Lower Duwamish Waterway Group

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

Appendix B
Updated Beach Play Risk Estimates, Species-Specific RBTC Calculations, and the Puget Sound Tissue Dataset

Final Feasibility Study

Lower Duwamish Waterway
Seattle, Washington

FOR SUBMITTAL TO:

The U.S. Environmental Protection Agency
Region 10
Seattle, WA

The Washington State Department of Ecology
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B.1 Introduction

This appendix presents the following additional risk-related information to support the feasibility study (FS):

- Section B.2 presents the details of the updated beach play risk estimates based on the FS dataset that support the updated risk estimates presented in Section 3 of the FS.
- Section B.3 presents the species-specific tissue risk-based threshold concentrations (RBTCs) and methodology for calculating these values. These species-specific RBTCs are presented in Section 3.3 of the FS.
- Section B.4 presents the non-urban Puget Sound tissue dataset that was compiled for the four human health risk drivers (i.e., total polychlorinated biphenyls [PCBs], inorganic arsenic, carcinogenic polycyclic aromatic hydrocarbons [cPAHs], dioxins/furans). The dataset is also presented in Section 3.3 of the FS and is compared with the tissue RBTCs. This appendix provides the details on dataset development, as well as additional summary statistics and figures that show the locations where these data were collected. Risk estimates for the three RME seafood consumption scenarios are also presented in this section.

B.2 Updated Risk Estimates for RME Beach Play Scenario

This section describes the calculation of updated beach play reasonable maximum exposure (RME) risk estimates using the FS dataset. The available data are described, followed by a discussion of the calculation of exposure point concentrations (EPCs) and a brief discussion of risk estimates.

B.2.1 Available Data

Estimates of risks associated with beach play were presented in the baseline human health risk assessment (HHRA; Windward 2007) based on the HHRA dataset. Since that time, several surface sediment sampling events have been conducted. One of these events was a targeted sampling of surface sediment in beach play areas in 2009 and 2010 (Windward 2010b). The main objective of this sampling was to supplement the existing dioxin/furan data for the Lower Duwamish Waterway (LDW), although additional data for all four human health risk drivers (i.e., total PCBs, inorganic arsenic, cPAHs, and dioxins/furans) were also collected from the beach play areas. As a result, more surface sediment chemistry data were available for the FS than for the HHRA. Data used in the HHRA have been combined with more recently collected data to form the FS dataset. Figures B-1 through B-4 present the available data for the four human health risk drivers in the beach play areas. In the HHRA, these four contaminants accounted for the majority of the risks associated with beach play.

B.2.2 Updated EPC Calculation

To update beach play risks, new EPCs for the risk drivers were calculated using the FS dataset. The HHRA (Windward 2007) described the general approach for EPC calculation based on the number of detected concentrations. When six or more locations within a beach play area had detected concentrations, ProUCL software was used to estimate an upper confidence limit on the mean (UCL), which served as the EPC. When one to five locations had detected concentrations, the higher of the maximum detected concentration or one-half of the maximum reporting limit (RL) was used as the EPC. When no locations had detected concentrations, one half the maximum RL was used as the EPC. These same general data rules were applied in this update.

At some beach play areas, both grab samples and composite samples were available (Figures B-1 through B-4). Thus, it was necessary to decide how the two data types would be used in developing updated EPCs; these decisions were made in consultation with the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology). The following additional data guidelines were developed:

- Data from the separate analyses of composite and grab samples within a beach play area were not combined.
- The data type (grab or composite) that included the most samples (or subsamples in the case of composites) and the best spatial coverage for a particular beach play area was selected to generate the EPC for a given beach.

Table B-1 identifies the data used to calculate the EPC for each risk driver and beach play area using the FS dataset. For comparison, Table B-1 also provides the EPCs that were used in the HHRA for each area (Windward 2007). Specific decisions regarding each of the beach play areas are described below, followed by a brief discussion of the risk estimates.

For Area 1, two composite samples covered the majority of the beach play area, and the number of subsamples that were included in the two composite samples outnumbered the grab samples. Therefore, the updated EPCs were based on the spatially-weighted averages of the two composite samples for all four risk drivers. One composite sample represented a 20,126-square-foot area, and the other composite sample represented a 28,645-square-foot area (i.e., 41% and 59% of the total beach play area, respectively).

With only a single exception (described below), updated EPCs for Areas 2, 3, 4, 5, and 8 were calculated using data only from grab samples for all four human health risk drivers. For Areas 2, 3, 4, and 8, only grab sample data were available so these data were used for the EPC calculation.

For Area 5, both composite and grab sample data were available. For PCBs, arsenic, and cPAHs, more grab samples were available than subsamples in the composite samples and the spatial coverage of the grab samples was better, so the grab samples were used for EPC calculations in this area. For dioxins/furans, two composite samples and two grab samples were collected in Area 5. Because of the limited spatial coverage and because fewer than six samples were available, the maximum concentration was selected as the EPC for dioxins/furans.

For Area 6, the number of subsamples included in the composite sample (n = 8) was greater than the number of grab samples available for the area (n = 2 for PCBs; n = 1 for arsenic and cPAHs; n = 0 for dioxins/furans). The spatial extent of Area 6 was also well represented by the composite sample. Therefore, the composite sample data were used to calculate the updated EPCs for all four human health risk drivers for Area 6.

For Area 7, the grab sample data were used to calculate updated EPCs for PCBs, arsenic, and cPAHs because the spatial coverage was better and more grab samples were analyzed for these risk drivers than there were subsamples in the composite samples. For dioxins/furans, the composite data were used because more subsamples were included in the composite sample (n = 8), and the spatial coverage of the composite sample was greater when compared with the one grab sample analyzed for dioxins/furans.

To provide additional information for risk communication, EPCs were also calculated separately for Duwamish Waterway Park (which is part of Area 5, see Figures B-1 through B-4). Data from a composite sample were used to calculate updated EPCs for all four human health risk drivers for Duwamish Waterway Park because the spatial extent of that composite sample was specifically determined in consultation with EPA and stakeholders to represent intertidal exposures at the park.

In addition, Areas 4 and 5 were each modified by dividing the original beach area presented in the HHRA into two parts as follows:

- **Area 4**: In the HHRA, this beach area included intertidal areas ranging from river mile (RM) 2.0W to 2.4W and the inlet at RM 2.2W. This beach area was divided into two parts. The first part included all sediment samples except those in the inlet at RM 2.2W (referred to as Area 4 modified – without inlet). The other part included only those samples in the inlet at RM 2.2W (referred to as Area 4 modified – inlet only).

- **Area 5**: In the HHRA, this beach area included three separate beaches, all located between RM 2.5W and RM 3.4W. This area was divided into two parts. The first part (referred to as Area 5 modified – south) included the two southernmost sections of Area 5. The other part (referred to as Area 5 modified – north) included only the northernmost section of Area 5.

These modifications were made to facilitate remedial decision-making (i.e., clarify which portions of the beach play areas were causing most of the risk). To assess risks in these areas, it was necessary to calculate EPCs for each of these Area 4 and Area 5 subareas. For Area 4, grab sample data from areas within the beach play area but outside the inlet in Area 4 were used to calculate EPCs for Area 4 modified – without inlet, and grab samples from only the inlet in the beach play area were used to calculate EPCs for Area 4 modified – inlet only (Figures B-1 through B-4). For Area 5, data from the two southernmost sections were used to calculate EPCs for Area 5 modified – south (i.e., data from the northernmost of the three disjointed sections that comprise this beach play area were excluded), and data from the northernmost section of Area 5 was used to calculate EPCs for Area 5 modified – north. For total PCBs, arsenic, and cPAHs, grab sample data were used because they provided better spatial coverage and more grab samples were available than subsamples in each of the composite samples analyzed. For dioxins/furans in Area 5 modified – south, the available data were limited to one grab sample and two composite samples. Because of the limited spatial coverage and because fewer than six samples were available, the maximum concentration was selected as the EPC for dioxins/furans.

B.2.3 Updated Risk Estimates

Based on these updated EPCs, updated excess cancer and non-cancer risk estimates were calculated for the beach play areas (Table B-2) and summarized below. Based on the FS dataset, the estimated total excess cancer risks (all four human health risk drivers combined) ranged from 4 in 1,000,000 (4×10^{-6}) to 6 in 10,000 (6×10^{-4}) for the eight individual beach play areas (Table B-2). The estimated total excess cancer risks for beach play were lower for Areas 1, 3, 7, and 8 based on the FS dataset compared with estimated total excess cancer risks based on the HHRA dataset. The other beach play areas (Areas 2, 4, 5, and 6) had higher risk estimates based on the FS dataset, with Area 4 having the greatest increase in the estimated risk. This increase was largely the result of high PCB concentrations in two post-remedial investigation (RI) samples that were collected from the head of the inlet at RM 2.2W.

The estimated total excess cancer risk for Duwamish Waterway Park presented in the HHRA uncertainty section (Section B.6.3.3.2 of the HHRA; Windward 2007) was 4×10^{-6}, based only on total PCBs, arsenic, and cPAHs, because no dioxin/furan data were available for Duwamish Waterway Park when the HHRA was completed. The updated total excess cancer risk for Duwamish Waterway Park using the FS dataset for total PCBs, arsenic, cPAHs, and dioxins/furans was 2×10^{-6}.

As discussed above, Areas 4 and 5 were each divided into two parts (referred to as Area 4 modified [without inlet and inlet only] and Area 5 modified [north and south]). Risks were calculated for each of these parts to investigate which portions of the beach play areas were contributing the most to the risk estimate. The estimated total excess cancer risk for Area 4 modified – without inlet (1×10^{-5}) was much lower than that for the entire Area 4 (6×10^{-4}) because of the higher concentrations of arsenic, dioxins/furans, cPAHs, and especially total PCBs, within the inlet. The estimated total excess cancer risk for Area 4 modified – inlet only was 3×10^{-3}. Therefore, the majority of the risk for Area 4 was from exposures to sediments in the inlet. The estimated total excess cancer risk for Area 5 modified – south (4×10^{-6}) was also much lower than that for the entire Area 5 (3×10^{-5}) because of the higher concentrations of cPAHs and dioxins/ furans in the northerly segment (Figures B-3 and B-4). The estimated total excess cancer risk for Area 5 modified – north was 5×10^{-5}. Although the difference in the risk estimates for the two parts of Area 5 modified were not as large (as compared with the two parts of Area 4 modified), the majority of the risk in Area 5 is from exposure to sediment in the northernmost beach segment.

In the HHRA (Windward 2007), non-cancer hazard quotients (HQs) for beach play did not exceed 1 for any of the areas evaluated (Table B-2). Using the FS dataset, the highest non-cancer HQ for total PCBs increased from 1 (in Area 4; Figure B-1), as presented in the HHRA, to 187, largely as a result of two samples with very high total PCB concentrations (2,900,000 µg/kg dw and 230,000 µg/kg dw) from the head of the inlet at RM 2.2W. If those two high total PCB concentrations are omitted, the non-cancer HQ for total PCBs for Area 4 would be 2 (similarly, the excess cancer risk would decrease from 6×10^{-4} to 6×10^{-6} if these two samples were excluded). The non-cancer HQ for total PCBs for Area 4 modified – without inlet was 0.4. This again suggests the area of most concern is the inlet at Area 4. None of the other beach play areas had non-cancer HQs greater than 1 for any risk driver.

B.3 Calculation of Species-Specific Tissue RBTCs

Tissue RBTCs for the three human health RME seafood consumption scenarios, and the risk equations and parameters used to calculate the tissue RBTCs, were presented in Section 8 of the RI (Windward 2010a) and summarized in Section 3.3 of the FS. The tissue RBTCs presented in the RI represent the ingestion-weighted average concentrations in tissue that correspond to certain risk thresholds for each scenario. At the request of EPA, species-specific RBTCs were also developed. The methodology and the resulting species-specific RBTCs are presented in this section.

Two main factors influence species-specific RBTCs: 1) the relative ingestion rates for the various items in the market basket diet (i.e., the percentages of various seafood types that people eat), and 2) the relative tissue contaminant concentrations among the food items. Both factors may change in the future. Thus, these species-specific RBTCs are: 1) meaningful only in the context of the suite of exposure assumptions that make up the exposure scenario and 2) uncertain because the relative contaminant concentrations in various species may be different in the future in response to a variety of factors.

The RBTCs are presented as ranges when possible to acknowledge the uncertainty in the relative contaminant concentrations in different species. These ranges of species-specific RBTCs may be compared with tissue data from other parts of Puget Sound (as was done in Section 3.3 of the FS) and with data that may be collected as part of future long-term monitoring in the LDW, within the context of the overall exposure scenario and risk level that they represent.

The following subsections present the methodology used to calculate these values and the bases of the species-specific tissue RBTCs for all four risk drivers.

B.3.1 Methodology

This section describes the methodology used to calculate species-specific RBTCs. To clarify this process, this section provides a step-by-step process for species-specific RBTC derivation. As an example, the following steps were used to calculate a species-specific RBTC for the 1×10^{-4} risk level for total PCBs based on the Adult Tribal RME scenario. Species-specific RBTCs for this scenario, corresponding to the 1×10^{-4}, 1×10^{-5}, and 1×10^{-6} excess cancer risk levels and an HQ of 1, are provided in Section B.3.2.

1. **Overall RBTC**: The starting point for calculating a species-specific RBTC is the ingestion-weighted RBTC (as presented in Section 8 of the RI and Section 3.3 of the FS). These ingestion-weighted RBTCs, which are also referred to as "overall RBTCs," are calculated based on the overall seafood ingestion rate (IR) and other scenario-specific parameters (e.g., body weight and exposure duration). The overall tissue RBTC for total PCBs at the 1×10^{-4} risk level for the Adult Tribal RME scenario based on Tulalip data is 42 µg/kg wet weight (ww) (Table B-3).

2. **Ingestion-weighted average concentration equation**: To calculate species-specific RBTCs, the ingestion-weighted RBTC must be broken down into its component pieces, which represent all the components of the diet (Equation 1).

$$C_{ingestionweighted} = (IR\%_{clam} \times C_{clam}) + (IR\%_{crabEM} \times C_{crabEM}) + (IR\%_{crabWB} \times C_{crabWB}) + (IR\%_{perch} \times C_{perch}) + (IR\%_{ES-WB} \times C_{ES-WB}) + (IR\%_{ES-fil} \times C_{ES-fil}) \quad \textbf{Equation 1}$$

   Where IR% is the species-specific percentage of the total seafood ingestion rate; C is the species-specific tissue contaminant concentration; and $C_{ingestion\text{-}weighted}$ is the ingestion-weighted average contaminant concentration discussed in Step 1.

   For the Adult Tribal RME scenario based on Tulalip data, Equation 2 presents the same equation but with the actual ingestion rate percentages and the overall RBTC of 42 µg/kg ww substituted, as appropriate.

$$42 = (44.8\% \times C_{clam}) + (29.6\% \times C_{crabEM}) + (9.3\% \times C_{crabWB}) + (8.4\% \times C_{perch}) + (0\% \times C_{ES-WB}) + (7.8\% \times C_{ES-fil}) \quad \textbf{Equation 2}$$

   Note that the species-specific percentages of the total seafood ingestion rate provided in this equation are slightly different from those reported in the HHRA (Windward 2007); those percentages were adjusted by EPA in an errata to the HHRA (Windward 2009). In cases where there were no data for an individual contaminant of potential concern (COPC) in mussel tissue, the percentage of the consumption rate attributed to mussels was distributed proportionally to the other consumption groups (see Table B-4). At the ingestion-weighted RBTC of 42 µg/kg ww (i.e., the overall RBTC), the "C" for each species is equal to the species-specific total PCB RBTC for the 1×10^{-4} risk level for the Adult Tribal RME scenario based on Tulalip data.

3. **Species-to-species relationship**: As shown in Equation 2, six different variables (i.e., the concentrations of the different consumption categories) remain once all the ingestion rates have been substituted. This equation cannot be solved for a single species concentration (i.e., single variable) unless the concentration relationships among the various species are known and are assumed to be constant over time. The relationship among species (represented by ratios, as shown in Equation 3) can be approximated based on empirical data from the LDW or data predicted using the food web model (FWM). In this example, relationships among the concentrations in various species were derived based on the HHRA tissue dataset for the LDW. Thus, to calculate the total PCB concentration of a single species (e.g., clams) in the market basket, it is necessary to use the ratio of the average total PCB concentration for that species to the ingestion-weighted average total PCB concentration (which is calculated as shown in Step 4).

4. **Solving the equation for species-specific RBTCs**: Based on the assumptions in Step 3, Equation 2 can be simplified to Equation 3 and solved for a single species (in this example, clams).

$$C_{clam} = \frac{RBTC_{overall} \times Average_{clam}}{C_{ingestionweighted}}$$

Equation 3

In this example, the overall RBTC is equal to 42 µg/kg ww, and based on the HHRA empirical dataset, the average clam concentration is equal to 140 µg/kg ww, and the ingestion-weighted tissue concentration is equal to 394 µg/kg ww (Table B-3). Note that the ingestion-weighted concentration of 394 µg/kg ww was calculated by substituting the empirical tissue concentrations from the HHRA dataset into Equation 1, as shown in Equation 4.

$$C_{ingestionweighted} = 394 = (44.8\% \times 140) + (29.6\% \times 170) + (9.3\% \times 890) + (8.4\% \times 1700) + (0\% \times 2200) + (7.8\% \times 700)$$

Equation 4

To calculate the clam RBTC, these values are substituted into Equation 3, as shown in Equation 5.

$$C_{clam} = RBTC_{clam} = \frac{RBTC_{overall} \times Average_{clam}}{Average_{ingestionweighted}} = \frac{42 \times 140}{394} = 15$$

Equation 5

This approach assumes that relative contaminant concentrations among the species remain the same even when conditions change. This proportionality calculation is then repeated for the other tissue types that comprise the diet. Different species-to-species relationships may be calculated if multiple empirical datasets or model outputs are available, which in turn would result in a range of RBTCs (rather than a single number). This concept is further explored in Section B.3.2.

B.3.2 Species-Specific RBTCs for Risk Drivers

Following the methodology described in Section B.3.1, species-specific RBTCs were calculated for the risk drivers identified for the LDW: total PCBs, inorganic arsenic, and cPAHs (Tables B-5 through B-9). Species-specific RBTCs could not be derived for dioxins/furans because no site-specific empirical data were available to calculate the ratios that describe concentration relationships among the species. Data and methods used to establish the species-specific RBTCs for each risk driver are summarized below.

Species-specific RBTCs for total PCBs were developed based on three sources of species-to-species relationship information: 1) the LDW HHRA empirical dataset (as in the example in Section B.3.1), 2) the LDW 2007 empirical dataset, and 3) the calibrated FWM. Because the calibrated FWM predicts concentrations for each species in the scenario-specific diets, it can also be used to estimate the concentration relationships among the different species. Because the relationships were similar, but not exactly the same based on the three sources of information, a range of species-specific RBTCs were developed for each RME seafood consumption scenario/risk level combination for total PCBs, as presented in Tables B-5 through B-7.

It was not possible to calculate a range of species-specific RBTCs for inorganic arsenic or cPAHs because the 2007 tissue samples were not analyzed for these contaminants for all market basket species and because no FWM exists for these risk drivers. Therefore, species-specific RBTCs for inorganic arsenic and cPAHs are presented as single values.

B.4 Non-Urban Puget Sound Tissue Dataset

To help provide context for tissue RBTCs, a tissue dataset of samples collected from non-urban areas away from known contaminated sites in Puget Sound was compiled for each of the four risk drivers (i.e., total PCBs, arsenic, cPAHs, and dioxins/furans).

Section B.4.1 describes the criteria used to develop the non-urban Puget Sound tissue dataset and provides detailed tables and figures showing the data included in this dataset. Section B.4.2 presents human health risk estimates calculated based on the non-urban Puget Sound tissue dataset.

B.4.1 Dataset Development

The non-urban Puget Sound tissue dataset consists of data from various studies. For total PCBs and arsenic, the tissue data from some of these studies were presented in the LDW RI; this RI dataset served as a starting point for these two risk drivers. In addition, data for all four risk drivers were obtained from Ecology's Environmental Information Management (EIM) database. It is important to note that the non-urban Puget Sound dataset has been compiled from various sources, and the datasets from these sources were generally used as reported without further data quality reviews. In addition, the sampling and analytical methods used to produce these datasets varied from study to study. Thus, although these data provide a general indication of the concentrations of these risk drivers in tissues collected throughout Puget Sound, they should not be regarded as a single dataset generated using a consistent methodology that is representative of Puget Sound.

Once the preliminary data had been compiled, criteria for using the data in the non-urban Puget Sound tissue dataset were determined in consultation with EPA and Ecology. The following list summarizes the criteria for including data in this dataset:

- **Species**: Only those species representative of the consumption categories evaluated in the LDW HHRA (i.e., benthic fish, pelagic fish, crabs, clams, and mussels) were included in the dataset. Available data for other species, including shrimp, oysters, and other fish species (e.g., salmon and rockfish[1]) were excluded.
- **Proximity to urban areas:** In consultation with EPA and Ecology, sampling locations near urban areas were excluded from the non-urban Puget Sound tissue dataset. Examples of excluded areas include: Commencement Bay (Tacoma), Elliott Bay (Seattle), Budd Inlet (Olympia), Port Gardner (Everett), Sinclair Inlet (Bremerton), Port Angeles Harbor, and Bellingham Bay.
- **Proximity to known contaminated sources:** In consultation with EPA and Ecology, sampling locations near known contaminant sources were excluded based on consideration of the type, distance, and magnitude of any known sources identified in the Integrated Site Information System (ISIS) and EIM

[1] Rockfish were not included in the non-urban Puget Sound dataset as a surrogate pelagic species for two reasons: 1) rockfish were not included in the LDW market basket because "adult rockfish are likely to constitute a very small component of a seafood consumption scenario because existing data suggest that adult rockfish abundance is low in the LDW" (Windward 2004), and 2) their long life spans may contribute to higher contaminant concentrations than in other pelagic fish with shorter life spans.

databases. Examples of sampling locations excluded based on proximity to a known source include the areas of Fidalgo Bay/March Point (near Anacortes), Point Wells (near Edmonds), Port Washington Narrows (near Bremerton), and Keyport (near Poulsbo).

- **Inorganic arsenic data quality**: For inorganic arsenic, only those data collected as part of the LDW RI/FS specifically for the purpose of evaluating Puget Sound tissue concentrations were used in this dataset. This RI/FS dataset was sufficiently large to meet the goals associated with the non-urban Puget Sound dataset and had already undergone extensive review and validation, whereas the analytical methods and the data quality of the relatively small number of additional available samples analyzed for inorganic arsenic were less well known.

The resulting non-urban Puget Sound tissue dataset contains different numbers of samples for the various risk drivers and tissue types, depending on data availability. Acceptable data are summarized in Tables B-10 through B-13; sampling locations are shown on Figures B-5 through B-12. In summary, the following numbers of samples were available for each risk driver (after filtering based on criteria listed above):

- **Total PCBs**: 344 tissue samples, including 242 fish samples, 17 crab edible-meat samples, 15 crab whole-body samples,[2] and 70 clam samples;
- **Inorganic arsenic**: 81 tissue samples, including 33 fish samples, 12 crab edible-meat samples, 12 crab whole-body samples, and 24 clam samples;
- **cPAHs**: 28 samples, including 1 fish sample, 8 crab edible-meat samples, 7 crab whole-body samples, 1 mussel sample, and 11 clam samples;
- **Dioxins/furans**: 106 samples, including 11 fish samples, 27 crab edible-meat samples, 25 crab whole-body samples, and 43 clam samples.

Fish sample counts included both benthic fish and pelagic fish (although relatively few pelagic fish data were available), crab sample counts were divided by tissue type (i.e., edible-meat and whole-body samples), and clam sample counts included various clam species.

B.4.2 Risk Estimates Based on the Non-Urban Puget Sound Tissue Dataset

This section provides risk estimates calculated using the non-urban Puget Sound tissue dataset. In consultation with EPA, it was agreed that a market basket approach would be used to more closely approximate the approach taken in the LDW HHRA. However, because the available non-urban Puget Sound data did not perfectly match all of the

[2] Crab whole-body samples for all risk drivers were calculated based on concentrations in edible meat and hepatopancreas samples, as described in Tables B-10 through B-13.

seafood consumption categories used in the LDW HHRA, a simplified approach was used. The following five consumption categories were used to calculate risks based on the Puget Sound tissue dataset: clams, mussels, crab edible meat, crab whole-body, and fish (pelagic and benthic fish combined) (Table B-4).

In the LDW HHRA, concentrations of the four risk drivers in seafood were represented by an upper confidence limit (UCL). This approach was not selected for the non-urban Puget Sound risk estimates because the compiled dataset represents various studies, sample sizes, and methods. Instead, risk estimates for the four risk drivers were calculated based on the minimum, mean, and maximum values for each consumption category (Table B-14). These values were used to calculate the ingestion-weighted concentrations that were presented in Figures 3-3 through 3-6 in Section 3 of the FS (see Section B.3.1 for details on how these values were calculated).

Excess cancer risk estimates (both for the individual risk drivers and as total risk estimates across all four risk drivers) are shown in Figures B-13 through B-15 and in Table B-15 for the three RME scenarios. Total excess cancer risks ranged from 1×10^{-5} to 6×10^{-5} using minimum exposure values, from 5×10^{-5} to 3×10^{-4} using mean exposure values, and from 2×10^{-4} to 9×10^{-4} using maximum exposure values. Total excess cancer risks were greater than the MTCA threshold of 1×10^{-5} for all scenarios and exposure values with one exception: the total excess cancer risk for the Child Tribal RME scenario using the minimum exposure values was 1×10^{-5}. Additionally, risk estimates for the individual risk drivers were compared with MTCA's 1×10^{-6} excess cancer risk threshold. For inorganic arsenic and dioxin/furan TEQ, excess cancer risks were greater than this threshold regardless of the statistic used (i.e., when minimum, mean, or maximum values were used; Table B-15). For total PCBs and cPAHs, excess cancer risks were greater than this threshold for all scenarios when maximum values were used and for some scenarios (i.e., the Adult Tribal RME and/or Adult API RME scenarios; see Table B-15) when either the minimum or mean values were used.

As shown in Figures B-13 through B-15, the majority of the total excess cancer risk for each of the RME scenarios was attributable to inorganic arsenic and dioxins/furans. The risks associated with inorganic arsenic in the non-urban Puget Sound dataset were attributable primarily to clams (as was the case in the LDW HHRA). Risks associated with dioxins/furans were attributable primarily to clams for risks based on the mean and maximum concentrations but were attributable primarily to fish for risks based on the minimum concentrations. Risks associated with total PCBs and cPAHs were lower, together contributing 5% or less to the total excess cancer risk.

For both total PCBs and inorganic arsenic, non-cancer HQs were less than 1 when using the minimum and mean exposure values. When the maximum exposure values were used, HQs for the three RME scenarios ranged from 0.6 to 3 (Table B-15). The only HQs greater than 1 were those calculated using the maximum exposure values for the Child Tribal RME scenario (the total PCB HQ was equal to 2, and the inorganic arsenic HQ was equal to 3). The proportional contributions of the various seafood consumption categories to the HQs for total PCBs and inorganic arsenic were similar to those to the excess cancer risks (Figures B-13 through B-15). Thus, clams were the primary contributor to the inorganic arsenic HQs, while fish were the primary contributor to the total PCB HQ.

Figures B-16 through B-19 present a comparison of excess cancer risks and non-cancer HQs estimated for the non-urban Puget Sound tissue dataset and those estimated for the LDW HHRA tissue dataset for both total PCBs and inorganic arsenic. For both the non-urban Puget Sound and LDW tissue datasets, the risk estimates shown in these figures were calculated using mean exposure values. The excess cancer risk estimates and non-cancer HQs calculated for total PCBs based on the LDW data were approximately 120 to 200 times higher than those calculated based on the non-urban Puget Sound dataset. For inorganic arsenic, excess cancer risks and non-cancer HQs calculated based on the LDW dataset were also higher than those based on the non-urban Puget Sound dataset; although, unlike PCBs, LDW excess cancer risks and non-cancer HQs were only approximately 5 times higher than those in non-urban Puget Sound locations. The majority of risk for inorganic arsenic (in both these datasets) is attributable to clam consumption. Similar figures were not created for cPAHs because of low detection frequencies in the non-urban Puget Sound tissue dataset. Similar figures were not created for dioxins/furans because insufficient tissue data were available from the LDW to calculate a market basket risk estimate.

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Table B-1 Exposure Point Concentrations and Summary Statistics for Beach Play Areas Using the FS and HHRA Datasets

Beach Play Area	Dataset	Unit	No. Samples with Detected Concentrations/ Total No. Samples	Mean Value	Range of Detects	Range of RLs	Statistic Used	EPC	Notes on FS Dataset EPCs
Total PCBs									
1	HHRA	µg/kg dw	3/5	29	3.1 J – 119	19 – 20	maximum detect	120	
	FS	µg/kg dw	2/2 composites	56	26 – 86	n/a	weighted composite samples (41% LDW-SS502-comp; 59% LDW-SS503-comp)	51	EPC based on concentrations of two composite samples weighted by area. One of the two composites contained sediment collected over an average depth of 43 cm.
2	HHRA	µg/kg dw	6/7	100	7.6 J – 290	20	95% KM (t) UCL	180	
	FS	µg/kg dw	7/8	160	7.6 J – 560	20	95% KM (t) UCL	290	ProUCL using only grab data.
3	HHRA	µg/kg dw	11/14	89	2.2 J – 419 J	16 – 17	95% KM (Chebyshev) UCL	240	
	FS	µg/kg dw	14/18	93.5	2.2 J – 419 J	0.8 – 17	95% KM (Chebyshev) UCL	220	ProUCL using only grab data.
4	HHRA	µg/kg dw	12/12	2,800	11 J – 23,000	n/a	95% Adjusted gamma UCL	11,000	
	FS	µg/kg dw	28/29	109,000	11 J – 2,900,000	40	99% KM (Chebyshev) UCL	1,100,000	ProUCL using only grab data.
4 modified[a]	FS – without inlet	µg/kg dw	20/21	443	19.6 – 4,700	40	97.5% KM (Chebyshev) UCL	1,900	ProUCL using only grab data.
	FS – inlet only	µg/kg dw	8/8	395,000	11 J – 2,900,000	n/a	95% Adjusted gamma UCL	5,200,000	ProUCL using only grab data.
5	HHRA	µg/kg dw	31/32	100	24 J – 655	20	95% KM (Chebyshev) UCL	190	
	FS	µg/kg dw	34/36	124	24 J – 860	20	95% KM (Chebyshev) UCL	250	ProUCL using only grab data.
5 modified[b]	FS – south	µg/kg dw	26/28	98.3	24 J – 655	20	95% KM (Chebyshev) UCL	200	ProUCL using only grab samples from southerly two segments of Area 5.
	FS – north	µg/kg dw	8/8	215	52 – 860	n/a	95% Adjusted gamma UCL	480	ProUCL using only grab samples from northerly segment of Area 5.
6	HHRA	µg/kg dw	2/2	540	100 – 970	n/a	maximum detect	970	
	FS	µg/kg dw	1/1 composite	860	860	n/a	composite sample (LDW-SS529-comp)	860	EPC is based on single composite sample collected over an average depth of 41 cm.

Table B-1 Exposure Point Concentrations and Summary Statistics for Beach Play Areas Using the FS and HHRA Datasets (continued)

Beach Play Area	Dataset	Unit	No. Samples with Detected Concentrations/ Total No. Samples	Mean Value	Range of Detects	Range of RLs	Statistic Used	EPC	Notes on FS Dataset EPCs
7	HHRA	µg/kg dw	10/14	63	9.8 J – 340	19 – 40	97.5% KM (Chebyshev) UCL	230	
	FS	µg/kg dw	16/22	48	9.8 J – 340	19 – 40	95% KM (BCA) UCL	85	ProUCL using only grab data.
8	HHRA	µg/kg dw	12/18	56	6.1 J – 520	20 – 40	97.5% KM (Chebyshev) UCL	230	
	FS	µg/kg dw	15/22	54.6	6.1 J – 520	20 – 40	95% KM (BCA) UCL	100	ProUCL using only grab data.
Duwamish Waterway Park	HHRA	µg/kg dw	4/5	54	24 J – 104	20	maximum detect	104	
	FS	µg/kg dw	1/1 composite	280	280	n/a	composite sample (LDW-SS533-comp)	280	EPC based on single composite sample collected over an average depth of 43 cm.
Arsenic									
1	HHRA	mg/kg dw	4/4	6.5	3.5 – 14.9	n/a	maximum detect	15	
	FS	mg/kg dw	2/2 composites	17.5	9.6 – 25.3	n/a	weighted composite samples (41% LDW-SS502-comp; 59% LDW-SS503-comp)	16	EPC based on concentrations of two composite samples weighted by area. One of the two composites contained sediment collected over an average depth of 43 cm.
2	HHRA	mg/kg dw	5/5	12.1	3.62 – 20.7	n/a	maximum detect	21	
	FS	mg/kg dw	6/6	13.1	3.62 – 20.7	n/a	95% Student's t UCL	19	ProUCL using only grab data.
3	HHRA	mg/kg dw	6/9	8.5	7.2 – 18.3	3.1 – 6.6	95% KM (percentile bootstrap) UCL	13	
	FS	mg/kg dw	10/13	8.39	5.3 – 18.3	3.1 – 6.6	95% KM (percentile bootstrap) UCL	11	ProUCL using only grab data.
4	HHRA	mg/kg dw	10/10	8.2	2.7 – 17.3	n/a	95% Student's t UCL	11	
	FS	mg/kg dw	25/25	9.35	1.8 – 48.7	n/a	95% approximate gamma UCL	12	ProUCL using only grab data.

Table B-1 Exposure Point Concentrations and Summary Statistics for Beach Play Areas Using the FS and HHRA Datasets (continued)

Beach Play Area	Dataset	Unit	No. Samples with Detected Concentrations/ Total No. Samples	Mean Value	Range of Detects	Range of RLs	Statistic Used	EPC	Notes on FS Dataset EPCs
4 modified[a]	FS – without inlet	mg/kg dw	18/18	7.21	1.8 – 17.3	n/a	95% Student's t UCL	8.8	ProUCL using only grab data.
	FS – inlet only	mg/kg dw	7/7	14.9	2.6 – 48.7	n/a	95% approximate gamma UCL	35	ProUCL using only grab data.
5	HHRA	mg/kg dw	22/22	8.1	3.94 – 11.8	n/a	95% Student's t UCL	8.9	
	FS	mg/kg dw	26/26	8.88	3.94 – 19.1	n/a	95% approximate gamma UCL	10	ProUCL using only grab data.
5 modified[b]	FS – south	mg/kg dw	20/20	7.78	3.94 – 11.5	n/a	95% Student's t UCL	8.5	ProUCL using only grab samples from southerly two segments of Area 5.
	FS – north	mg/kg dw	6/6	12.5	6.9 – 19.1	n/a	95% Student's t UCL	16	ProUCL using only grab samples from northerly segment of Area 5.
6	HHRA	mg/kg dw	1/1	9.8	9.8	n/a	maximum detect	9.8	
	FS	mg/kg dw	1/1 composite	93.8	93.8	n/a	composite sample (LDW-SS529-comp)	94	EPC is based on single composite sample collected over an average depth of 41 cm.
7	HHRA	mg/kg dw	9/9	8.9	5.05 J – 13.8	n/a	95% Student's t UCL	11	
	FS	mg/kg dw	14/14	8.2	3.5 – 13.8	n/a	95% Student's t UCL	9.7	ProUCL using only grab data.
8	HHRA	mg/kg dw	11/11	8.7	5.8 – 15.6	n/a	95% Student's t UCL	10	
	FS	mg/kg dw	15/15	8.25	5.8 – 15.6	n/a	95% approximate gamma UCL	9.4	ProUCL using only grab data.
Duwamish Waterway Park	HHRA	mg/kg dw	4/4	7.0	4.9 – 9.2	n/a	maximum detect	9.2	
	FS	mg/kg dw	1/1 composite	4.3	4.3	n/a	composite sample (LDW-SS533-comp)	4.3	EPC based on single composite sample collected over an average depth of 43 cm.

Table B-1 Exposure Point Concentrations and Summary Statistics for Beach Play Areas Using the FS and HHRA Datasets (continued)

Beach Play Area	Dataset	Unit	No. Samples with Detected Concentrations/ Total No. Samples	Mean Value	Range of Detects	Range of RLs	Statistic Used	EPC	Notes on FS Dataset EPCs
cPAH TEQ									
1	HHRA	µg/kg dw	3/4	330	23 – 1,200	9.1	maximum detect	1,200	
	FS	µg/kg dw	2/2 composites	380	360 J – 390 J	n/a	weighted composite samples (41% LDW-SS502-comp; 59% LDW-SS503-comp)	380	EPC based on concentrations of two composite samples weighted by area. One of the two composites contained sediment collected over an average depth of 43 cm.
2	HHRA	µg/kg dw	5/5	700	81 J – 3,000	n/a	maximum detect	3,000	
	FS	µg/kg dw	6/6	1,070	81 J – 3,000	n/a	99% Chebyshev (Mean, SD) UCL	7,000	ProUCL using only grab data.
3	HHRA	µg/kg dw	7/9	660	38 – 2,900	35 – 36	95% KM (Chebyshev) UCL	2,100	
	FS	µg/kg dw	10/13	517	38 – 2,800 J	4.3 – 36	95% KM (Chebyshev) UCL	1,500	ProUCL using only grab data.
4	HHRA	µg/kg dw	9/10	200	19 – 750	9.1	97.5% KM (Chebyshev) UCL	730	
	FS	µg/kg dw	23/25	510	19 – 4,800 J	9.1 – 18	95% KM (Chebyshev) UCL	1,400	ProUCL using only grab data.
4 modified[a]	FS – without inlet	µg/kg dw	16/18	275	19 – 1,900	9.1 – 18	95% KM (Chebyshev) UCL	740	ProUCL using only grab data.
	FS – inlet only	µg/kg dw	7/7	1,110	37 – 4,800	n/a	95% approximate gamma UCL	4,000	ProUCL using only grab data.
5	HHRA	µg/kg dw	22/22	210	15 J – 1,000 J	n/a	95% Chebyshev (MVUE) UCL	410	
	FS	µg/kg dw	26/26	424	15 J – 4,400 J	n/a	99% Chebyshev (Mean, SD) UCL	2,200	ProUCL using only grab data.
5 modified[b]	FS – south	µg/kg dw	20/20	93.1	15 J – 190	n/a	95% Student's t UCL	110	ProUCL using only grab samples from southerly two segments of Area 5.
	FS – north	µg/kg dw	6/6	1,530	220 – 4,400	n/a	95% approximate gamma UCL	3,900	ProUCL using only grab samples from northerly segment of Area 5.

Table B-1 Exposure Point Concentrations and Summary Statistics for Beach Play Areas Using the FS and HHRA Datasets (continued)

Beach Play Area	Dataset	Unit	No. Samples with Detected Concentrations/ Total No. Samples	Mean Value	Range of Detects	Range of RLs	Statistic Used	EPC	Notes on FS Dataset EPCs
6	HHRA	µg/kg dw	1/1	440	440	n/a	maximum detect	440	
	FS	µg/kg dw	1/1 composite	7,100	7,100 J	n/a	composite sample (LDW-SS529-comp)	7,100	EPC is based on single composite sample collected over an average depth of 41 cm.
7	HHRA	µg/kg dw	8/9	77	24 J – 150	9.4	95% KM (t) UCL	110	
	FS	µg/kg dw	12/14	73	21 J – 150	9.4 – 17	95% KM (t) UCL	98	ProUCL using only grab data.
8	HHRA	µg/kg dw	11/11	230	49 – 620	n/a	95% Student's t UCL	320	
	FS	µg/kg dw	14/15	194	49 – 620	45	95% KM (BCA) UCL	270	ProUCL using only grab data.
Duwamish Waterway Park	HHRA	µg/kg dw	4/4	58.8	32 – 110	n/a	maximum detect	110	
	FS	µg/kg dw	1/1 composite	61	61 J	n/a	composite sample (LDW-SS533-comp)	61	EPC based on single composite sample collected over an average depth of 43 cm.
Dioxin/Furan TEQ									
1	HHRA	ng/kg dw	0/0	n/a	n/a	n/a	n/a	n/a	
	FS	ng/kg dw	2/2 composites	2.42	2.06 J – 2.77 J	n/a	weighted composite samples (41% LDW-SS502-comp; 59% LDW-SS503-comp)	2.5	EPC based on concentrations of two composite samples weighted by area. One of the two composites contained sediment collected over an average depth of 43 cm.
2	HHRA	ng/kg dw	0/0	n/a	n/a	n/a	n/a	n/a	
	FS	ng/kg dw	1/1	74.5	74.5 J	n/a	maximum detect	74.5	EPC based on single grab sample.
3	HHRA	ng/kg dw	0/0	n/a	n/a	n/a	n/a	n/a	
	FS	ng/kg dw	1/1	4.31	4.31 J	n/a	maximum detect	4.31	EPC based on single grab sample.
4	HHRA	ng/kg dw	1/1	412	412 J	n/a	maximum detect	412	
	FS	ng/kg dw	4/4	110	1.69 J – 412 J	n/a	maximum detect	412	EPC based on maximum grab sample.

Table B-1 Exposure Point Concentrations and Summary Statistics for Beach Play Areas Using the FS and HHRA Datasets (continued)

Beach Play Area	Dataset	Unit	No. Samples with Detected Concentrations/ Total No. Samples	Mean Value	Range of Detects	Range of RLs	Statistic Used	EPC	Notes on FS Dataset EPCs
4 modified[a]	FS – without inlet	ng/kg dw	3/3	9.25	1.69 J – 17.0 J	n/a	maximum detect	17	EPC based on maximum grab sample.
	FS – inlet only	ng/kg dw	1/1	412	412 J	n/a	maximum detect	412	EPC based on single grab sample.
5	HHRA	ng/kg dw	1/1	2.2	2.2 J	n/a	maximum detect	2.2	
	FS	ng/kg dw	4/4 (2 composites and 2 grab samples)	n/a[c]	1.71 J – 35.7 J	n/a	maximum detect	35.7	Maximum of available data (2 composite samples and 2 grab samples).
5 modified[b]	FS – south	ng/kg dw	3/3 (2 composites and 1 grab sample)	n/a[c]	1.71 J – 6.28 J	n/a	maximum detect	6.28 J	Maximum of available data (2 composite samples and 1 grab sample).
	FS – north	ng/kg dw	1/1 (grab sample)	37.5	35.7 J	n/a	maximum detect	35.7	EPC based on single grab sample.
6	HHRA	ng/kg dw	0/0	n/a	n/a	n/a	n/a	n/a	
	FS	ng/kg dw	1/1 composite	8.99	8.99 J	n/a	composite sample (LDW-SS529-comp)	8.99	EPC is based on single composite sample collected over an average depth of 41 cm.
7	HHRA	ng/kg dw	1/1	1.7	1.7	n/a	maximum detect	1.7	
	FS	ng/kg dw	1/1 composite	3.73	3.73 J	n/a	composite sample (LDW-SS544-comp)	3.73	EPC based on single composite sample.
8	HHRA	ng/kg dw	0/0	n/a	n/a	n/a	n/a	n/a	
	FS	ng/kg dw	1/1	3.79	3.79 J	n/a	maximum detect	3.79	EPC based on a single grab sample.
Duwamish Waterway Park	HHRA	ng/kg dw	0/0	n/a	n/a	n/a	n/a	n/a	
	FS	ng/kg dw	1/1 composite	6.28	6.28 J	n/a	composite sample (LDW-SS533-comp)	6.28	EPC based on single composite sample collected over an average depth of 43 cm.

Table B-1 Exposure Point Concentrations and Summary Statistics for Beach Play Areas Using the FS and HHRA Datasets (continued)

Notes:

1. In some cases, the FS dataset appears smaller than the HHRA dataset because a composite sample was used to represent the average concentration of the area.

a. Area 4 modified divided the original Area 4 into two parts. Area 4 modified without inlet excludes samples from the inlet at RM 2.2W. Area 4 modified – inlet only includes only samples from the inlet.

b. Area 5 modified divided the original Area 5 into two parts. Area 5 modified – north includes only the northernmost beach. Area 5 modified – south includes only the two southernmost beaches and excludes the northerly section.

c. Because data were a mixture of composite and grab samples, a mean value was not calculated.

BCA = bias-corrected accelerated; cPAH = carcinogenic polycyclic aromatic hydrocarbon; dw = dry weight; EPC = exposure point concentration; FS = feasibility study; HHRA = human health risk assessment; J = estimated concentration; kg = kilograms; KM = Kaplan-Meier (method for calculating a UCL); LDW = Lower Duwamish Waterway; µg = micrograms; mg = milligrams; MVUE = minimum-variance unbiased eliminator; n/a = not applicable; ng = nanograms; RL = reporting limit; SD = standard deviation; t = t-distribution (statistical method used to calculate the mean for a normally distributed set of samples); TEQ = toxic equivalent; UCL = upper confidence limit on the mean

Table B-2 Updated Risk Estimates for Beach Play Areas

Beach Play Area	Risk Driver	Excess Cancer Risk Estimate		Non-Cancer HQ	
		HHRA Dataset	FS Dataset	HHRA Dataset	FS Dataset
1	Total PCBs	7×10^{-8}	3×10^{-8}	0.02	0.009
	Arsenic	5×10^{-6}	5×10^{-6}	0.1	0.1
	cPAHs[a]	1×10^{-5}	4×10^{-6}	n/a[b]	n/a[b]
	Dioxins/furans	n/a	1×10^{-7}	n/a[b]	n/a[b]
	Total risk[c]	**2×10^{-5}**	**9×10^{-6}**	**n/a**	**n/a**
2	Total PCBs	1×10^{-7}	1×10^{-7}	0.03	0.05
	Arsenic	7×10^{-6}	6×10^{-6}	0.2	0.2
	cPAHs[a]	4×10^{-5}	8×10^{-5}	n/a[b]	n/a[b]
	Dioxins/furans	n/a	3×10^{-6}	n/a[b]	n/a[b]
	Total risk[c]	**5×10^{-5}**	**9×10^{-5}**	**n/a**	**n/a**
3	Total PCBs	1×10^{-7}	1×10^{-7}	0.04	0.04
	Arsenic	4×10^{-6}	4×10^{-6}	0.1	0.1
	cPAHs[a]	3×10^{-5}	1×10^{-5}	n/a[b]	n/a[b]
	Dioxins/furans	n/a	1×10^{-7}	n/a[b]	n/a[b]
	Total risk[c]	**3×10^{-5}**	**1×10^{-5}**	**n/a**	**n/a**
4	Total PCBs	6×10^{-6}	6×10^{-4}	1	187
	Arsenic	4×10^{-6}	4×10^{-6}	0.1	0.1
	cPAHs[a]	8×10^{-6}	1×10^{-5}	n/a[b]	n/a[b]
	Dioxins/furans	1×10^{-5}	1×10^{-5}	n/a[b]	n/a[b]
	Total risk[c]	**3×10^{-5}**	**6×10^{-4}**	**n/a**	**n/a**
4 modified (without inlet)[d]	Total PCBs	n/a	1×10^{-6}	n/a	0.4
	Arsenic	n/a	3×10^{-6}	n/a	0.09
	cPAHs[a]	n/a	9×10^{-6}	n/a[b]	n/a[b]
	Dioxins/furans	n/a	6×10^{-7}	n/a[b]	n/a[b]
	Total risk[c]	**n/a**	**1×10^{-5}**	**n/a**	**n/a**
4 modified (inlet only)[d]	Total PCBs	n/a	3×10^{-3}	n/a	883
	Arsenic	n/a	1×10^{-5}	n/a	0.3
	cPAHs[a]	n/a	4×10^{-5}	n/a[b]	n/a[b]
	Dioxins/furans	n/a	2×10^{-5}	n/a[b]	n/a[b]
	Total risk[c]	**n/a**	**3×10^{-3}**	**n/a**	**n/a**
5	Total PCBs	1×10^{-7}	1×10^{-7}	0.04	0.04
	Arsenic	3×10^{-6}	3×10^{-6}	0.09	0.1
	cPAHs[a]	5×10^{-6}	3×10^{-5}	n/a[b]	n/a[b]
	Dioxins/furans	8×10^{-8}	1×10^{-6}	n/a[b]	n/a[b]
	Total risk[c]	**8×10^{-6}**	**3×10^{-5}**	**n/a**	**n/a**
5 modified – south[e]	Total PCBs	n/a	1×10^{-7}	n/a	0.04
	Arsenic	n/a	3×10^{-6}	n/a	0.08
	cPAHs[a]	n/a	1×10^{-6}	n/a[b]	n/a[b]
	Dioxins/furans	n/a	2×10^{-7}	n/a[b]	n/a[b]
	Total risk[c]	**n/a**	**4×10^{-6}**	**n/a**	**n/a**

Table B-2 Updated Risk Estimates for Beach Play Areas (continued)

Beach Play Area	Risk Driver	Excess Cancer Risk Estimate		Non-Cancer HQ	
		HHRA Dataset	FS Dataset	HHRA Dataset	FS Dataset
5 modified – north[e]	Total PCBs	n/a	3×10^{-7}	n/a	0.08
	Arsenic	n/a	6×10^{-6}	n/a	0.2
	cPAHs[a]	n/a	4×10^{-5}	n/a[b]	n/a[b]
	Dioxins/furans	n/a	1×10^{-6}	n/a[b]	n/a[b]
	Total risk[c]	**n/a**	**5×10^{-5}**	**n/a**	**n/a**
6	Total PCBs	5×10^{-7}	5×10^{-7}	0.1	0.1
	Arsenic	3×10^{-6}	3×10^{-5}	0.1	0.9
	cPAHs[a]	5×10^{-6}	8×10^{-5}	n/a[b]	n/a[b]
	Dioxins/furans	n/a	3×10^{-7}	n/a[b]	n/a[b]
	Total risk[c]	**9×10^{-6}**	**1×10^{-4}**	**n/a**	**n/a**
7	Total PCBs	1×10^{-7}	5×10^{-8}	0.04	0.01
	Arsenic	4×10^{-6}	3×10^{-6}	0.1	0.1
	cPAHs[a]	1×10^{-6}	1×10^{-6}	n/a[b]	n/a[b]
	Dioxins/furans	6×10^{-8}	1×10^{-7}	n/a[b]	n/a[b]
	Total risk[c]	**5×10^{-6}**	**4×10^{-6}**	**n/a**	**n/a**
8	Total PCBs	1×10^{-7}	6×10^{-8}	0.04	0.01
	Arsenic	3×10^{-6}	3×10^{-6}	0.1	0.09
	cPAHs[a]	4×10^{-6}	3×10^{-6}	n/a[b]	n/a[b]
	Dioxins/furans	n/a	1×10^{-7}	n/a[b]	n/a[b]
	Total risk[c]	**7×10^{-6}**	**6×10^{-6}**	**n/a**	**n/a**
Duwamish Waterway Park	Total PCBs	6×10^{-8}	1×10^{-7}	0.01	0.05
	Arsenic	3×10^{-6}	1×10^{-6}	0.09	0.04
	cPAHs[a]	1×10^{-6}	7×10^{-7}	n/a[b]	n/a[b]
	Dioxins/furans	n/a	2×10^{-7}	n/a[b]	n/a[b]
	Total risk	**4×10^{-6}**	**2×10^{-6}**	**n/a**	**n/a**

Notes:

a. cPAHs are presented as benzo(a)pyrene TEQs. Because of the potential for the increased susceptibility of children to carcinogens with mutagenic activity, as described in EPA guidance (2005), the risk estimate for beach play RME for cPAHs is based on dose adjustments across the 0-to-6-year-old age range of children. See Section B.5.1 of the HHRA (Windward 2007) for more information.

b. Non-cancer HQs were not calculated for cPAHs or dioxins/furans because no non-cancer RfDs are available for these COCs.

c. Total HHRA excess cancer risk estimates include the risks associated with all COPCs. The total FS excess cancer risk estimates include only the risk drivers listed in this table. In the HHRA (Windward 2007), risks from other COPCs made up 1% or less of the total excess cancer risk for any given beach play area; thus, if the risks for these other COPCs were added, it is unlikely that the total risk estimates presented here would change. No total risks are presented for non-cancer HQs because these sums are not directly interpretable for risk assessment (i.e., HQs are for different endpoints).

d. Area 4 was modified to examine the influence of higher concentrations in the inlet at RM 2.2W. Risks are presented both for Area 4 modified – without inlet and Area 4 modified – inlet only.

e. Area 5 was modified to examine the influence of higher concentrations in the northernmost section. Risks are presented both for Area 5 modified – south and Area 5 modified -- north.

COC = contaminant of concern; COPC = contaminant of potential concern; cPAH = carcinogenic polycyclic aromatic hydrocarbon; EPA = U.S. Environmental Protection Agency; FS = feasibility study; HHRA = human health risk assessment; HQ = hazard quotient; n/a = not applicable; PCB = polychlorinated biphenyl; RfD = reference dose; RME = reasonable maximum exposure; TEQ = toxic equivalent

Table B-3 Average Total PCB Concentrations in the HHRA Tissue Dataset and Species-Specific RBTCs at the 1 × 10^{-4} Risk Level for the Adult Tribal RME Scenario Based on Tulalip Data

Dataset or RBTC Type[a]	Average Total PCB Concentration (µg/kg ww)					
	Clam	Crab EM	Crab WB	Perch WB	English Sole Fillet	Ingestion-Weighted Average
Empirical dataset: HHRA dataset[b]	140	170	890	1,700	700	394
Calculated species-specific RBTCs using the HHRA dataset	15	18	95	181	75	42

Notes:

a. This table presents values used for the example species-specific RBTC calculations discussed in Section B.3.1. Tables B-5 through B-9 present the full range of species-specific RBTCs for all risk driver-scenario-risk level combinations.

b. Includes data collected between 1992 and 2005.

EM = edible meat; HHRA = human health risk assessment; PCB = polychlorinated biphenyl; RBTC = risk-based threshold concentration; RME = reasonable maximum exposure; WB = whole-body; ww = wet weight

Table B-4 Seafood Consumption Categories and Consumption Rates Used in the Puget Sound Risk Calculations

Consumption Category	Consumption Rate (g/day)[a]			Comparison with LDW HHRA Consumption Categories
	Adult Tribal RME (Tulalip data)	Child Tribal RME (Tulalip data)	Adult API RME	
Fish	15.6 (15.8 with no mussels)	6.2 (same with no mussels)	7.3 (8.0 with no mussels)	Consumption category is combination of benthic fish and pelagic fish consumption categories in the LDW HHRA.
Clams	43.4 (43.7 with no mussels)	17.4 (17.5 with no mussels)	29.0 (31.8 with no mussels)	Consumption category is the same as that in the LDW HHRA, except it includes all available clam species.
Mussels	0.8	0.3	4.6	Consumption category is the same as that in the LDW HHRA
Crab – edible meat	28.7 (28.9 with no mussels)	11.5 (11.6 with no mussels)	5.7 (6.3 with no mussels)	Consumption category is the same as that in the LDW HHRA.
Crab – whole-body	9.0 (9.1 with no mussels)	3.6 (same with no mussels)	4.9 (5.4 with no mussels)	Consumption category is the same as that in the LDW HHRA.

Notes:

a. Consumption rates are the same as those used in the LDW HHRA (Windward 2007, 2009). Additionally, as was done in the LDW HHRA for COPCs for which no mussel data were available, the proportion of the consumption rate attributed to mussels was distributed proportionally to the other consumption groups when no mussel data were available.

API = Asian and Pacific Islanders; COPC = contaminant of potential concern; g/day = grams per day; HHRA = human health risk assessment; LDW = Lower Duwamish Waterway; RME = reasonable maximum exposure

Table B-5 Species-Specific Tissue RBTCs for Total PCBs for the Adult Tribal RME Seafood Consumption Scenario Based on Tulalip Data

Basis for Species-Specific Ratios	Risk Level	Total PCB RBTC (µg/kg ww)					
		Ingestion-weighted	Clams	Crab EM	Crab WB	Pelagic Fish WB	Benthic Fish Fillet
RBTCs for 1 × 10^{-4} risk level							
Empirical data: HHRA database[a]	1 × 10^{-4}	42	15	18	95	181	75
Empirical data: 2007 LDW data	1 × 10^{-4}	42	32	12	53	138	97
FWM results: sediment = 380 µg/kg dw; water = 1.2 ng/L	1 × 10^{-4}	42	12	18	92	152	128
RBTC ranges for 1 × 10^{-4}		**42**	**12 – 32**	**12 – 18**	**53 – 95**	**138 – 181**	**75 – 128**
RBTCs for 1 × 10^{-5} risk level							
Empirical data: HHRA database[a]	1 × 10^{-5}	4.2	1.5	1.8	9.5	18	7.5
Empirical data: 2007 LDW data	1 × 10^{-5}	4.2	3.2	1.2	5.3	14	9.7
FWM results: sediment = 380 µg/kg dw; water = 1.2 ng/L	1 × 10^{-5}	4.2	1.2	1.8	9.2	15	13
RBTC ranges for 1 × 10^{-5}		**4.2**	**1.2 – 3.2**	**1.2 – 1.8**	**5.3 – 9.5**	**14 – 18**	**7.5 – 13**
RBTCs for 1 × 10^{-6} risk level							
Empirical data: HHRA database[a]	1 × 10^{-6}	0.42	0.15	0.18	0.95	1.8	0.75
Empirical data: 2007 LDW data	1 × 10^{-6}	0.42	0.32	0.12	0.53	1.4	0.97
FWM results: sediment = 380 µg/kg dw; water = 1.2 ng/L	1 × 10^{-6}	0.42	0.12	0.18	0.92	1.5	1.3
RBTC ranges for 1 × 10^{-6}		**0.42**	**0.12 – 0.32**	**0.12 – 0.18**	**0.53 – 0.95**	**1.4 – 1.8**	**0.75 – 1.3**
RBTCs for HQ = 1							
Empirical data: HHRA database[a]	HQ = 1	17	6.0	7.3	38	73	30
Empirical data: 2007 LDW data	HQ = 1	17	13	4.8	21	56	39
FWM results: sediment = 380 µg/kg dw; water = 1.2 ng/L	HQ = 1	17	4.7	7.3	37	62	52
RBTC ranges for HQ = 1		**17**	**4.7 – 13**	**4.8 – 7.3**	**21 – 38**	**56 – 73**	**30 – 52**

Notes:

a. Includes data collected between 1992 and 2005.

dw = dry weight; EM = edible meat; FWM = food web model; HHRA = human health risk assessment; HQ =hazard quotient; LDW = Lower Duwamish Waterway; µg/kg = micrograms per kilogram; ng/L = nanograms per liter; PCB = polychlorinated biphenyl; RBTC = risk-based threshold concentration; RME = reasonable maximum exposure; WB = whole-body; ww = wet weight

Table B-6 Species-Specific Tissue RBTCs for Total PCBs for the Child Tribal RME Seafood Consumption Scenario Based on Tulalip Data

Basis for Species-Specific Ratios	Risk Level	Total PCB RBTC (µg/kg ww)					
		Ingestion-Weighted	Clams	Crab EM	Crab WB	Pelagic Fish WB	Benthic Fish Fillet
RBTCs for 1 × 10^{-4} risk level							
Empirical data: HHRA database[a]	1 × 10^{-4}	230	82	100	523	1,000	412
Empirical data: 2007 LDW data	1 × 10^{-4}	230	176	65	291	760	534
FWM results: sediment = 380 µg/kg dw; water = 1.2 ng/L	1 × 10^{-4}	230	64	100	509	840	706
RBTC ranges for 1 × 10^{-4}		**230**	**64 – 176**	**65 – 100**	**291 – 523**	**760 – 1,000**	**412 – 706**
RBTCs for 1 × 10^{-5} risk level							
Empirical data: HHRA database[a]	1 × 10^{-5}	23	8.2	10	52	100	41
Empirical data: 2007 LDW data	1 × 10^{-5}	23	18	6.5	29	76	53
FWM results: sediment = 380 µg/kg dw; water = 1.2 ng/L	1 × 10^{-5}	23	6.4	10	51	84	71
RBTC ranges for 1 × 10^{-5}		**23**	**6.4 – 18**	**6.5 – 10**	**29 – 52**	**76 – 100**	**41 – 71**
RBTCs for 1 × 10^{-6} risk level							
Empirical data: HHRA database[a]	1 × 10^{-6}	2.3	0.82	1.0	5.2	10	4.1
Empirical data: 2007 LDW data	1 × 10^{-6}	2.3	1.8	0.65	2.9	7.6	5.3
FWM results: sediment = 380 µg/kg dw; water = 1.2 ng/L	1 × 10^{-6}	2.3	0.64	1.0	5.1	8.4	7.1
RBTC ranges for 1 × 10^{-6}		**2.3**	**0.64 – 1.8**	**0.65 – 1.0**	**2.9 – 5.2**	**7.6 – 10**	**4.1 – 7.1**
RBTCs for HQ = 1							
Empirical data: HHRA database[a]	HQ = 1	7.8	2.8	3.4	18	34	14
Empirical data: 2007 LDW data	HQ = 1	7.8	6.0	2.2	9.9	26	18
FWM results: sediment = 380 µg/kg dw; water = 1.2 ng/L	HQ = 1	7.8	2.2	3.4	17	28	24
RBTC ranges for HQ = 1		**7.8**	**2.2 – 6.0**	**2.2 – 3.4**	**9.9 – 18**	**26 – 34**	**14 – 24**

Notes:
a. Includes data collected between 1992 and 2005.

dw = dry weight; EM = edible meat; FWM = food web model; HHRA = human health risk assessment; HQ = hazard quotient; LDW = Lower Duwamish Waterway; µg/kg = micrograms per kilogram; ng/L = nanograms per liter; PCB = polychlorinated biphenyl; RBTC = risk-based threshold concentration; RME = reasonable maximum exposure; WB = whole-body; ww = wet weight

Table B-7 Species-Specific Tissue RBTCs for Total PCBs for the Adult API RME Seafood Consumption Scenario

Basis for Species-Specific Ratios	Risk Level	Total PCB RBTC (µg/kg ww)						
		Ingestion-Weighted	Clams	Crab EM	Crab WB	Pelagic Fish WB	Benthic Fish WB	Benthic Fish Fillet
RBTCs for 1 × 10^{-4} risk level								
Empirical data: HHRA database[a]	1 × 10^{-4}	140	46	56	293	559	723	230
Empirical data: 2007 LDW data	1 × 10^{-4}	140	96	35	158	412	560	290
FWM results: sediment = 380 µg/kg dw; water = 1.2 ng/L	1 × 10^{-4}	140	38	60	305	503	803	422
RBTC ranges for 1 × 10^{-4}		**140**	**38 – 96**	**35 – 60**	**158 – 305**	**412 – 559**	**560 – 803**	**230 – 422**
RBTCs for 1 × 10^{-5} risk level								
Empirical data: HHRA database[a]	1 × 10^{-5}	14	4.6	5.6	29	56	72	23
Empirical data: 2007 LDW data	1 × 10^{-5}	14	9.6	3.5	16	41	56	29
FWM results: sediment = 380 µg/kg dw; water = 1.2 ng/L	1 × 10^{-5}	14	3.8	6.0	30	50	80	42
RBTC ranges for 1 × 10^{-5}		**14**	**3.8 – 9.6**	**3.5 – 6.0**	**16 – 30**	**41 – 56**	**56 – 80**	**23 – 42**
RBTCs for 1 × 10^{-6} risk level								
Empirical data: HHRA database[a]	1 × 10^{-6}	1.4	0.46	0.56	2.9	5.6	7.2	2.3
Empirical data: 2007 LDW data	1 × 10^{-6}	1.4	1.0	0.35	1.6	4.1	5.6	2.9
FWM results: sediment = 380 µg/kg dw; water = 1.2 ng/L	1 × 10^{-6}	1.4	0.38	0.60	3.0	5.0	8.0	4.2
RBTC ranges for 1 × 10^{-6}		**1.4**	**0.38 – 0.96**	**0.35 – 0.60**	**1.6 – 3.0**	**4.1 – 5.6**	**5.6 – 8.0**	**2.3 – 4.2**
RBTCs for HQ = 1								
Empirical data: HHRA database[a]	HQ = 1	24	7.9	9.6	50	96	124	39
Empirical data: 2007 LDW data	HQ = 1	24	16	6.1	27	71	96	50
FWM results: sediment = 380 µg/kg dw; water = 1.2 ng/L	HQ = 1	24	6.6	10	52	86	138	72
RBTC ranges for HQ = 1		**24**	**6.6 – 16**	**6.1 – 10**	**27 – 52**	**71 – 96**	**96 – 138**	**39 – 72**

Notes:

a. Includes data collected between 1992 and 2005.

API = Asian and Pacific Islander; dw = dry weight; EM = edible meat; FWM = food web model; HHRA = human health risk assessment; HQ = hazard quotient; LDW = Lower Duwamish Waterway; µg/kg = micrograms per kilogram; ng/L = nanograms per liter; PCB = polychlorinated biphenyl; RBTC = risk-based threshold concentration; RME = reasonable maximum exposure; WB = whole-body; ww = wet weight

Table B-8 Species-Specific Tissue RBTCs for Inorganic Arsenic for the RME Seafood Consumption Scenarios

Basis for Species-Specific Ratios	Risk Level	Inorganic Arsenic RBTC (mg/kg ww)						
		Ingestion-Weighted	Clams	Crab EM	Crab WB	Pelagic Fish WB	Benthic Fish WB	Benthic Fish Fillet
Adult Tribal RME Scenario based on Tulalip data								
Empirical data: HHRA database[a]	1×10^{-4}	0.056	0.12	0.0022	0.0073	0.0056	n/a	0.00039
Empirical data: HHRA database[a]	1×10^{-5}	0.0056	0.012	0.00022	0.00073	0.00056	n/a	0.000039
Empirical data: HHRA database[a]	1×10^{-6}	0.00056	0.0012	0.000022	0.000073	0.000056	n/a	0.0000039
Empirical data: HHRA database[a]	HQ = 1	0.25	0.54	0.010	0.033	0.025	n/a	0.0017
Child Tribal RME Scenario based on Tulalip data								
Empirical data: HHRA database[a]	1×10^{-4}	0.30	0.65	0.012	0.039	0.030	n/a	0.0021
Empirical data: HHRA database[a]	1×10^{-5}	0.030	0.065	0.0012	0.0039	0.0030	n/a	0.00021
Empirical data: HHRA database[a]	1×10^{-6}	0.0030	0.0065	0.00012	0.00039	0.00030	n/a	0.000021
Empirical data: HHRA database[a]	HQ = 1	0.12	0.26	0.0048	0.016	0.012	n/a	0.00083
Adult API RME Scenario								
Empirical data: HHRA database[a]	1×10^{-4}	0.19	0.30	0.0056	0.018	0.014	0.014	0.00097
Empirical data: HHRA database[a]	1×10^{-5}	0.019	0.030	0.00056	0.0018	0.0014	0.0014	0.000097
Empirical data: HHRA database[a]	1×10^{-6}	0.0019	0.0030	0.000056	0.00018	0.00014	0.00014	0.0000097
Empirical data: HHRA database[a]	HQ = 1	0.37	0.59	0.011	0.035	0.027	0.026	0.0019

Notes:
a. Includes data collected between 1992 and 2005. Inorganic arsenic data were not collected for all consumption categories in 2007.

API = Asian and Pacific Islander; EM = edible meat; FWM = food web model; HHRA = human health risk assessment; HQ = hazard quotient; mg/kg = milligrams per kilogram; n/a = not applicable (not part of the diet for this scenario); RBTC = risk-based threshold concentration; RME = reasonable maximum exposure; WB = whole-body

Table B-9 Species-Specific Tissue RBTCs for cPAHs for the RME Seafood Consumption Scenarios

Basis for Species-Specific Ratios	Risk Level	cPAH RBTC (µg TEQ /kg ww)						
		Ingestion-Weighted	Clams	Crab EM	Crab WB	Pelagic Fish WB	Benthic Fish WB	Benthic Fish Fillet
Adult Tribal RME Scenario based on Tulalip data								
Empirical data: HHRA database[a]	1×10^{-4}	11	24	0.69	1.2	1.2	n/a	0.61
Empirical data: HHRA database[a]	1×10^{-5}	1.1	2.4	0.069	0.12	0.12	n/a	0.061
Empirical data: HHRA database[a]	1×10^{-6}	0.11	0.24	0.0069	0.012	0.012	n/a	0.0061
Child Tribal RME Scenario based on Tulalip data								
Empirical data: HHRA database[a]	1×10^{-4}	12	26	0.75	1.3	1.3	n/a	0.66
Empirical data: HHRA database[a]	1×10^{-5}	1.2	2.6	0.075	0.13	0.13	n/a	0.066
Empirical data: HHRA database[a]	1×10^{-6}	0.12	0.26	0.0075	0.013	0.013	n/a	0.0066
Adult API RME Scenario								
Empirical data: HHRA database[a]	1×10^{-4}	39	61	1.8	3.1	3.2	5.7	1.6
Empirical data: HHRA database[a]	1×10^{-5}	3.9	6.1	0.18	0.31	0.32	0.57	0.16
Empirical data: HHRA database[a]	1×10^{-6}	0.39	0.61	0.018	0.031	0.032	0.057	0.016

Notes:
a. Includes data collected between 1992 and 2005. cPAH tissue data were not collected in 2007.

API = Asian and Pacific Islander; cPAH = carcinogenic polycyclic aromatic hydrocarbon; EM = edible meat; FWM = food web model; HHRA = human health risk assessment; HQ = hazard quotient; µg/kg = micrograms per kilogram; n/a = not applicable (not part of the diet for this scenario); RBTC = risk-based threshold concentration; RME = reasonable maximum exposure; TEQ = toxic equivalent; WB = whole-body

Table B-10 Total PCB Concentrations in Fish and Shellfish Collected from Non-Urban Puget Sound Locations Outside of Known Contaminated Sites

Species	Tissue Type	Sampling Location	Sampling Year(s)	Detection Frequency	Individuals per Composite (Average)	Total PCB Concentration[a] (µg/kg ww)			Source
						Mean[b]	Minimum	Maximum	
Clams									
Butter clam	soft parts	Various locations[c]	1994 – 2005	0/42	NS	nc	2.5 U	6.5 U	King County 1995, 2000, 2001, 2002, 2005, 2006, 2009
Butter clam	soft parts	Padilla/Fidalgo Bay	1999	0/1	50	nc	2.5 U	2.5 U	Ecology 2000
Littleneck clam	soft parts	Padilla/Fidalgo Bay	1999	0/1	50	nc	2.5 U	2.5 U	Ecology 2000
Littleneck clam	soft parts	Salsbury Point	2003	0/2	NS (10-20)	nc	2.5 U	2.6 U	Parametrix 2003
Geoduck	edible meat	Freshwater Bay[d]	2006	8/8	1	0.64	0.24	1.43	Malcolm Pirnie 2007[e]
	gut ball			5/5	1	1.35	0.92	2.10	
Horse clam	edible meat	Dungeness Bay[d]	2006	8/8	1	0.12	0.09	0.14	Malcolm Pirnie 2007[e]
	gut ball			5/5	1	1.26	0.95	1.49	
Horse clam	edible meat	Freshwater Bay[d]	2006	8/8	1	0.14	0.10	0.23	Malcolm Pirnie 2007[e]
	gut ball			5/5	1	1.66	1.35	2.14	
Crabs									
Dungeness crab	edible meat	Padilla/Fidalgo Bay	1999	2/2	5	1.3	1.2 J	1.4 J	Ecology 2000
Dungeness crab	edible meat	Dungeness Bay[d]	2006	7/7	1	1.02	0.46	1.92	Malcolm Pirnie 2007[e]
	hepatopancreas			7/7	1	25.0	13.1	49.5	
	calculated whole-body[f]			7/7	1	8.44	4.39	16.0	
Dungeness crab	edible meat	Freshwater Bay[c]	2006	8/8	1	0.62	0.43	0.99	Malcolm Pirnie 2007[e]
	hepatopancreas			8/8	1	17.8	8.80	32.3	
	calculated whole-body[f]			8/8	1	5.96	3.03	10.7	

Table B-10 Total PCB Concentrations in Fish and Shellfish Collected from Non-Urban Puget Sound Locations Outside of Known Contaminated Sites (continued)

Species	Tissue Type	Sampling Location	Sampling Year(s)	Detection Frequency	Individuals per Composite (Average)	Total PCB Concentration[a] (µg/kg ww)			Source
						Mean[b]	Minimum	Maximum	
Benthic fish									
English sole	fillet	PSAMP – non urban[g]	1989 – 1999	117/189	15.2	11.6	1.3	50.8	West et al. 2001
English sole	fillet	PSAMP – near urban[g]	1989 – 1999	36/42	13.6	15.9	2.0	75.4	West et al. 2001
English sole	fillet	Case Inlet/Dana Passage	2005	3/3	4.7	8.5	5.6 J	13.2 J	Era-Miller 2006
English sole	fillet	Pickering Passage	2005	0/2	5	nc	5.5 U	5.6 U	Era-Miller 2006
English sole	fillet	South Puget Sound	2005	2/2	20	6.5	6.1 J	6.8 J	Era-Miller 2006
Rock sole	fillet	Carr Inlet	2005	0/1	5	nc	5.5 U	5.5 U	Era-Miller 2006
Rock sole	fillet	Case Inlet/Dana Passage	2005	0/1	5	nc	5.5 U	5.5 U	Era-Miller 2006
Rock sole	fillet	Hale Passage	2005	0/2	5	nc	5.1 U	5.5 U	Era-Miller 2006

Note: Rows highlighted in light green indicate new total PCB tissue concentrations in fish and shellfish collected from Puget Sound locations outside of known contaminated sites, not previously reported in the RI (Windward 2010a).

a. For PCB Aroclors, the total PCB concentration represents the sum of detected concentrations of up to nine individual PCB Aroclors for a given sample. For samples in which none of the individual Aroclors were detected, the maximum RL for an individual PCB Aroclor in that sample is used as the concentration. For PCB congeners, the total PCB concentration represents the sum of the detected PCB congener concentrations for a given sample.

b. Mean concentrations were calculated using one-half of the RL for non-detect values. A mean value was not calculated when there were no detected values.

c. Locations include Edmonds, Carkeek Park, Golden Gardens, Alki Point, Vashon Island, and Normandy Park. Data for clams collected by King County were compiled from seven King County reports (1995, 2000, 2001, 2002, 2005, 2006, 2009).

d. Dungeness Bay and Freshwater Bay were the reference sites used in the Rayonier Mill RI near Port Angeles, Washington (Malcom Pirnie 2007).

e. The total PCB concentrations in this study were analyzed as PCB congeners.

f. Data from composite hepatopancreas samples were mathematically combined with data from composite samples of edible meat to form composite samples of edible meat plus hepatopancreas. Total PCB concentrations in whole-body (i.e., edible meat plus hepatopancreas) crab were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weights of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data).

g. PSAMP data are from various non-urban and near-urban sites around Puget Sound (Figure B-5).

cm = centimeters; J = estimated concentration; µg/kg = micrograms per kilogram; nc = not calculated (no detected values); NS = not specified; PCB = polychlorinated biphenyl; PSAMP = Puget Sound Ambient Monitoring Program; RI = remedial investigation; RL = reporting limit; U = not detected; ww = wet weight

Table B-11 Inorganic Arsenic Concentrations in Fish and Shellfish Collected from Non-Urban Puget Sound Locations Outside of Known Contaminated Sites

Species	Tissue Type	Sampling Location	Sampling Year	Detection Frequency	Individuals Per Composite (Average)	Inorganic Arsenic Concentration (mg/kg ww)			Source
						Mean[a]	Minimum	Maximum	
Clams									
Various species[b]	soft parts	Bainbridge Island	2004	6/6	22.0	0.201	0.0440 J	0.485 J	Windward 2005a
Various species[b]	soft parts	Seahurst Park	2004	6/6	21.7	0.443	0.0980 J	0.616 J	Windward 2005a
Eastern soft-shell clam	soft parts	Dungeness NWR	2005	6/6	11.7	0.0637	0.0470	0.112	Windward 2006
Eastern soft-shell clam	soft parts	Vashon Island	2005	6/6	19.8	0.145	0.0930	0.227	Windward 2006
Crabs									
Dungeness and slender crabs[c]	edible meat	Blake Island	2004	6/6	4.3	0.023	0.020	0.030	Windward 2005b
	hepatopancreas			2/2	13	0.31	0.27	0.34	
	calculated whole-body[d]			6/6	4.3	0.11	0.098	0.13	
Dungeness and slender crabs[c]	edible meat	East Passage	2004	6/6	5	0.018	0.010 J	0.040	Windward 2005b
	hepatopancreas			2/2	15	0.08	0.08	0.08	
	calculated whole-body[d]			6/6	5	0.037	0.032 J	0.052	
Pelagic fish									
Shiner surfperch	whole-body	Blake Island	2004	6/6	10	0.02	0.01	0.03	Windward 2005b
Shiner surfperch	whole-body	East Passage	2004	2/3	5.7	0.008	0.009 J	0.01 J	Windward 2005b
Benthic fish									
English sole	fillet	Blake Island	2004	2/6	4	0.003	0.002	0.01 U	Windward 2005b
	whole-body			6/6	4	0.02	0.01	0.03	
English sole	fillet	East Passage	2004	1/6	4	0.002	0.003 U	0.004 J	Windward 2005b
	whole-body			6/6	4	0.01	0.007 J	0.02	

Notes:

a. Mean concentrations were calculated using one-half of the RL for non-detect values.

b. Composite clam tissue samples from Seahurst Park and Bainbridge Island included multiple species (butter clam, cockle, bent-nose clam, white sand macoma, horse clam, and littleneck clam).

c. Each composite sample was made up of either Dungeness or slender crab specimens. Half the total number of samples is from each species.

d. Data from composite hepatopancreas samples were mathematically combined with data from composite samples of edible meat to form composite samples of edible meat plus hepatopancreas. Arsenic concentrations in whole-body (i.e., edible meat plus hepatopancreas) crab were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weights of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data).

cm = centimeters; mg/kg = milligrams per kilogram; NWR = National Wildlife Refuge; J = estimated concentration; RI = remedial investigation; RL = reporting limit; U = not detected; ww = wet weight

Table B-12 Carcinogenic PAH Concentrations in Fish and Shellfish Collected from Non-Urban Puget Sound Locations Outside of Known Contaminated Sites

Species	Tissue Type	Sampling Location	Sampling Year	Detection Frequency	Individuals Per Composite (Average)	Carcinogenic PAH[a] (µg TEQ/kg ww) Mean[b]	Minimum	Maximum	Source
Clams									
Butter clam	soft parts	Padilla/Fidalgo Bay	1999	0/1	50	nc	0.851 U	0.851 U	Ecology 2000
Littleneck clam	soft parts	Padilla/Fidalgo Bay	1999	0/1	50	nc	0.878 U	0.878 U	Ecology 2000
Littleneck clam	soft parts	Salsbury Point	2003	0/2	NS (10-20)	nc	0.114 U	0.114 U	Parametrix 2003
Geoduck	soft parts	Freshwater Bay[c]	2002	1/3	1	0.123	0.114 U	0.142	Malcolm Pirnie 2007
Geoduck	soft parts	Dungeness Bay[c]	2002	1/3	1	0.133	0.114 U	0.171	Malcolm Pirnie 2007
Geoduck	soft parts	Dungeness Bay	2008	1/1	2	0.069	0.069	0.069	Ecology 2009
Mussels									
Bay mussel	soft parts	Padilla/Fidalgo Bay	1999	0/1	50	nc	0.860 U	0.860 U	Ecology 2000
Crabs									
Dungeness crab	edible meat	Padilla/Fidalgo Bay	1999	0/2	5	nc	0.935 U	1.63 U	Ecology 2000
	hepatopancreas			0/1	5	nc	0.896 U	0.896 U	
	calculated whole-body[d]			0/1	5	nc	0.923 U	0.923 U	
Dungeness crab	edible meat	Dungeness Bay[c]	2002	0/3	1	nc	0.114 U	0.114 U	Malcolm Pirnie 2007
	hepatopancreas			0/3	1	nc	0.114 U	0.114 U	
	calculated whole-body[d]			0/3	1	nc	0.114 U	0.114 U	
Dungeness crab	edible meat	Freshwater Bay[c]	2002	0/3	1	nc	0.114 U	0.114 U	Malcolm Pirnie 2007
	hepatopancreas			0/3	1	nc	0.114 U	0.114 U	
	calculated whole-body[d]			0/3	1	nc	0.114 U	0.114 U	
Benthic fish									
Starry flounder	fillet	Dungeness Bay[c]	2002	0/1	1	nc	0.114 U	0.114 U	Malcolm Pirnie 2007

Notes:

a. cPAH TEQs were calculated by summing the products of individual PAH concentrations and compound-specific PEFs for the seven individual cPAH compounds (benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene). cPAH TEQs were considered detected if one or more of the individual cPAH compounds were detected. For non-detect cPAH compounds, one-half the RL was multiplied by the PEF when calculating cPAH TEQs.

b. A mean value was not calculated when there were no detected values.

c. Dungeness Bay and Freshwater Bay were the reference sites used in the Rayonier Mill RI near Port Angeles, Washington (Malcom Pirnie 2007).

d. Data from composite hepatopancreas samples were mathematically combined with data from composite samples of edible meat to form composite samples of edible meat plus hepatopancreas. cPAH TEQs in whole-body (i.e., edible meat plus hepatopancreas) crab were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weights of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data).

µg/kg = micrograms per kilogram; nc = not calculated (no detected values); NS = not specified (range of individuals); cPAH = carcoinogenic polycyclic aromatic hydrocarbon; PEF = potency equivalency factor; RI = remedial investigation; TEQ = toxic equivalent; U = not detected; ww = wet weight

Table B-13 Dioxins/Furans in Fish and Shellfish Collected from Non-Urban Puget Sound Locations Outside of Known Contaminated Sites

Species	Tissue Type	Sampling Location	Sampling Year	Detection Frequency	Individuals Per Composite (Average)	Dioxins/Furans[a] (ng TEQ/kg ww) Mean	Minimum	Maximum	Source
Clams									
Butter clam	soft parts	Padilla/Fidalgo Bay	1999	1/1	50	0.907	0.907	0.907	Ecology 2000
Littleneck clam	soft parts	Padilla/Fidalgo Bay	1999	1/1	50	1.63	1.63	1.63	Ecology 2000
Littleneck clam	soft parts	Salsbury Point	2003	2/2	NS (10-20)	0.249	0.232	0.266	Parametrix 2003
Geoduck	whole-body	Dungeness Bay[b]	2002	3/3	1	0.263	0.220	0.297	Malcolm Pirnie 2007
Geoduck	edible meat	Freshwater Bay[b]	2006	8/8	1	0.025	0.016	0.038	Malcolm Pirnie 2007
	gut ball		2006	5/5	1	0.068	0.055	0.099	
	whole-body		2002	3/3	1	0.226	0.212	0.238	
Horse clam	edible meat	Dungeness Bay[b]	2006	8/8	1	0.038	0.011	0.161	Malcolm Pirnie 2007
	gut ball		2006	5/5	1	0.045	0.029	0.061	
	whole-body		2002	3/3	1	0.259	0.209	0.318	
Horse clam	edible meat	Freshwater Bay[b]	2006	8/8	1	0.033	0.017	0.062	Malcolm Pirnie 2007
	gut ball		2006	5/5	1	0.060	0.047	0.075	
	whole-body		2002	3/3	1	0.252	0.247	0.259	
Geoduck	whole-body	Dungeness Bay	2008	1/1	1	1.42	1.42	1.42	Ecology 2009
Horse clam	whole-body	Dungeness Bay	2008	2/2	4.5	1.5	1.42	1.57	Ecology 2009
Crabs									
Dungeness crab	edible meat	Dungeness Bay/Skagit Bay	1991	1/1	3	0.332	0.332	0.332	PSEP 1991
	hepatopancreas			2/2	3	2.12	1.64	2.60	
	calculated whole-body[c]			1/1	3	0.844	0.844	0.844	
Dungeness crab	edible meat	Padilla/Fidalgo Bay	1999	2/2	5	1.27	1.16	1.37	Ecology 2000
Dungeness crab	edible meat	Dungeness Bay[b]	2002, 2006	10/10	1	0.102	0.044	0.273	Malcolm Pirnie 2007
	hepatopancreas			10/10	1	0.736	0.266	1.43	
	calculated whole-body[c]			10/10	1	0.315	0.132	0.589	

Table B-13 Dioxins/Furans in Fish and Shellfish Collected from Non-Urban Puget Sound Locations Outside of Known Contaminated Sites (continued)

Species	Tissue Type	Sampling Location	Sampling Year	Detection Frequency	Individuals Per Composite (Average)	Dioxins/Furans[a] (ng TEQ/kg ww)			Source
						Mean	Minimum	Maximum	
Dungeness crab	edible meat	Freshwater Bay[b]	2002, 2006	11/11	1	0.112	0.027	0.381	Malcolm Pirnie 2007
	hepatopancreas			11/11	1	0.397	0.182	0.706	
	calculated whole-body[c]			11/11	1	0.224	0.089	0.422	
Dungeness crab	edible meat	Anderson-Ketron disposal site	2007	3/3	5	0.467	0.214	0.716	SAIC 2008
	hepatopancreas			3/3	5	13.5	11.5	14.9	
	calculated whole-body[c]			3/3	5	4.51	3.90	5.12	
Benthic fish									
Rock sole	whole- body	Dungeness Bay[b]	2002	1/1	1	0.152	0.152	0.152	Malcolm Pirnie 2007
Rock sole	whole-body	Freshwater Bay[b]	2002	3/3	1	0.320	0.257	0.417	Malcolm Pirnie 2007
	fillet			2/2	1	0.179	0.166	0.191	
Starry flounder	fillet	Dungeness Bay[b]	2002	2/2	1	0.663	0.404	0.923	Malcolm Pirnie 2007
English sole	whole-body	Anderson-Ketron disposal site	2007	3/3	5	0.286	0.172	0.345	SAIC 2008

Notes:

a. Dioxin/furan TEQs were calculated by summing the products of individual congener concentrations and congener-specific TEFs. A dioxin/furan TEQ value was considered detected if one or more of the congeners were detected. For non-detect congeners, the TEF was multiplied by one-half the RL.

b. Dungeness Bay and Freshwater Bay were the reference sites used in the Rayonier Mill RI near Port Angeles, Washington (Malcom Pirnie 2007).

c. Data from composite hepatopancreas samples were mathematically combined with data from composite samples of edible meat to form composite samples of edible meat plus hepatopancreas. Dioxin/furan TEQs in whole-body (i.e., edible meat plus hepatopancreas) crab were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weights of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data).

cm = centimeters; ng/kg = nanograms per kilogram; NS = not specified (range of individuals); RI = remedial investigation; RL = reporting limit; TEF = toxic equivalency factor; TEQ = toxic equivalent; U = not detected; ww = wet weight

Table B-14 Exposure Concentrations Used for the Non-Urban Puget Sound Risk Calculations

Risk Driver and Seafood Consumption Category	Detection Frequency	Exposure Concentration		
		Minimum[a]	Mean[b]	Maximum[a]
Total PCBs[c] (µg/kg ww)				
Clams	24/70	0.09	0.3	1.43
Mussels	nd	nd	nd	nd
Crab – edible meat	17/17	0.43	0.86	1.92
Crab – whole-body	15/15	3.03	7.1	16
Fish (benthic fish fillet)[d]	158/242	1.3	11	75.4
Inorganic arsenic (mg/kg ww)				
Clams	24/24	0.044 J	0.21	0.62 J
Mussels	nd	nd	nd	nd
Crab – edible meat	12/12	0.01	0.02	0.04
Crab – whole-body	12/12	0.032	0.075	0.13
Fish (benthic fish fillet, pelagic fish)[d]	11/21	0.002	0.008	0.03
Fish (benthic fish fillet and whole-body, pelagic fish)[d]	23/33	0.002	0.01	0.03
cPAHs[e] (µg TEQ/kg ww)				
Clams	3/11	0.069	0.088	0.171
Mussels	0/1	0.860 U	0.860 U	0.860 U
Crab – edible meat	0/8	0.114 U	0.406[f]	1.63 U
Crab – whole-body	0/7	0.114 U	0.230[f]	0.923 U
Fish (benthic fish fillet)[d]	0/1	0.114 U	0.114[f]	0.114 U
Dioxins/furans[g] (ng TEQ /kg ww)				
Clams	43/43	0.011	0.26	1.63
Mussels	nd	nd	nd	nd
Crab – edible meat	27/27	0.027	0.24	1.37
Crab – whole- body	25/25	0.089	0.81	5.12
Fish (benthic fish fillet)[d]	4/4	0.166	0.421	0.923
Fish (benthic fish fillet and whole-body)[d]	11/11	0.152	0.332	0.923

Notes:

a. Minimum and maximum values are minimum or maximum detected concentrations when available. For cPAH TEQ, no detected results were available for the mussel, crab, and fish consumption categories, and thus the non-detect results were used.

b. Mean values were calculated arithmetically when there were no non-detect results. When non-detect results were present in a given dataset, ProUCL 4 was used to calculate the Kaplan Meier mean for the dataset.

c. For PCB Aroclors, the total PCB concentration represents the sum of detected PCB Aroclors for a given sample. For samples in which none of the individual Aroclors were detected, the maximum RL for any of the Aroclors in that sample is used as the concentration. For PCB congeners, the total PCB concentration represents the sum of the detected PCB congener concentrations for a given sample.

d. Exposure concentrations for the fish consumption category were calculated two ways when whole-body benthic fish data were available: both with and without whole-body benthic fish data. The Adult and Child Tribal RME scenarios based on Tulalip data assume that no consumption of whole-body benthic fish occurs, and thus the concentrations calculated without whole-body benthic fish data are used for these scenarios. The Adult API RME scenario assumes that some whole-body benthic fish is consumed, and thus the exposure concentrations that include whole-body benthic fish data are used for this scenario.

e. cPAH TEQs were calculated by summing the products of individual PAH concentrations and compound-specific PEFs for the seven individual cPAH compounds (benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, benzo(k) fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene). cPAH TEQs were considered detected if one or more individual cPAH compounds were detected. For non-detect cPAH compounds, one-half the RL was multiplied by the PEF when calculating cPAH TEQs.

f. There were no detected values for these consumption categories, and thus these mean values were based on cPAH TEQs calculated using half RLs (as described in footnote e).

g. Dioxin/furan TEQs were calculated by summing the products of individual congener concentrations and congener-specific TEFs. A dioxin/furan TEQ value was considered detected if one or more congeners were detected. For non-detect congeners, the TEF was multiplied by one-half the RL.

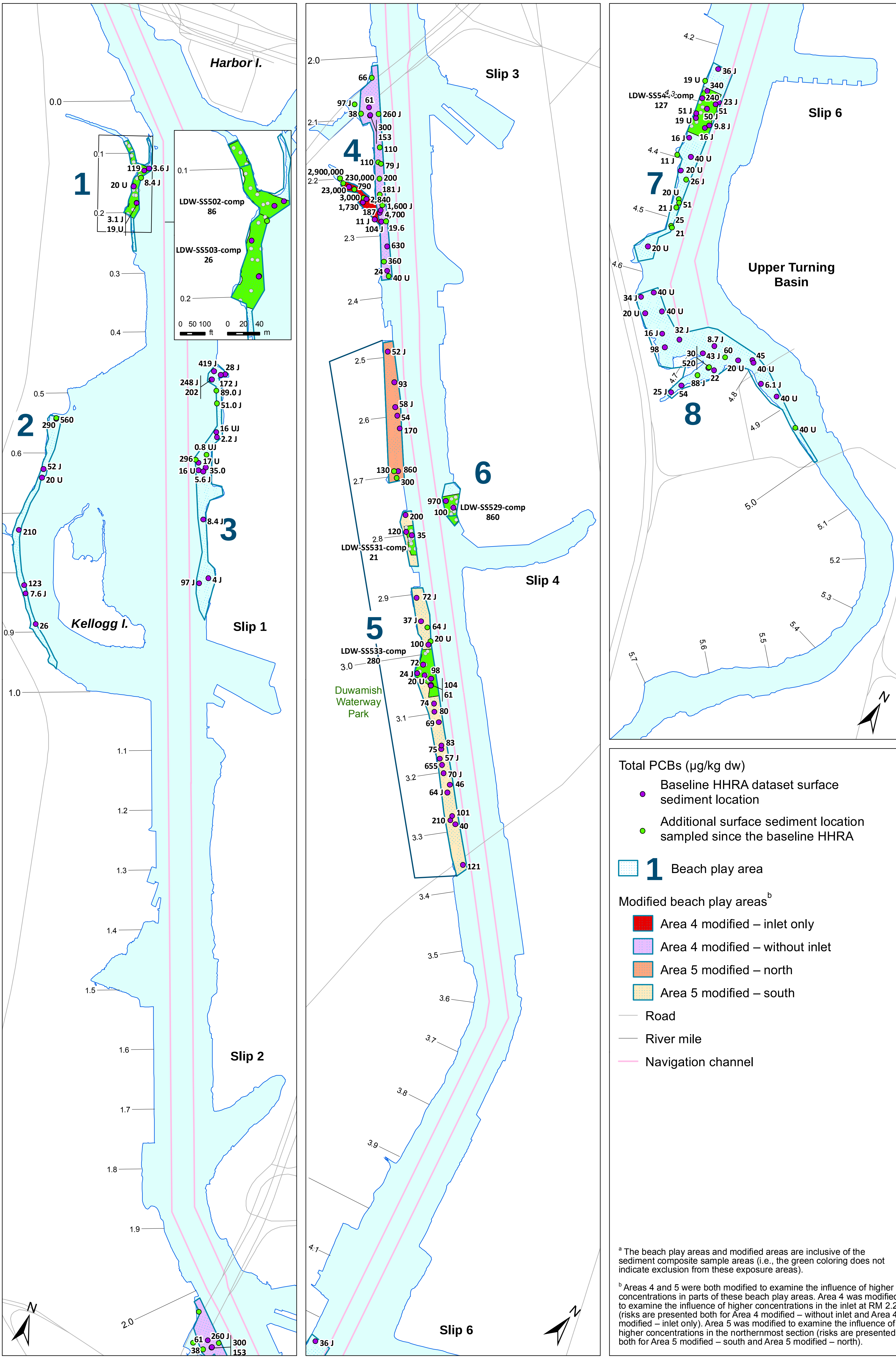
API = Asian and Pacific Islander; cPAH = carcinogenic polycyclic aromatic hydrocarbon; µg/kg = micrograms per kilogram; mg/kg = milligrams per kilogram; nd = no data; ng/kg nanograms per kilogram; PCB = polychlorinated biphenyl; PEF = potency equivalency factor; RL = reporting limit; RME = reasonable maximum exposure; TEF = toxic equivalency factor; TEQ = toxic equivalent; U = not detected; ww = wet weight

Table B-15 Risks Calculated for the Three RME Seafood Consumption Scenarios Using the Non-Urban Puget Sound Tissue Dataset

Seafood Consumption Scenario	Excess Cancer Risks			Non-Cancer HQs		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum
Total PCBs						
Adult Tribal RME (Tulalip data)	2×10^{-6}	7×10^{-6}	4×10^{-5}	0.04	0.2	0.9
Child Tribal RME (Tulalip data)	3×10^{-7}	1×10^{-6}	6×10^{-6}	0.08	0.4	2
Adult API RME	4×10^{-7}	2×10^{-6}	1×10^{-5}	0.03	0.1	0.6
Inorganic Arsenic						
Adult Tribal RME (Tulalip data)	5×10^{-5}	2×10^{-4}	5×10^{-4}	0.1	0.4	1
Child Tribal RME (Tulalip data)	9×10^{-6}	4×10^{-5}	1×10^{-4}	0.2	0.9	3
Adult API RME	2×10^{-5}	8×10^{-5}	2×10^{-4}	0.09	0.4	1
cPAHs						
Adult Tribal RME (Tulalip data)	9×10^{-7}	2×10^{-6}	9×10^{-6}	n/a	n/a	n/a
Child Tribal RME (Tulalip data)	2×10^{-7}	3×10^{-7}	2×10^{-6}	n/a	n/a	n/a
Adult API RME	4×10^{-7}	5×10^{-7}	2×10^{-6}	n/a	n/a	n/a
Dioxins/Furans						
Adult Tribal RME (Tulalip data)	9×10^{-6}	6×10^{-5}	3×10^{-4}	n/a	n/a	n/a
Child Tribal RME (Tulalip data)	2×10^{-6}	1×10^{-5}	6×10^{-5}	n/a	n/a	n/a
Adult API RME	2×10^{-6}	2×10^{-5}	1×10^{-4}	n/a	n/a	n/a

Notes:

API = Asian and Pacific Islander; cPAH = carcinogenic polycyclic aromatic hydrocarbon; HQ = hazard quotient; n/a = not applicable; PCB = polychlorinated biphenyl; RME = reasonable maximum exposure



Total PCBs (µg/kg dw)

- Baseline HHRA dataset surface sediment location
- Additional surface sediment location sampled since the baseline HHRA

1 Beach play area

Modified beach play areas[b]

- Area 4 modified – inlet only
- Area 4 modified – without inlet
- Area 5 modified – north
- Area 5 modified – south
- Road
- River mile
- Navigation channel

[a] The beach play areas and modified areas are inclusive of the sediment composite sample areas (i.e., the green coloring does not indicate exclusion from these exposure areas).

[b] Areas 4 and 5 were both modified to examine the influence of higher concentrations in parts of these beach play areas. Area 4 was modified to examine the influence of higher concentrations in the inlet at RM 2.2 (risks are presented both for Area 4 modified – without inlet and Area 4 modified – inlet only). Area 5 was modified to examine the influence of higher concentrations in the northernmost section (risks are presented both for Area 5 modified – south and Area 5 modified – north).

0 0.1 0.2 Miles

0 0.1 0.2 Kilometers

Scale is the same for each inset map

Figure B-1. Surface Sediment Total PCB Data in Beach Play Areas in the FS Dataset

Prepared by inmanm, 10/30/2012; L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\2012-10-15 LDW FS WW GIS Maps and Data\Fig B-01 4120 PCB data in beach play areas.mxd

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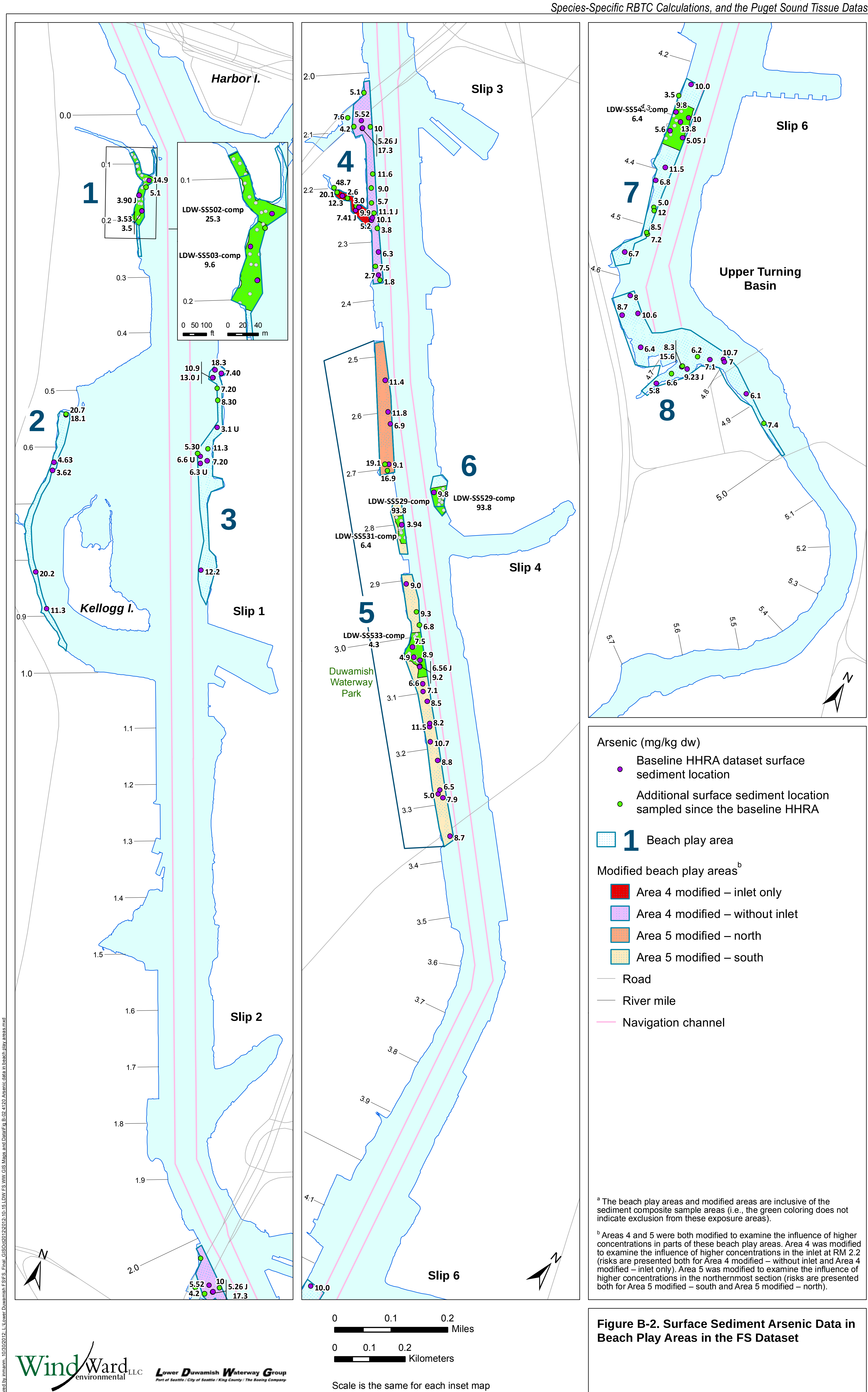
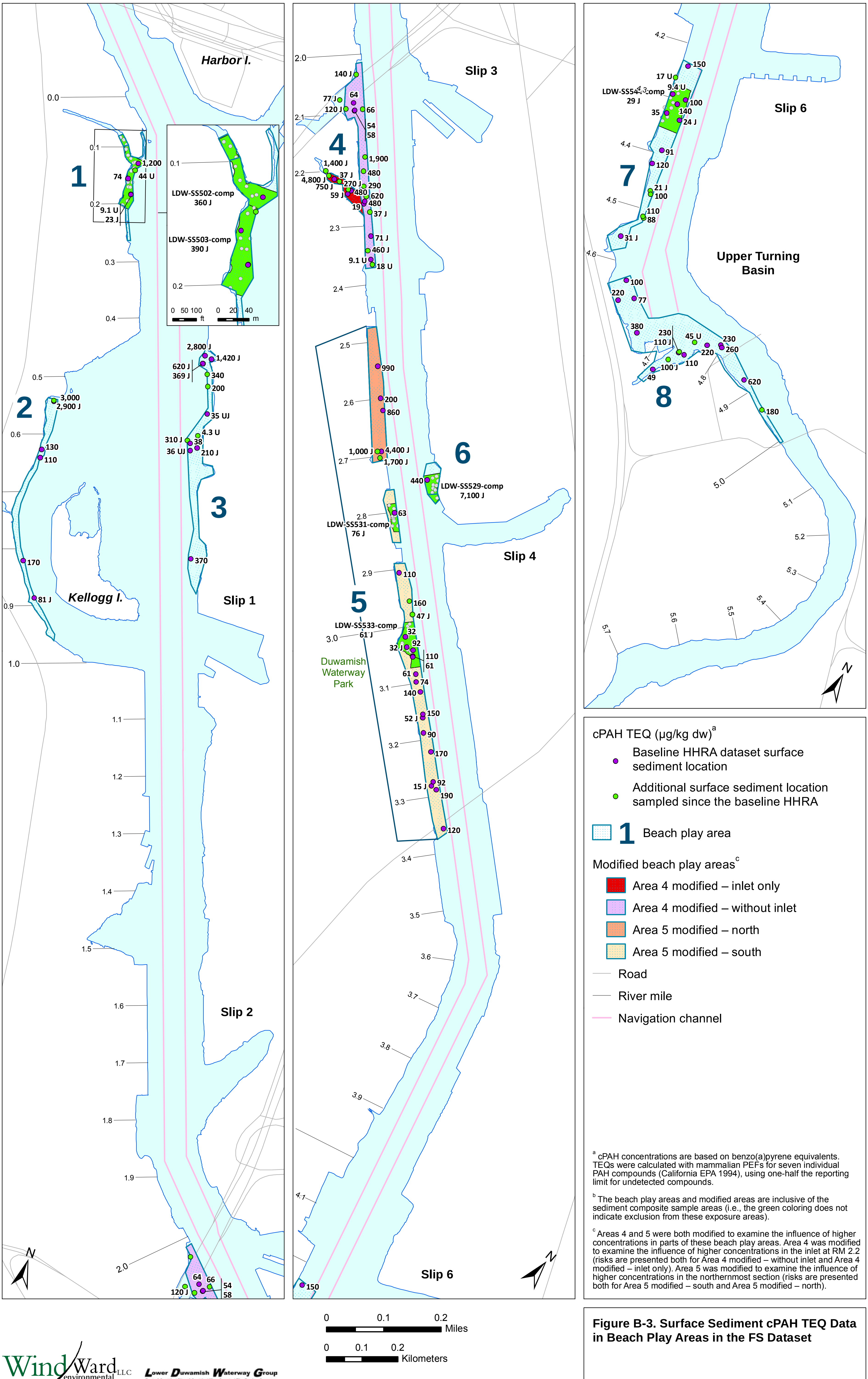


[a] The beach play areas and modified areas are inclusive of the sediment composite sample areas (i.e., the green coloring does not indicate exclusion from these exposure areas).

[b] Areas 4 and 5 were both modified to examine the influence of higher concentrations in parts of these beach play areas. Area 4 was modified to examine the influence of higher concentrations in the inlet at RM 2.2 (risks are presented both for Area 4 modified – without inlet and Area 4 modified – inlet only). Area 5 was modified to examine the influence of higher concentrations in the northernmost section (risks are presented both for Area 5 modified – south and Area 5 modified – north).

Figure B-2. Surface Sediment Arsenic Data in Beach Play Areas in the FS Dataset



[a] 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 reporting limit for undetected compounds.

[b] The beach play areas and modified areas are inclusive of the sediment composite sample areas (i.e., the green coloring does not indicate exclusion from these exposure areas).

[c] Areas 4 and 5 were both modified to examine the influence of higher concentrations in parts of these beach play areas. Area 4 was modified to examine the influence of higher concentrations in the inlet at RM 2.2 (risks are presented both for Area 4 modified – without inlet and Area 4 modified – inlet only). Area 5 was modified to examine the influence of higher concentrations in the northernmost section (risks are presented both for Area 5 modified – south and Area 5 modified – north).

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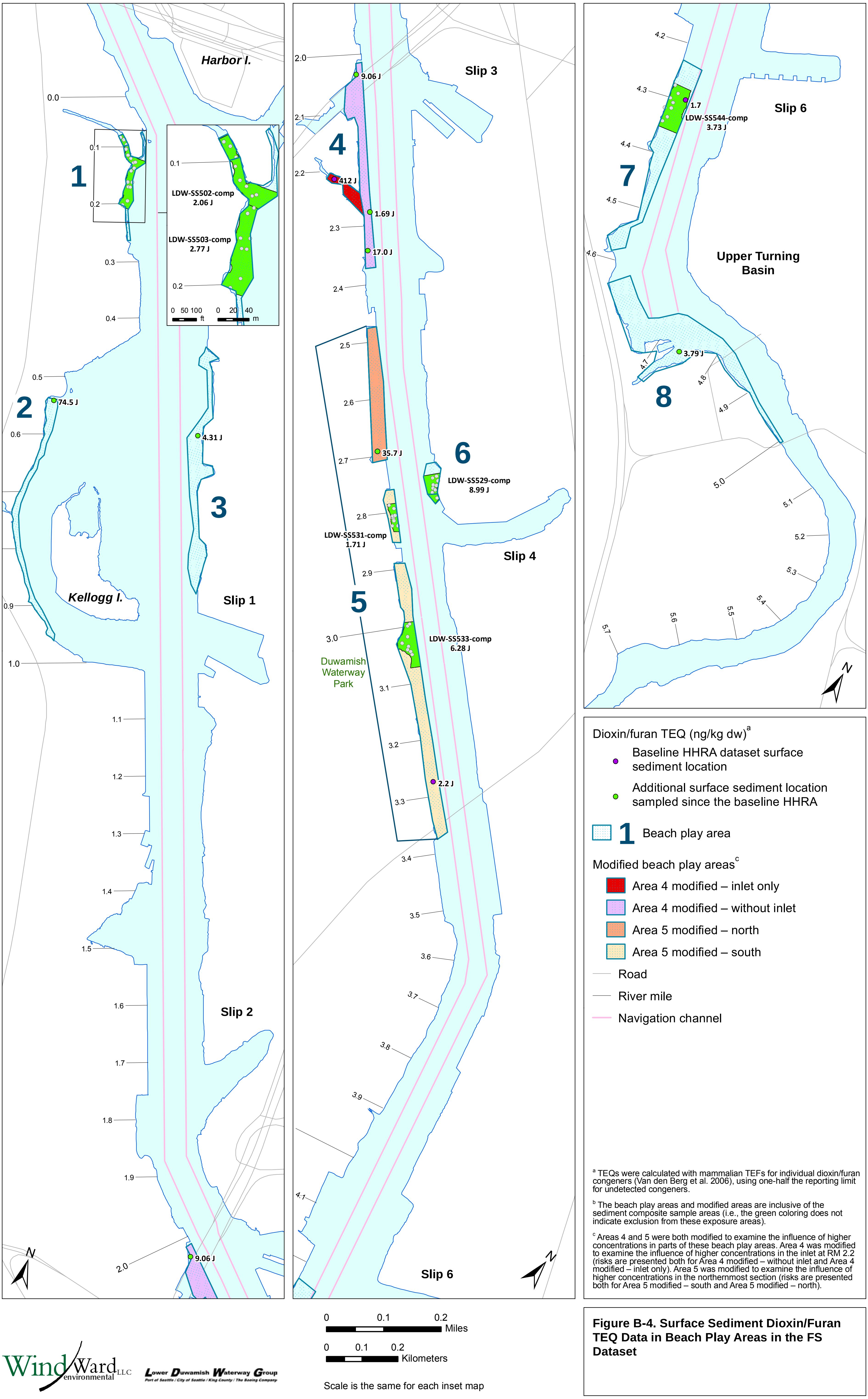
Figure B-3. Surface Sediment cPAH TEQ Data in Beach Play Areas in the FS Dataset



[a] TEQs were calculated with mammalian TEFs for individual dioxin/furan congeners (Van den Berg et al. 2006), using one-half the reporting limit for undetected congeners.

[b] The beach play areas and modified areas are inclusive of the sediment composite sample areas (i.e., the green coloring does not indicate exclusion from these exposure areas).

[c] Areas 4 and 5 were both modified to examine the influence of higher concentrations in parts of these beach play areas. Area 4 was modified to examine the influence of higher concentrations in the inlet at RM 2.2 (risks are presented both for Area 4 modified – without inlet and Area 4 modified – inlet only). Area 5 was modified to examine the influence of higher concentrations in the northernmost section (risks are presented both for Area 5 modified – south and Area 5 modified – north).

Figure B-4. Surface Sediment Dioxin/Furan TEQ Data in Beach Play Areas in the FS Dataset

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Figure B-5. Non-Urban Puget Sound Sampling Locations for Fish Tissue Analyzed for PCBs

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Figure B-6. Non-Urban Puget Sound Sampling Locations for Clam Tissue Analyzed for PCBs

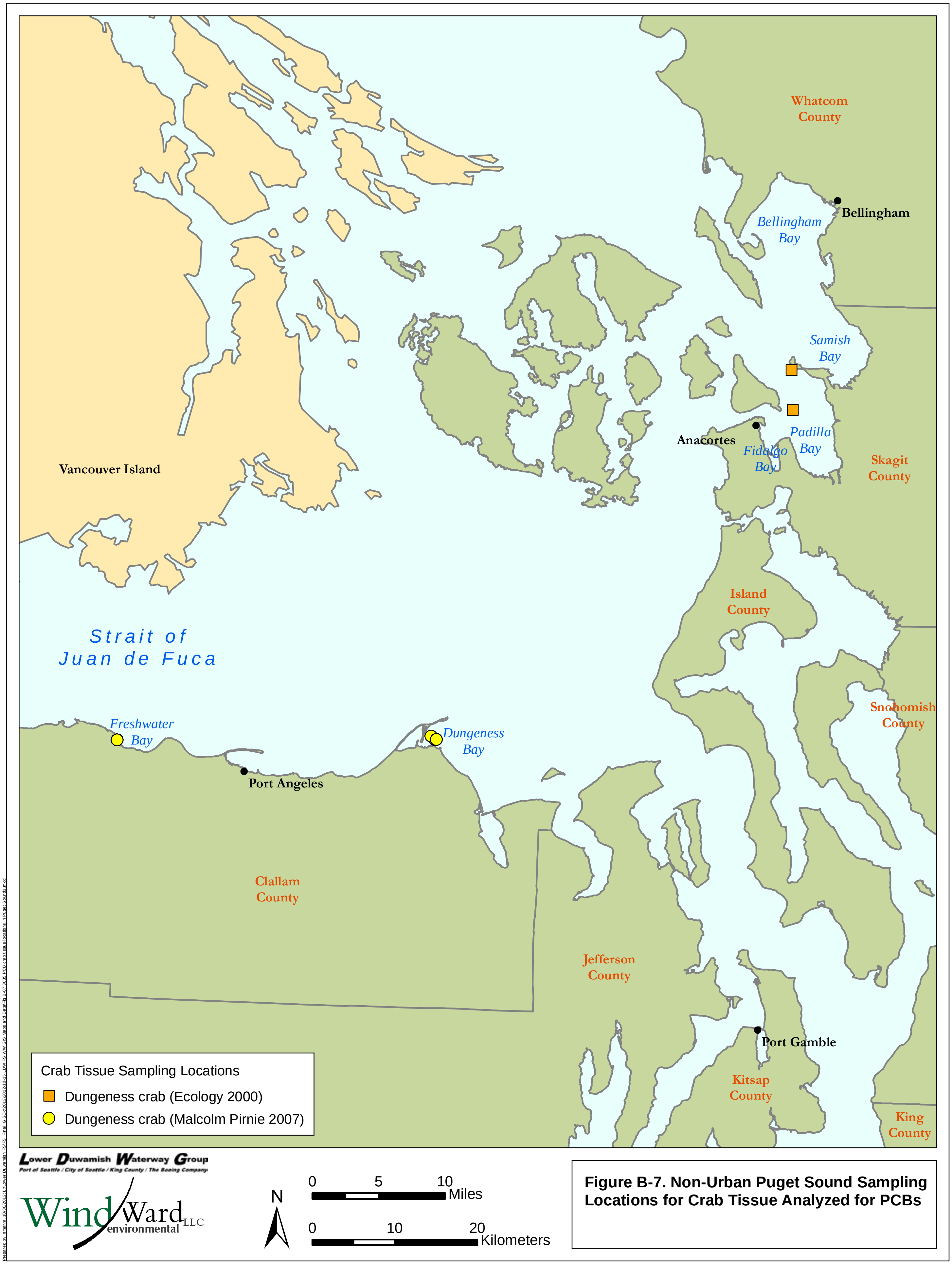

Figure B-7. Non-Urban Puget Sound Sampling Locations for Crab Tissue Analyzed for PCBs

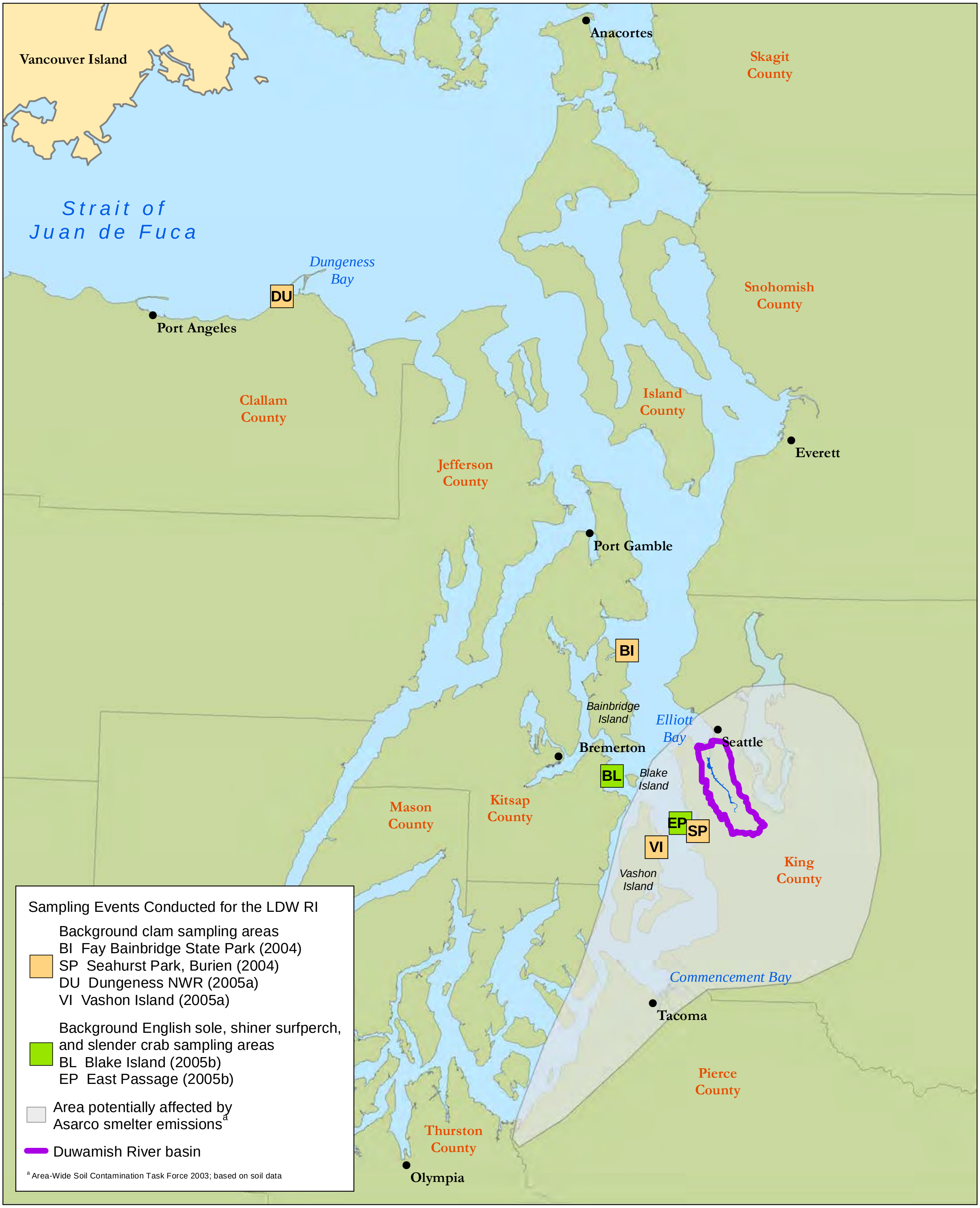

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Figure B-8. Non-Urban Puget Sound Sampling Locations for Tissue Analyzed for Inorganic Arsenic

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Figure B-9. Non-Urban Puget Sound Sampling Locations for Seafood Tissue Analyzed for cPAHs

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N

0 5.5 11 Miles

0 10 20 Kilometers

Figure B-10. Non-Urban Puget Sound Sampling Locations for Fish Tissue Analyzed for Dioxins/Furans

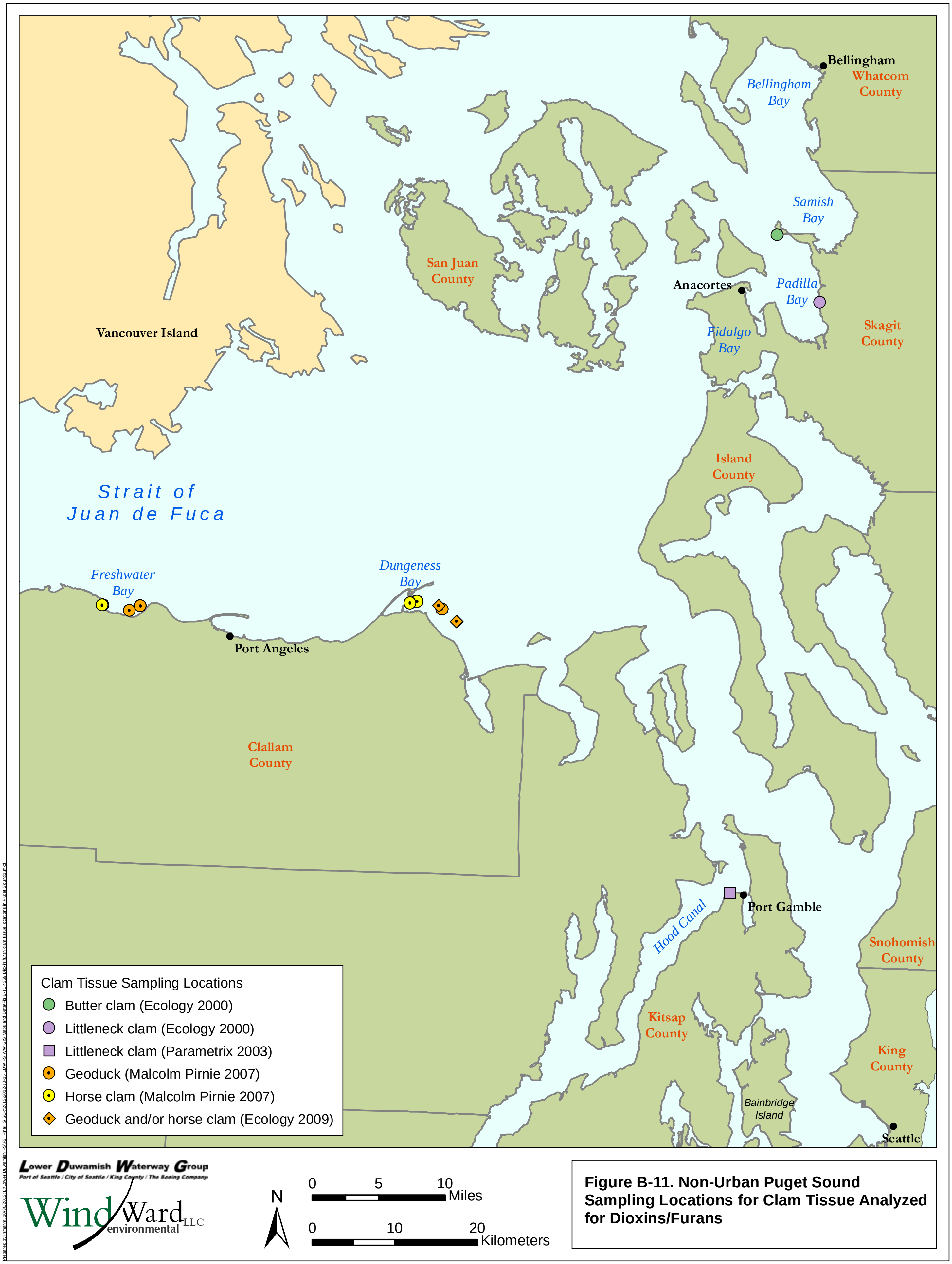

Figure B-11. Non-Urban Puget Sound Sampling Locations for Clam Tissue Analyzed for Dioxins/Furans

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N

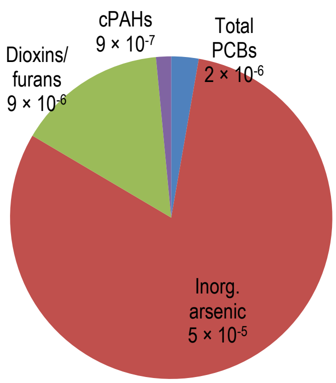
0 10 20 Miles

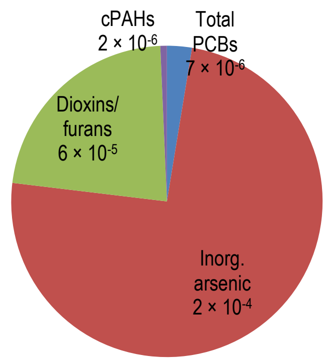
0 10 20 Kilometers

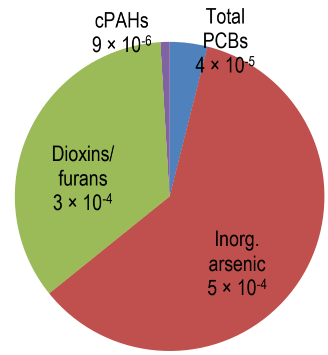
Figure B-12. Non-Urban Puget Sound Sampling Locations for Crab Tissue Analyzed for Dioxins/Furans

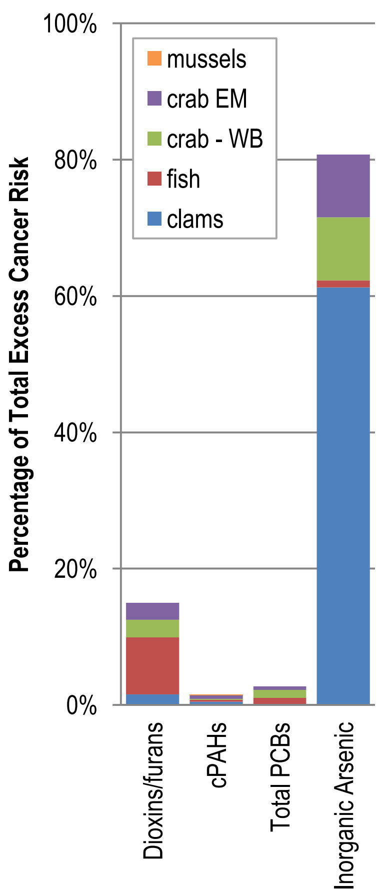
Figure B-13 Excess Cancer Risk Estimates Calculated Using the Non-Urban Puget Sound Tissue Dataset for the Adult Tribal RME Seafood Consumption Scenario Based on Tulalip Data

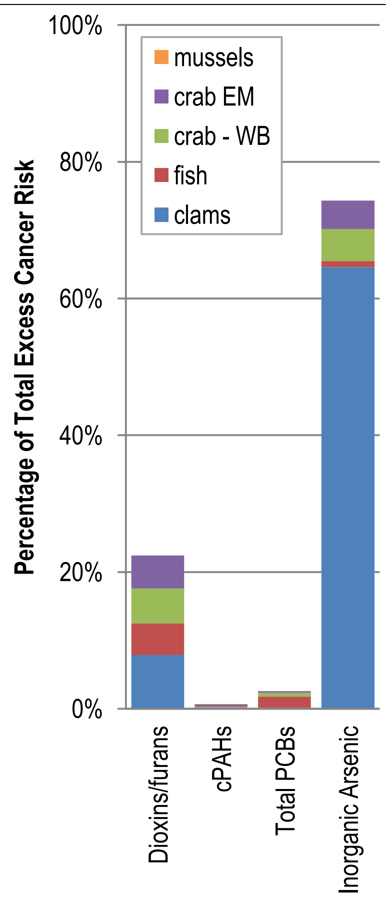
Minimum Concentrations: Total Excess Cancer Risk = 6×10^{-5}	Mean Concentrations: Total Excess Cancer Risk = 3×10^{-4}	Maximum Concentrations: Total Excess Cancer Risk = 9×10^{-4}

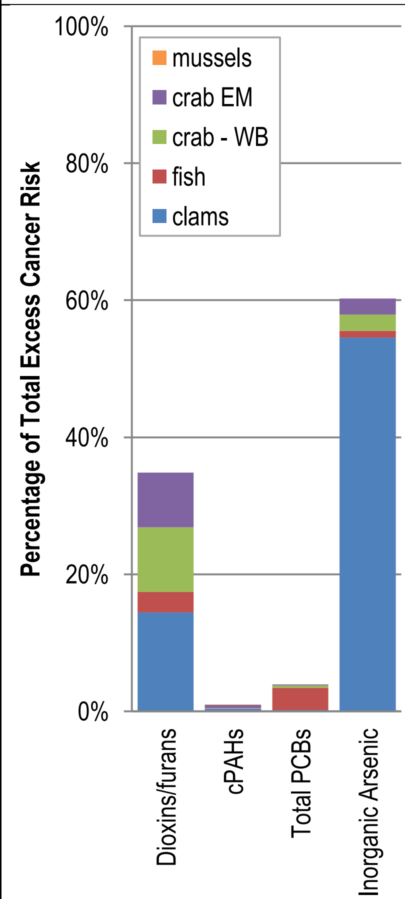








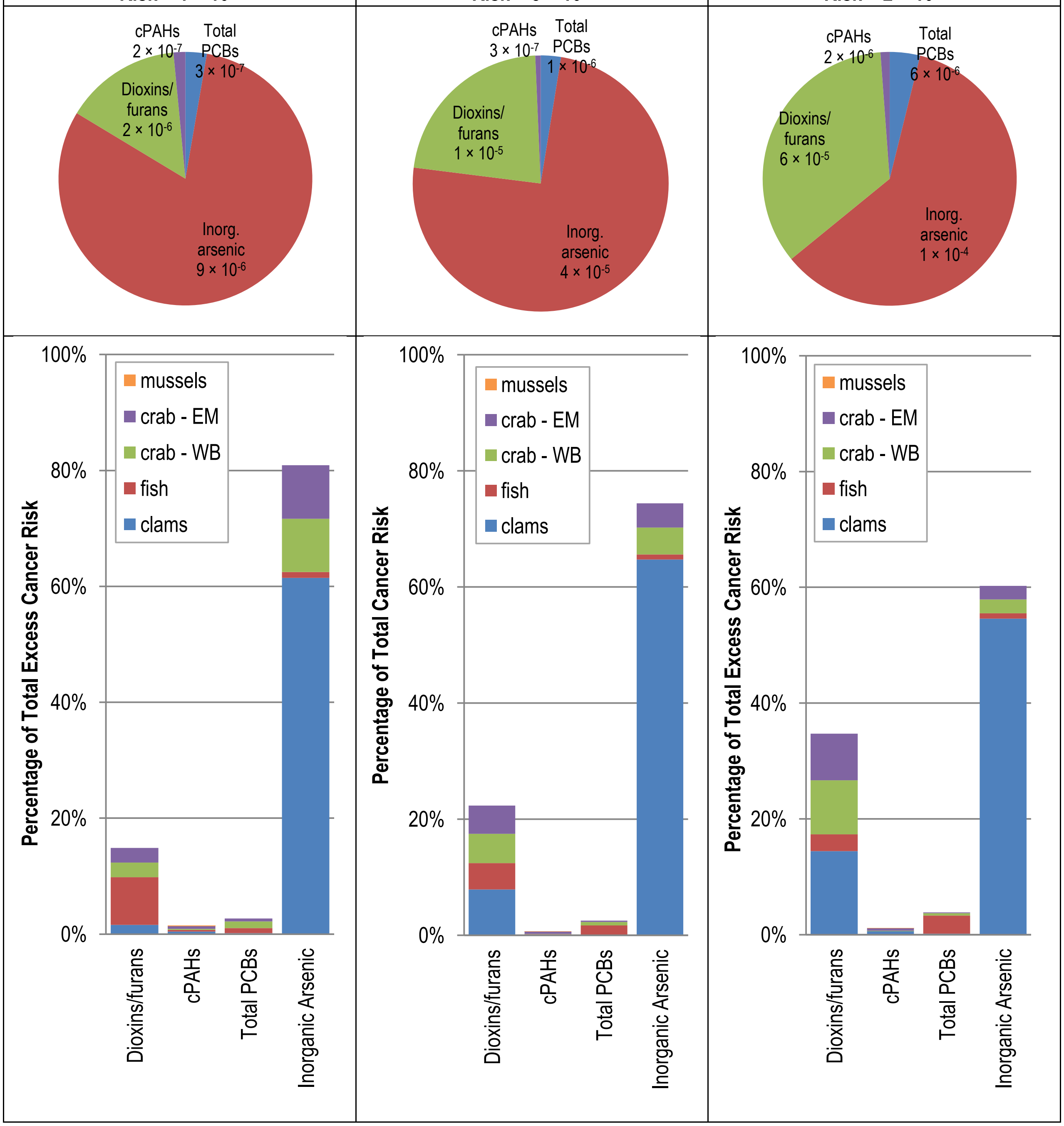




Notes: Minimum and maximum concentrations are based only on detected concentrations. Mean concentrations were calculated arithmetically when there were no non-detect results. When non-detect results were present in a given dataset, ProUCL 4 was used to calculate the Kaplan-Meier mean for the dataset.
cPAH = carcinogenic polycyclic aromatic hydrocarbon; EM = edible meat; PCB = polychlorinated biphenyl; WB = whole-body

Figure B-14 Excess Cancer Risk Estimates Calculated Using the Non-Urban Puget Sound Tissue Dataset for the Child Tribal RME Seafood Consumption Scenario Based on Tulalip Data

Minimum Concentrations: Total Excess Cancer Risk = 1×10^{-5}	Mean Concentrations: Total Excess Cancer Risk = 5×10^{-5}	Maximum Concentrations: Total Excess Cancer Risk = 2×10^{-4}



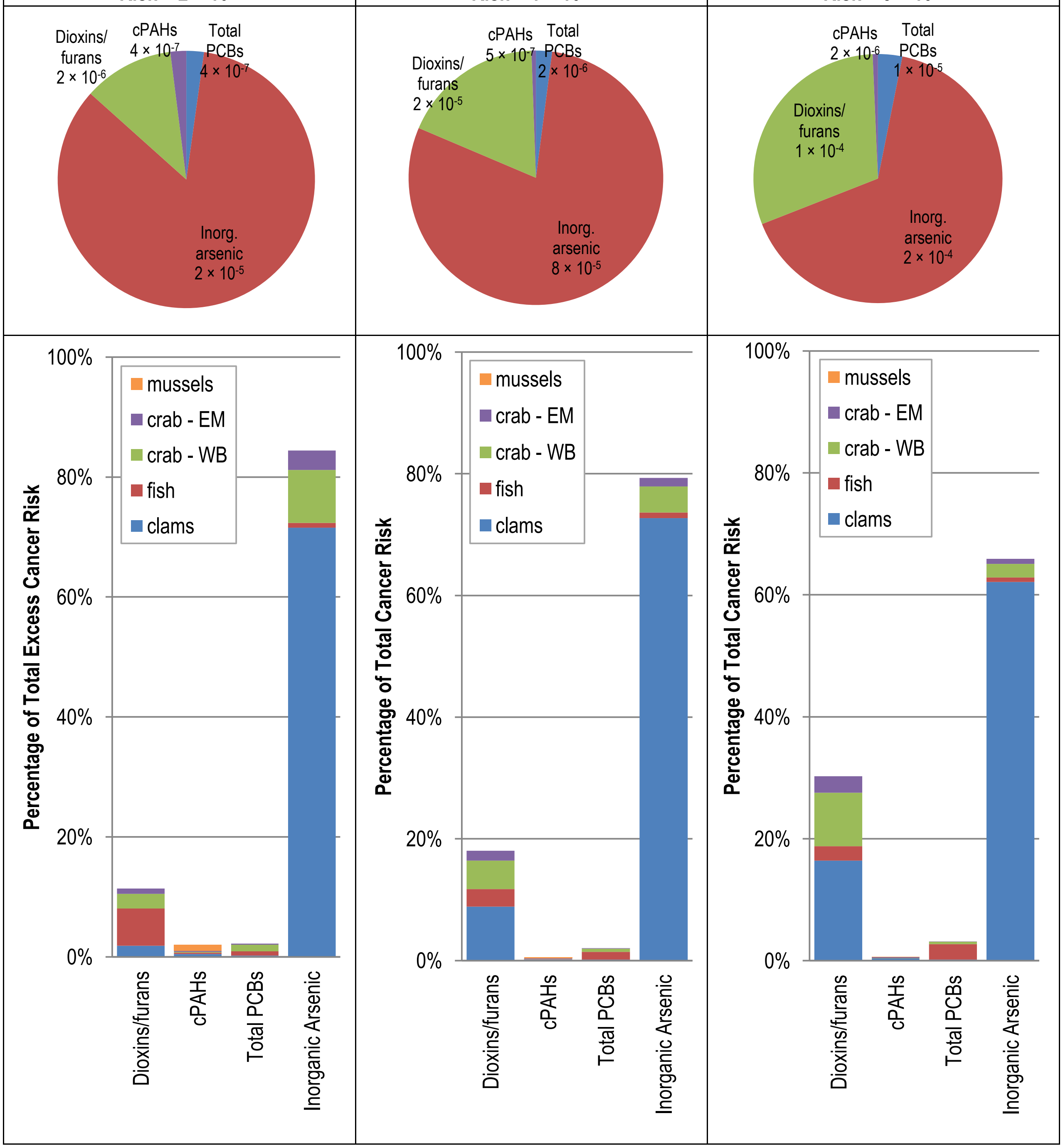
Notes:

Minimum and maximum concentrations are based only on detected concentrations. Mean concentrations were calculated arithmetically when there were no non-detect results. When non-detect results were present in a given dataset, ProUCL 4 was used to calculate the Kaplan-Meier mean for the dataset.

cPAH = carcinogenic polycyclic aromatic hydrocarbon; EM = edible meat; PCB = polychlorinated biphenyl; WB = whole-body

Figure B-15 Excess Cancer Risk Estimates Calculated Using the Non-Urban Puget Sound Tissue Dataset for the Adult API RME Seafood Consumption Scenario

Minimum Concentrations: Total Excess Cancer Risk = 2×10^{-5}	Mean Concentrations: Total Excess Cancer Risk = 1×10^{-4}	Maximum Concentrations: Total Excess Cancer Risk = 3×10^{-4}



Notes: Minimum and maximum concentrations are based only on detected concentrations. Mean concentrations were calculated arithmetically when there were no non-detect results. When non-detect results were present in a given dataset, ProUCL 4 was used to calculate the Kaplan-Meier mean for the dataset.
cPAH = carcinogenic polycyclic aromatic hydrocarbon; EM = edible meat; PCB = polychlorinated biphenyl; WB = whole-body

Figure B-16 Comparison of Total PCB Excess Cancer Risk Estimates Based on Non-Urban Puget Sound Tissue Data and Tissue Data from the LDW

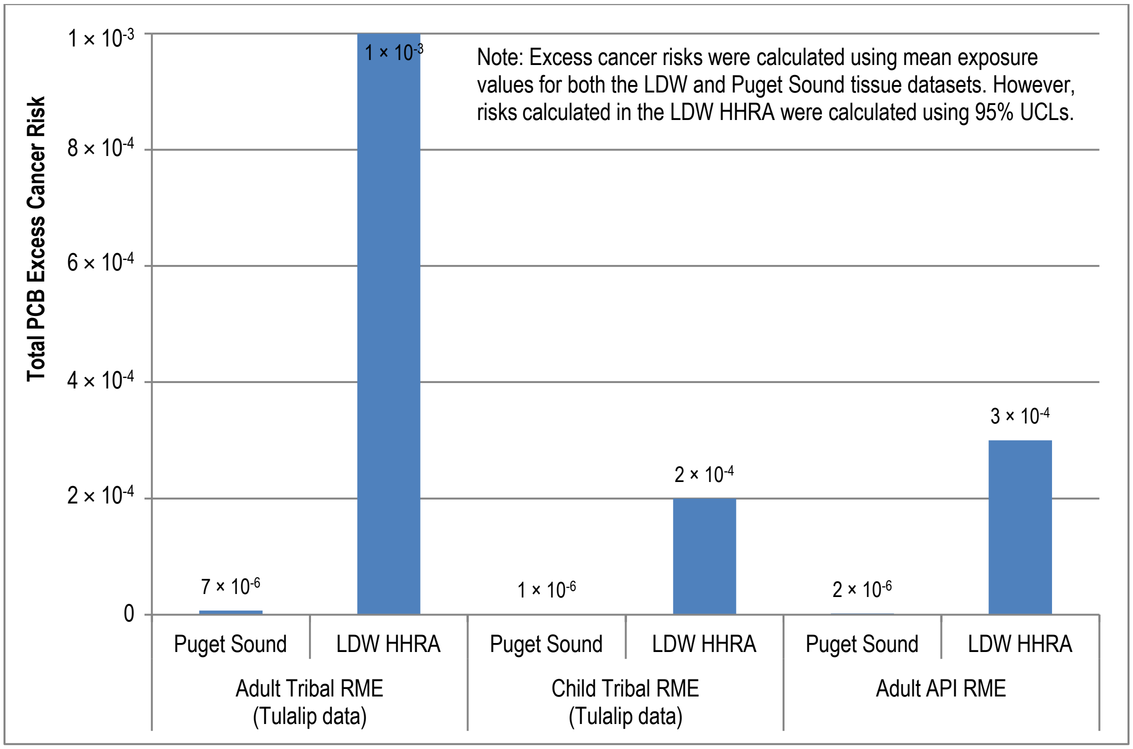


Figure B-17 Comparison of Inorganic Arsenic Excess Cancer Risk Estimates Based on Non-Urban Puget Sound Tissue Data and Tissue Data from the LDW

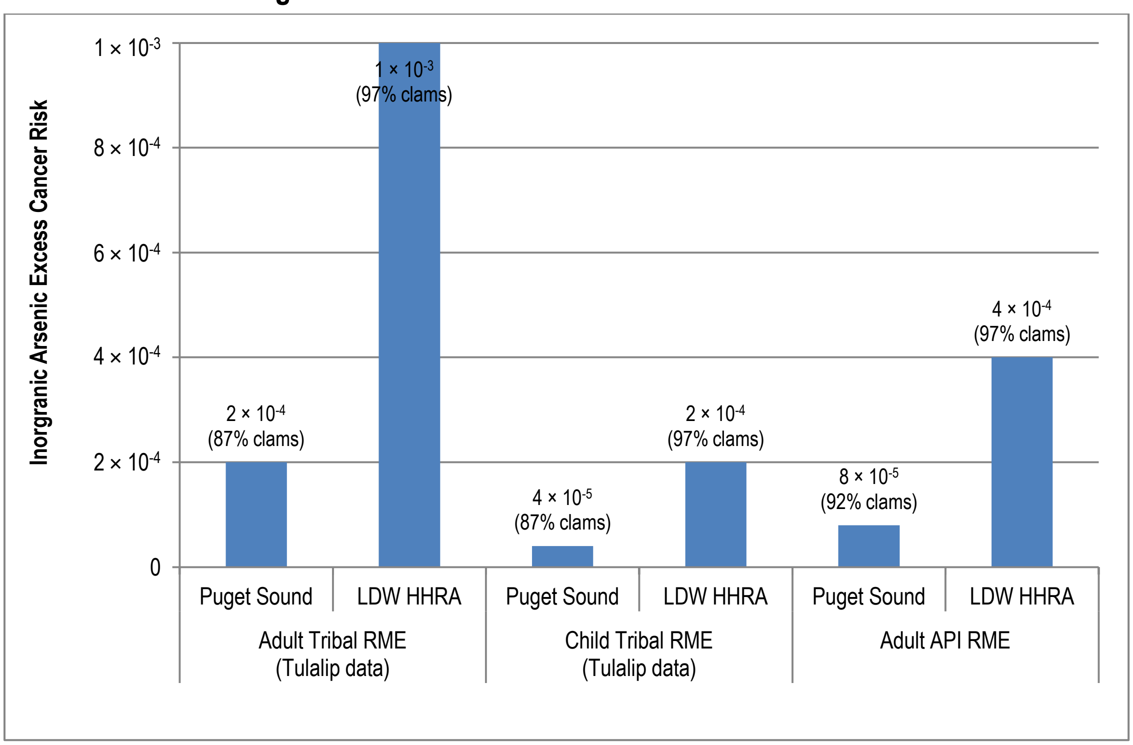


Figure B-18 Comparison of Total PCB Non-Cancer HQs Based on Non-Urban Puget Sound Tissue Data and Tissue Data from the LDW

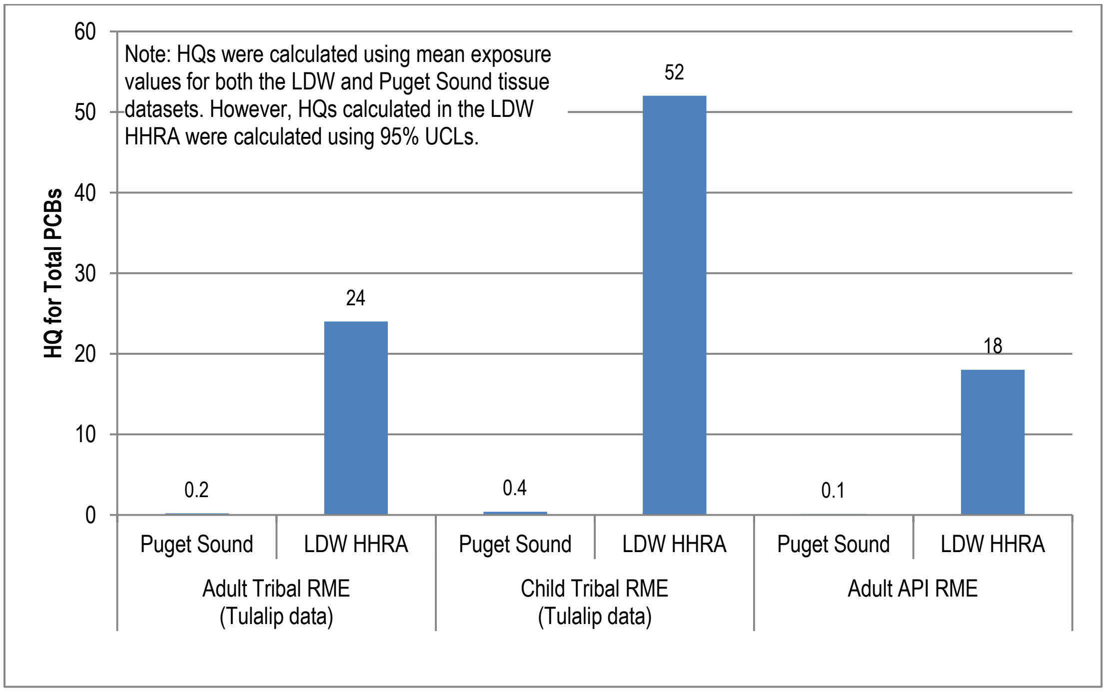


Figure B-19 Comparison of Inorganic Arsenic Non-Cancer HQs Based on Non-Urban Puget Sound Tissue Data and Tissue Data from the LDW