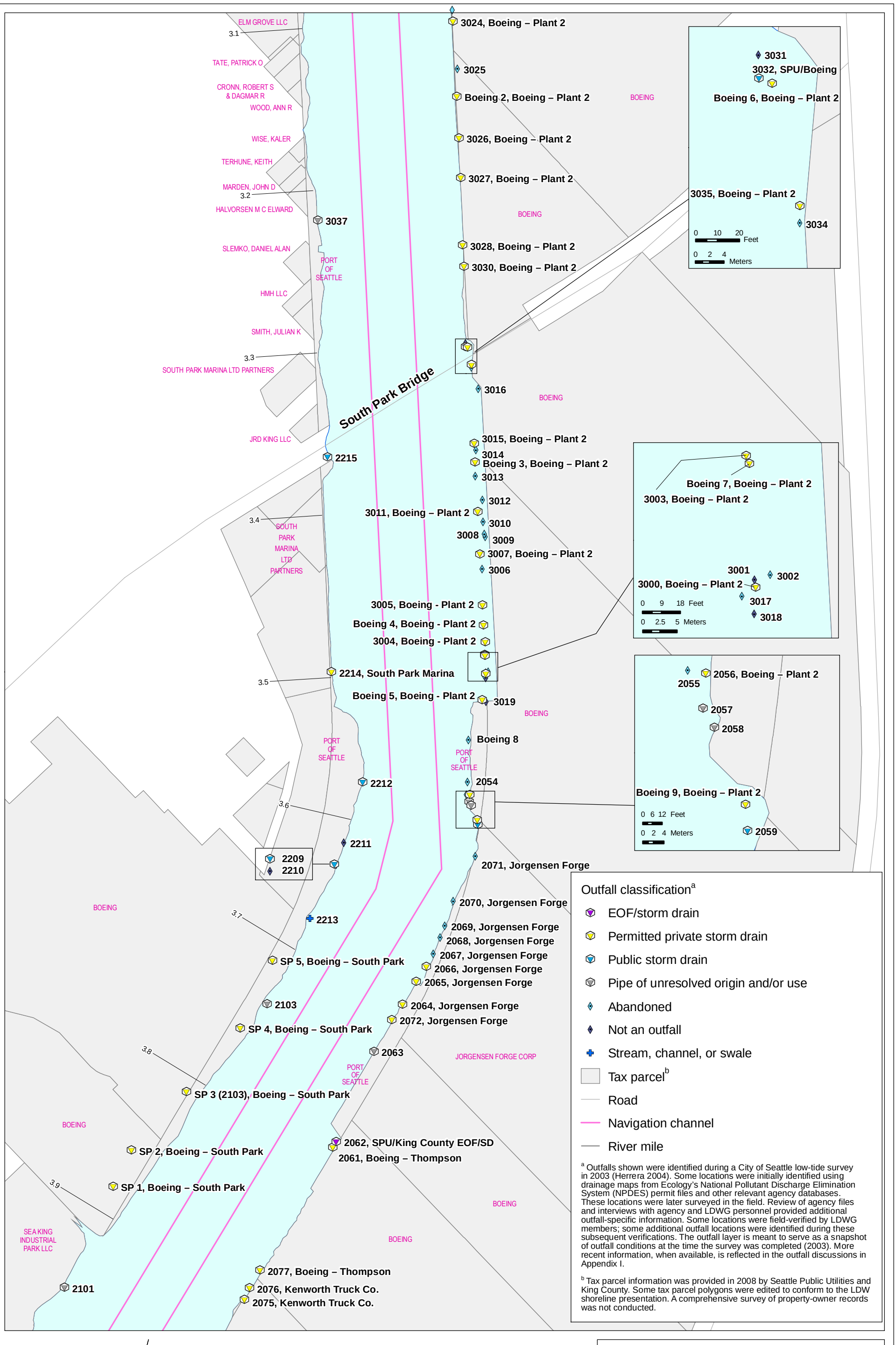
Wind Ward environmental LLC

0 200 400 Feet

0 50 100 Meters

Map 9-8d. Outfall locations and ownership, RM 2.4 to RM 3.1

Prepared by CEH, 07/15/2010, MAP 27:20; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Source Control\Section 9



[a] Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications. The outfall layer is meant to serve as a snapshot of outfall conditions at the time the survey was completed (2003). More recent information, when available, is reflected in the outfall discussions in Appendix I.

[b] Tax parcel information was provided in 2008 by Seattle Public Utilities and King County. Some tax parcel polygons were edited to conform to the LDW shoreline presentation. A comprehensive survey of property-owner records was not conducted.

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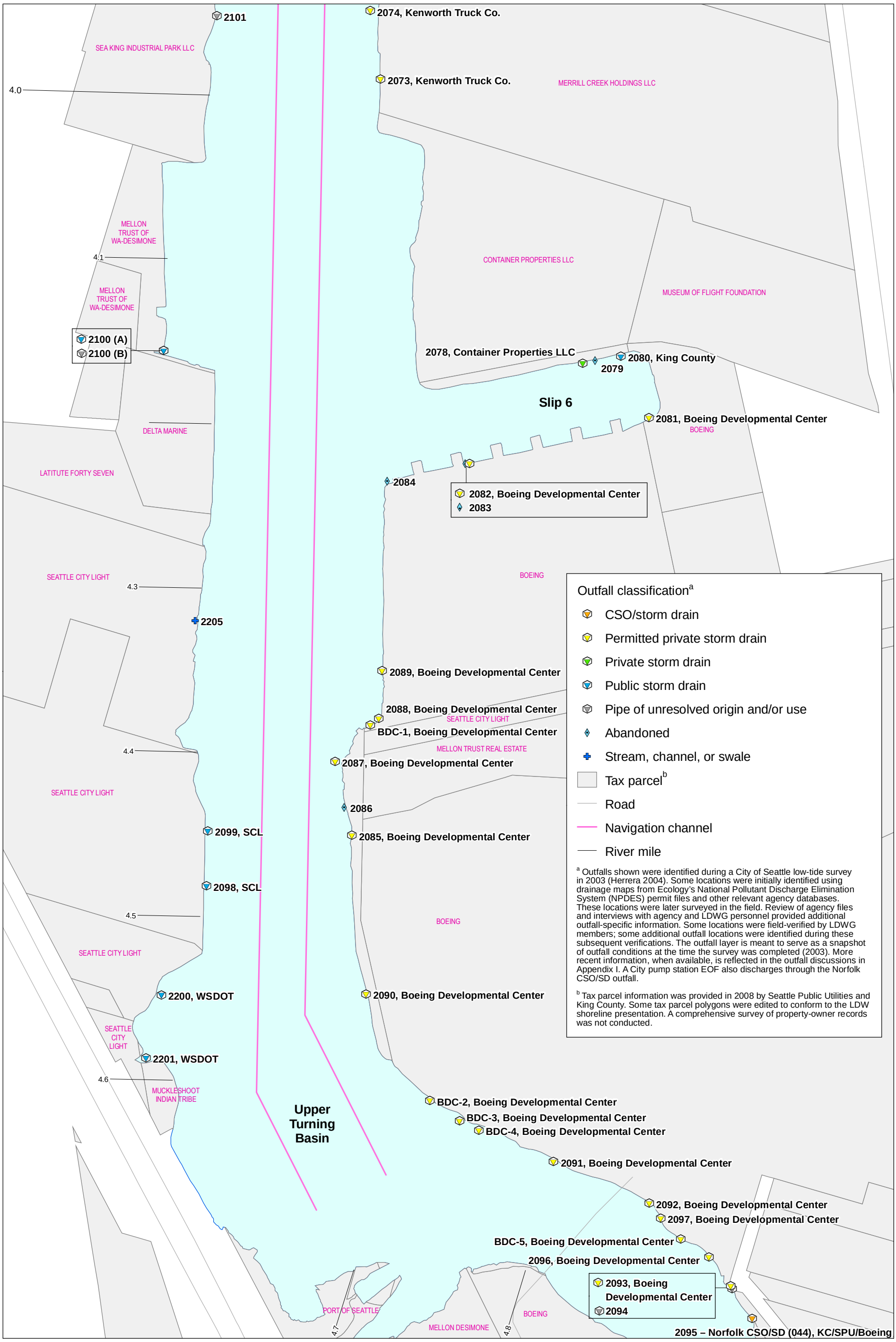
0 200 400 Feet

0 50 100 Meters

Map 9-8e. Outfall locations and ownership, RM 3.1 to RM 3.9

Prepared by CEH, 07/15/2010, MAP 2720: W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Source Control\Section 9



Wind Ward environmental LLC

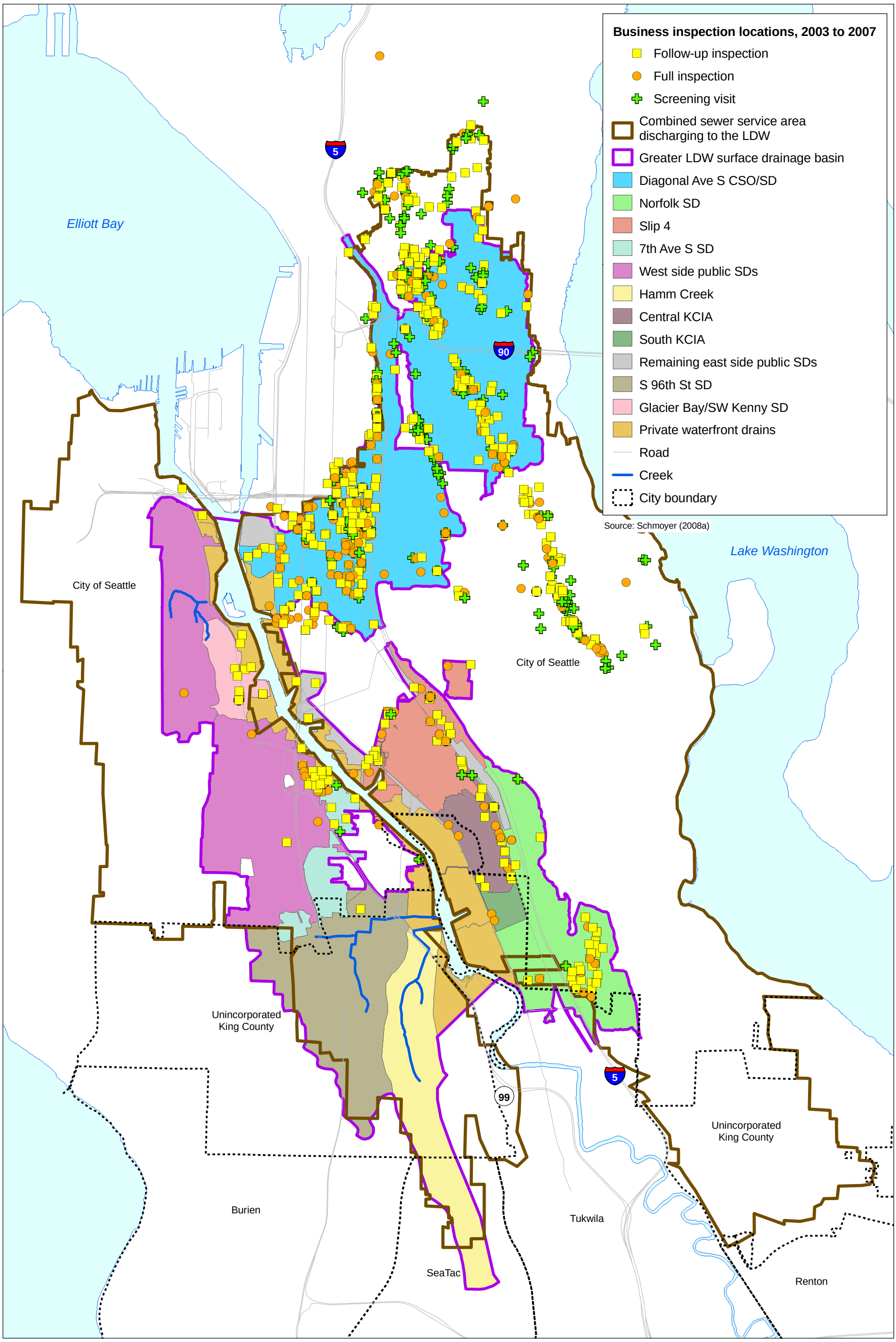
N

0 200 400 Feet

0 50 100 Meters

Map 9-8f. Outfall locations and ownership, RM 4.0 to RM 5.0

Prepared by CEH, 07/15/2010, MAP 2720; W:\Projects\00-08-06_Duwamish_Ri\data\gis\Phase2 RI\Source Control\Section 9



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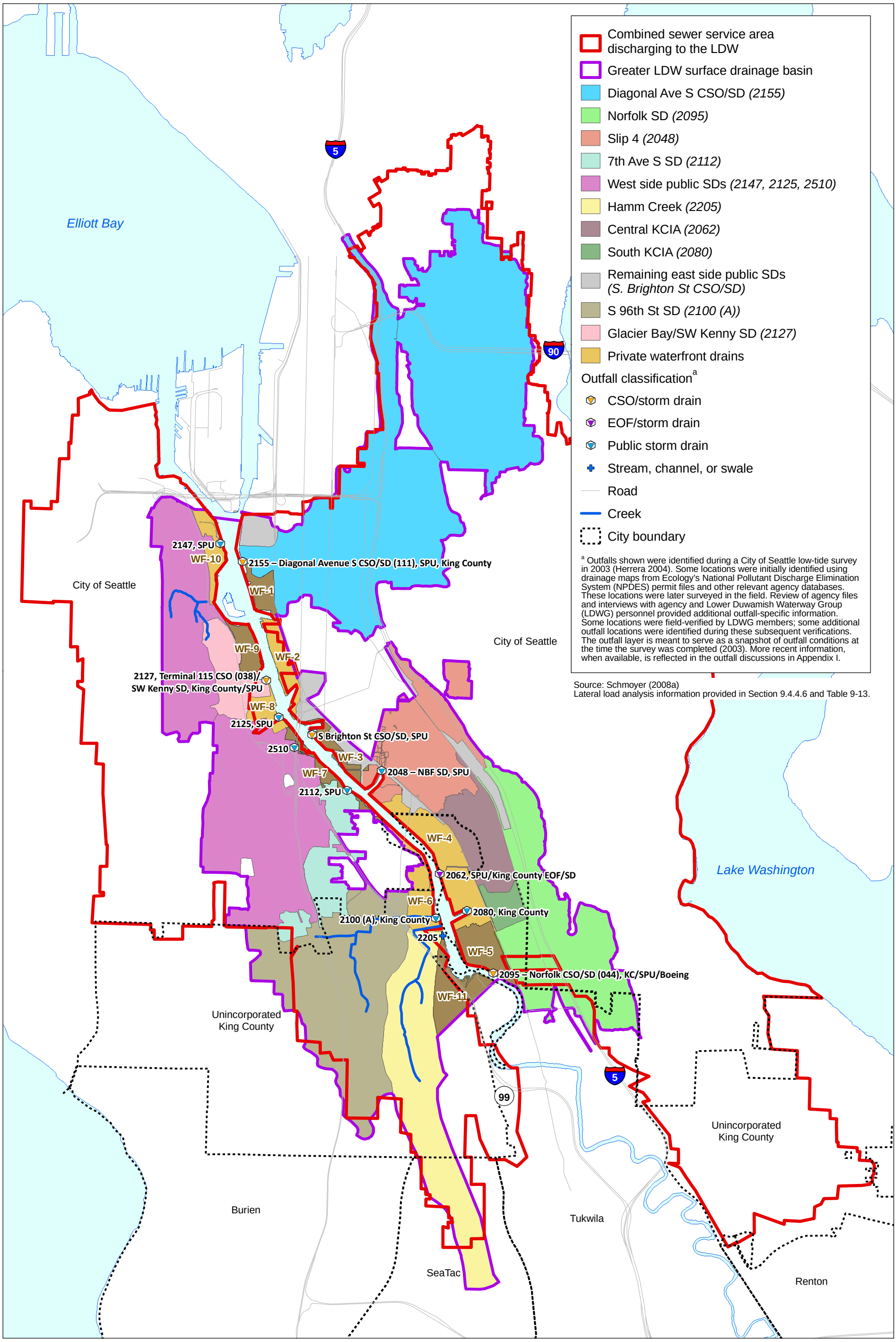
N

0 0.5 1 Miles

0 0.5 1 Kilometers

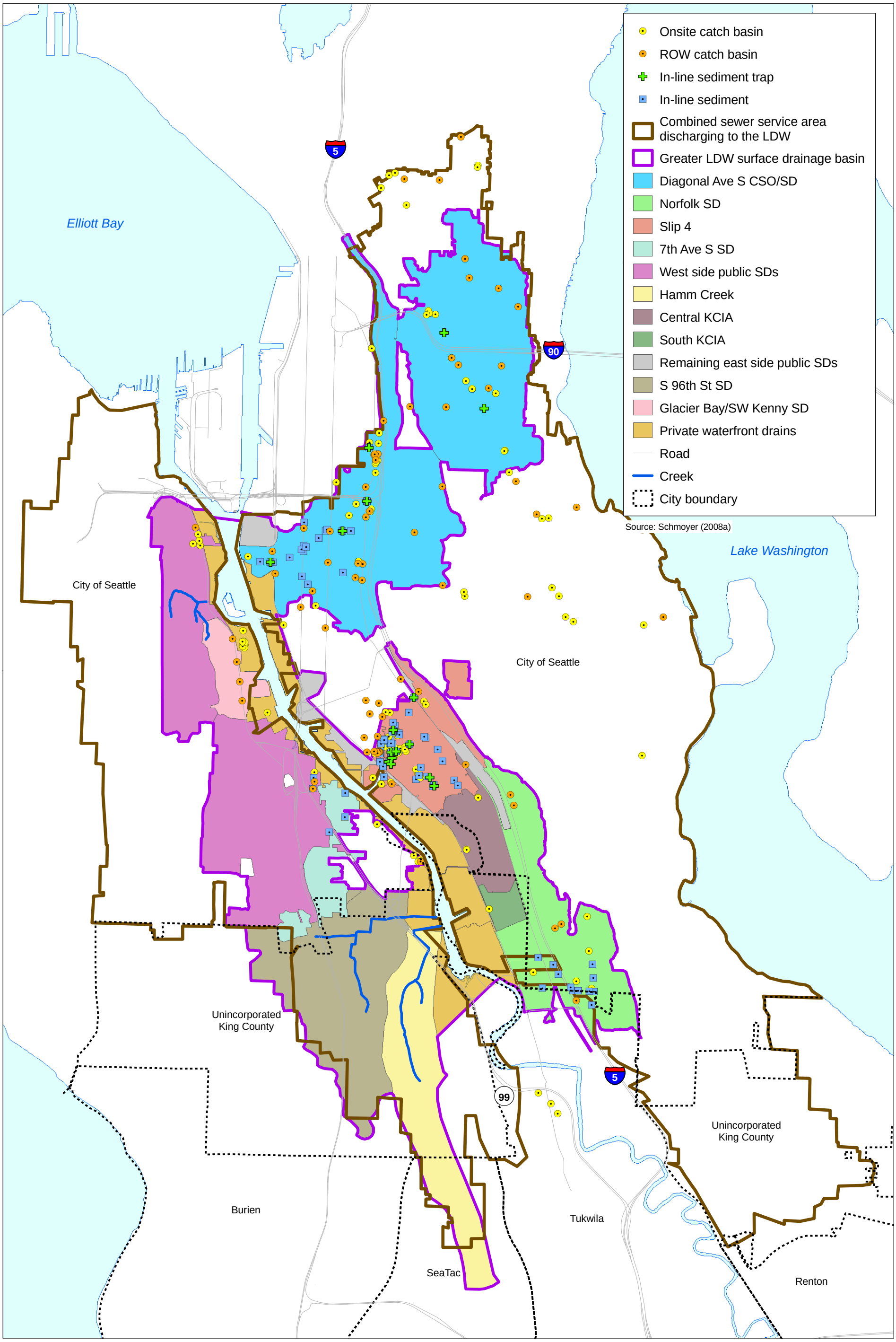
Map 9-9. Business inspections completed by SPU through December 2007

Prepared by CEH, 07/15/2010, MAP 3505; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Source Control\Section 9



Map 9-10. Input locations for storm drain sub-basins in the lateral load analysis

Prepared by CEH, 07/15/2010, MAP 3506; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Source Control\Section 9



Wind Ward environmental LLC

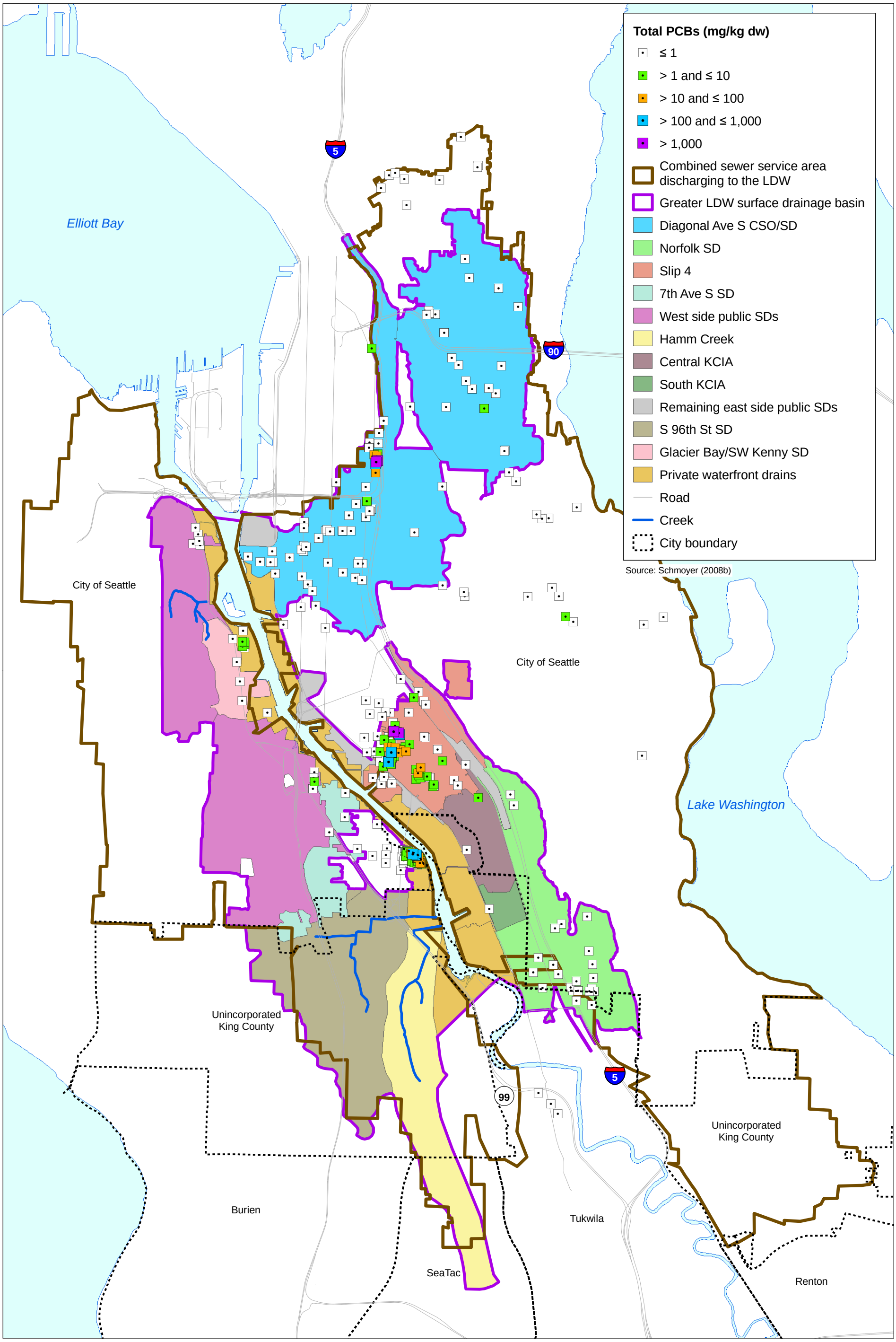
N

0 0.5 1 Miles

0 0.5 1 Kilometers

Map 9-11. Source-tracing program sampling locations through December 2007

Prepared by CEH, 07/15/2010, MAP 3507: W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Source Control\Section 9



Wind Ward environmental LLC

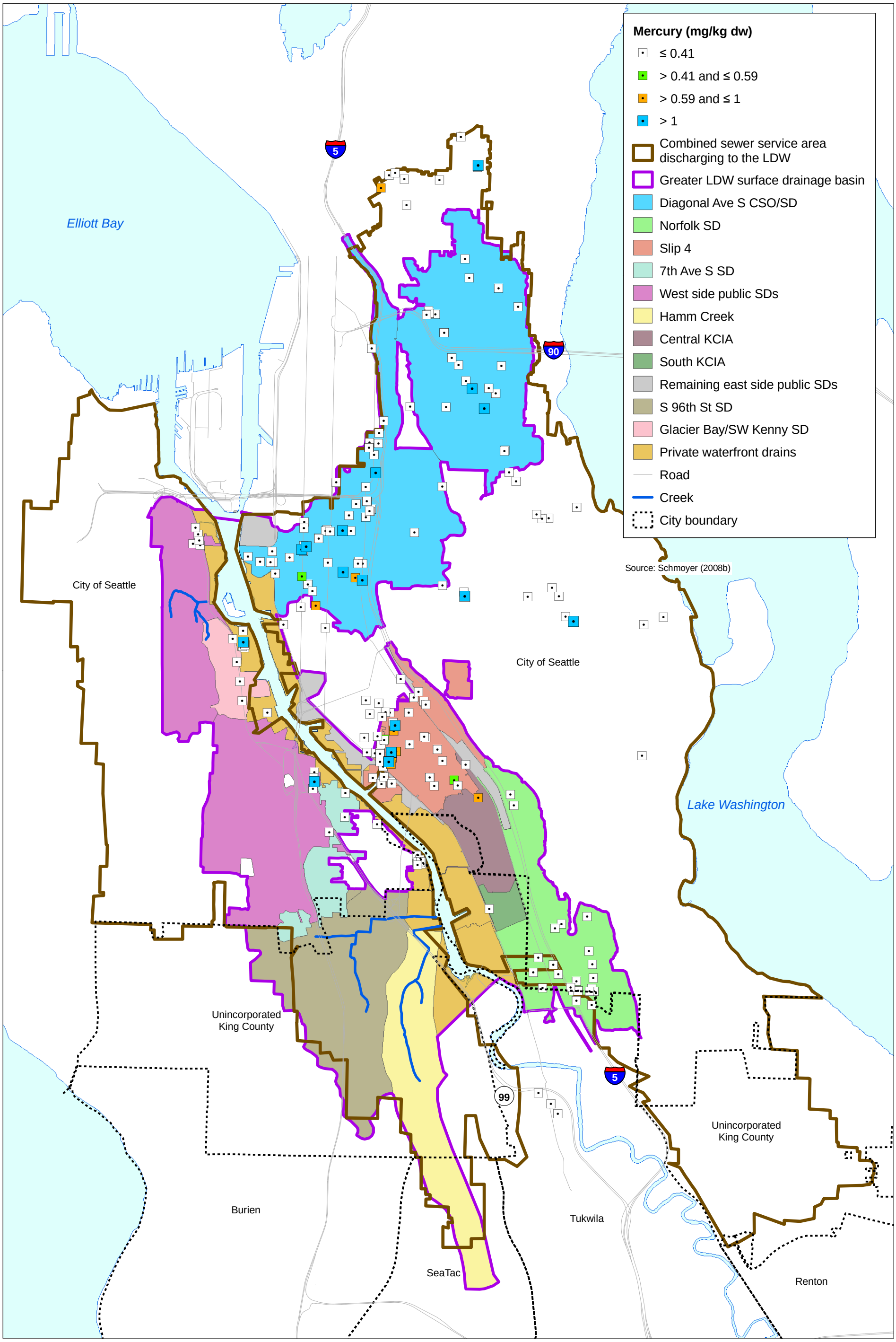
N

0 0.5 1 Miles

0 0.5 1 Kilometers

Map 9-12. Total PCB concentrations in source tracing sediment samples through December 2007

Prepared by CEH, 07/15/2010, MAP 3508; W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Source Control\Section 9



Wind Ward environmental LLC

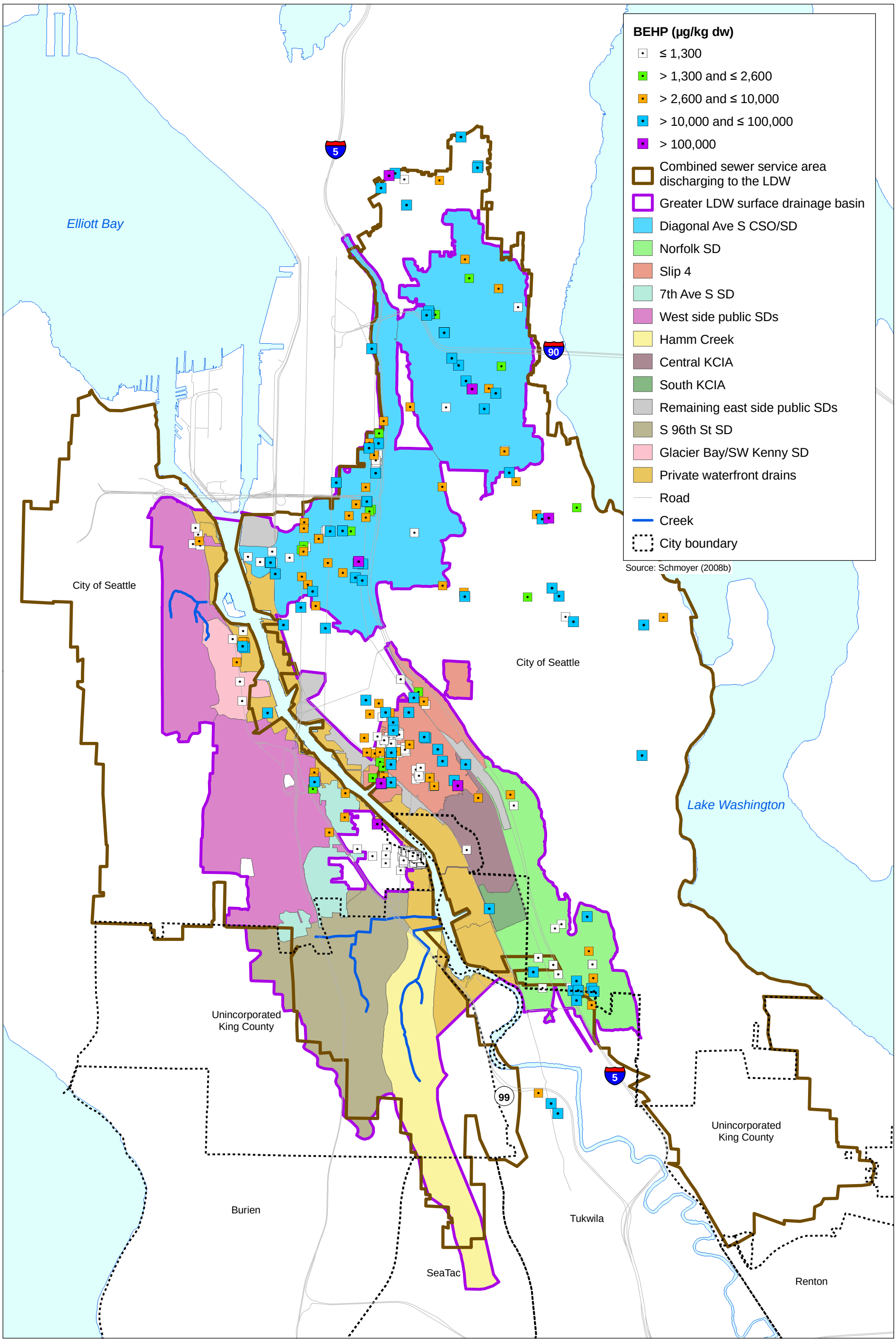
N

0 0.5 1 Miles

0 0.5 1 Kilometers

Map 9-13. Mercury concentrations in source tracing sediment samples through December 2007

Prepared by CEH, 07/15/2010, MAP 3509, W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Source Control\Section 9



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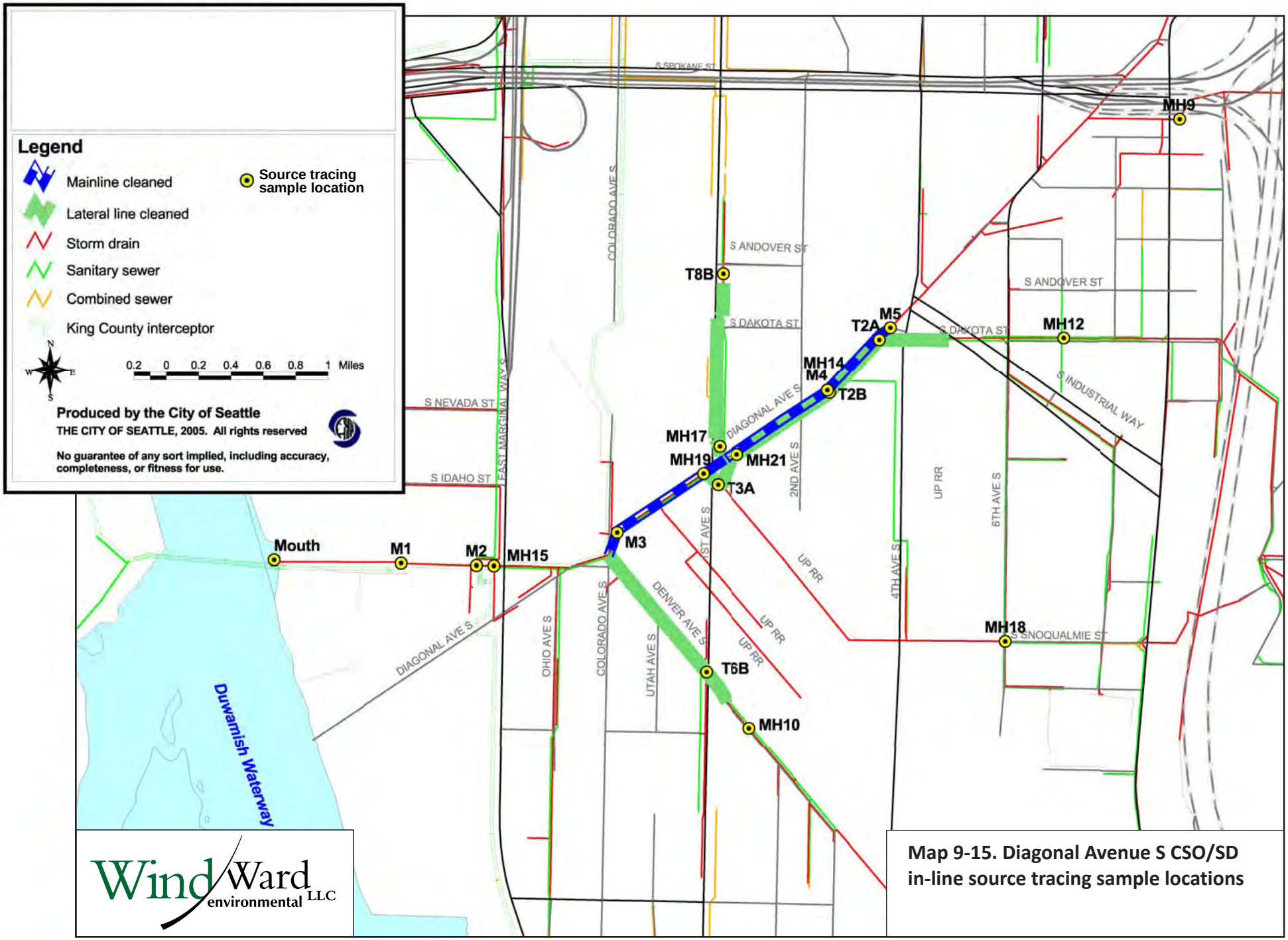
N

0 0.5 1 Miles

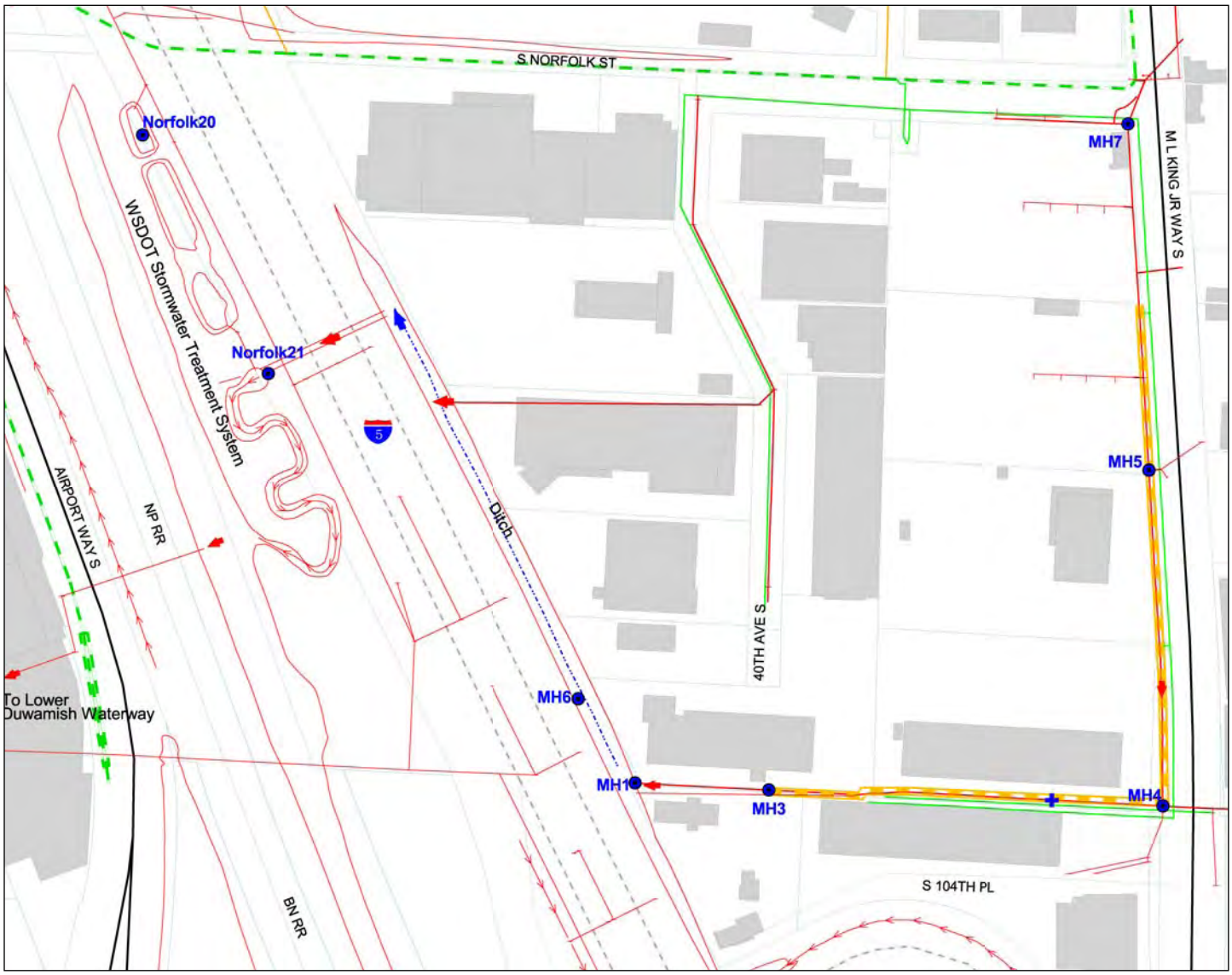
0 0.5 1 Kilometers

Map 9-14. BEHP concentrations in source tracing sediment samples through December 2007

Prepared by CEH, 07/15/2010, MAP 3510, W:\Projects\00-08-06_Duwamish_RI\data\gis\Phase2 RI\Source Control\Section 9



Map 9-15. Diagonal Avenue S CSO/SD in-line source tracing sample locations



Legend

Streets
- Arterial
- State Highway
- Interstate Freeway

Parcel boundary

Building

Storm drain

Sanitary sewer

County interceptor

Pipe cleaned in 2005

Source tracing sample location

50 0 50 100 150 Feet

Produced by the City of Seattle

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No guarantee of any sort implied, including accuracy, completeness, or fitness for use.

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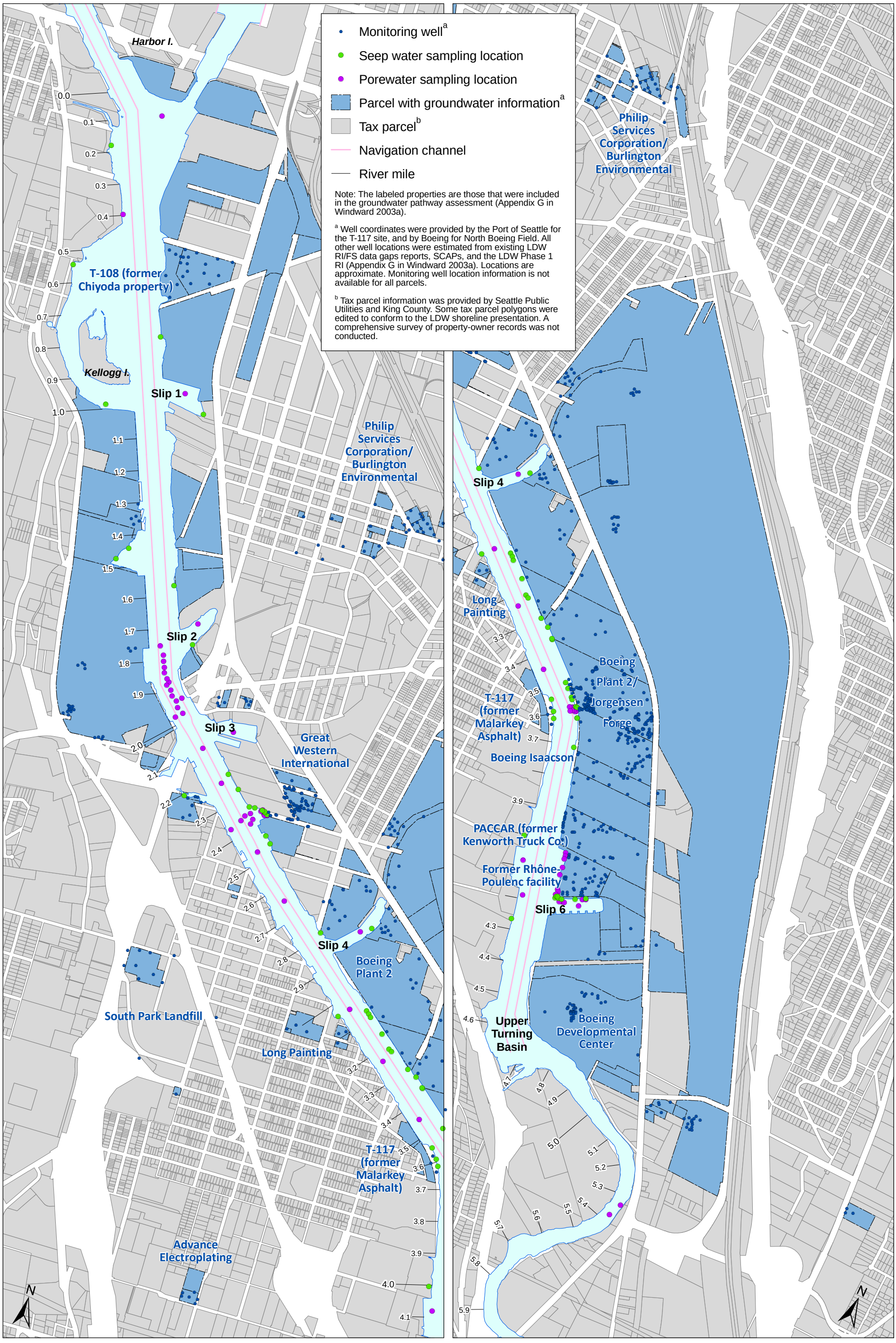
Map 9-16. Storm drain source tracing sample locations in the Norfolk drainage basin



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Map 9-17. Properties with documented groundwater information

Prepared by CEH, 07/15/2010; MAP #3438; W:\Projects\00-08-06_Duwamish_RI\data\GIS\Phase2 RI\Source Control\Section 9