HARTCROWSER

MEMORANDUM

DATE: July 2, 2012

TO: Hun Seak Park, PE, Washington State Department of Ecology

FROM: Brad Helland, PE, Hart Crowser

RE: **Human Health Risk Assessment Addendum for the Custom Plywood Interim Action Work Plan**
        17800-05

This technical memo refines the human health risk assessment (HHRA) presented in the Remedial Investigation (RI) report (AMEC 2011) with respect to releases of chlorinated dibenzo-*p*-dioxins and furans (D/F) from the Custom Plywood site.

Comments submitted to Ecology about the proposed interim action were addressed in a summary response (Ecology 2011) and included issues related to human health risk and D/F. This memorandum summarizes HHRA elements from the RI, along with comments on those elements, and incorporates those issues and responses in further assessing human health risk from D/F at the site.

Human health risk is of particular interest to several stakeholders, given the proximity of tribal land and usual and accustomed harvesting areas to the Custom Plywood site. Subsistence and tribal fishers, including the Samish, Swinomish, Lummi, Upper Skagit, and Suquamish consume greater amounts of fish and shellfish than the MTCA default average consumption rate of 54 grams per day (g/d). The only publicly available consumption data are from the Suquamish Tribe (2000). These data are used to represent subsistence fishing exposure to refine the HHRA presented in this memorandum.

1.0 SUMMARY OF HHRA ISSUES PRESENTED IN THE RI

Human health risks were addressed as part of an abbreviated risk assessment in Section 9 of the RI. A synopsis of that information is presented here for ease of reference. Subsequent sections of this report revise the human health risk analysis from the RI.

Section 9.2 of the RI identified D/F as the predominant bioaccumulative hazardous substance presenting risk to human health through the ingestion of seafood. Estimated excess cancer risks for D/F from seafood ingestion were calculated for various scenarios involving three target populations:

- **Target Population 1** – General public scenario. Lowest consumption rate (17.5 g/d), based on EPA ambient water quality criteria for protection of human health. This scenario assumed all seafood is consumed from the study area; in other words, the Area Use Factor (AUF) was 1.

- **Target Population 2** – Two scenarios used current MTCA default consumption rates (54 g/d):

  - Assumed all seafood consumed is from study area (AUF = 1).

  - Assumed 40 percent of seafood consumed is from study area (AUF = 0.4).

- **Target Population 3** – Three high-consumption rate scenarios used tribal seafood consumption rates (583 g/d):

  - Assumed all seafood consumed from study area (AUF = 1).

  - The RI[1] calculated an AUF based on ratio of study area to usual and accustomed fishing area (U&A) for the Swinomish Tribe from Canada to the south end of Whidbey Island. This resulted in a U&A of 100,700 acres for fish and crab harvest and 79,700 acres for clam harvest. The AUFs for fish/crab and clam were 0.0005759 and 0.0000258, respectively.

  - The RI calculated an AUF considering distance from the Swinomish Reservation. A linear weighting factor was applied to the U&A, resulting in somewhat higher AUFs for fish/crab and clam (0.0008396 and 0.0000373, respectively) compared to the previous scenario.

Table 1 summarizes risks calculated in the RI and shows that at least two scenarios, including the MTCA default scenario, exceed MTCA acceptable risk levels.

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[1] This report summarizes previous work and does not attempt to describe the rationale for calculating an AUF, nor does it address the proximity of any particular tribe to the Custom Plywood site.

Table 1 - Excess Cancer Risk from D/F for Seafood Consumption Scenarios Presented in the RI

Population	Consumption Rate (g/d)	AUF[a]	Excess Cancer Risk[b]
General Public	17.5	1	7.8×10^{-7}
MTCA Default	54	1	2.4×10^{-6}
	54	0.4	1.0×10^{-6}
High Consumers	583	1	6.7×10^{-5}
	583	Fish/Crab 0.0005759; Clam 0.0000258	2.0×10^{-8}
	583	Fish/Crab 0.0008396; Clam 0.0000373	2.9×10^{-8}

Notes:

a   The area use factor presented in the RI is not used in this revised risk analysis, which uses a default fish diet fraction parameter.

b   Excess cancer risk is expressed as the sum of risks from fish/crab and clam consumption. MTCA threshold requirement is 1×10^{-6} excess lifetime cancer risk. Highlighted cells indicate which RI scenarios exceed this criterion. Note that these values are recalculated in a subsequent section and are listed here for reference only.

2.0 COMMENTS SUMMARY RELATED TO HUMAN HEALTH RISK FROM DIOXIN-CONTAMINATED MARINE SEDIMENT

Stakeholder comments on human health risk for D/F were addressed as part of Ecology's response to comments (Ecology 2011). The issues raised in these comments can be categorized as follows:

■   The relationship between risk, screening level, remediation levels, cleanup level, and background concentrations. Expand upon the rationale for selection of remediation levels and cleanup levels.

■   Recalculation of risk based on corrections to Suquamish seafood consumption rates.

■   Risk to subsistence fishers. This included re-evaluation of risk calculations with modifications of parameters, including averaging time, fish diet fraction, area use factor, body weight (to include children), and inclusion of more recent tissue data in calculating risks, including non-cancer risks.

■   Risk reduction comparison analysis (before and after conducting the proposed Interim Remedial Action).

Understanding the relationship between calculated risk, cleanup level, remediation levels, and existing and potential future conditions is critical in understanding the cleanup process. The following section describes how cleanup levels and risks are calculated and their relationship to the interim action.

3.0 INTERIM ACTION IN MARINE SEDIMENT: CLEANUP LEVELS, REMEDIATION LEVELS, HUMAN HEALTH RISK, AND BACKGROUND CONCENTRATIONS

Ecology intends to perform an interim action in the marine sediment management areas of the Custom Plywood Site to address a major portion of D/F and wood waste contamination. This interim action will substantially reduce and control risks to human health and the environment to the maximum extent practicable under the site constraints. Interim action cleanup criteria are specified in Section 4.2.1 of the FS (Hart Crowser 2011) and are discussed in the following section as remediation levels pursuant to WAC 173-340-355.

3.1 The Role of Cleanup Levels and Remediation Levels in Site Cleanup

MTCA provides for the use of both cleanup levels and remediation levels. The sediment cleanup level defines the concentration of hazardous substances above which sediment must be remediated in some manner. A remediation level, on the other hand, defines the concentration (or other method of identification) of a hazardous substance in sediment above or below which a specific cleanup action component (e.g., dredging, capping, or natural recovery) will be used.[2]

As described in Section 5.3.1 of the FS, the cleanup level proposed for D/F is based on sediment concentrations defined as "natural background" in Fidalgo Bay. Data from Fidalgo Bay background locations ranged from 0.31 to 2.22 parts per trillion (ppt) TEC, and the estimate of the mean is 1.3 ppt TEC.[3] The preferred alternative (A-3, see Section 9.2) becomes an interim action and is intended to attain D/F concentrations in marine sediment as close as practicable to the eventual cleanup level. Because of the uncertainty in sustaining such low concentrations and the interim nature of the preferred alternative action, the cleanup criteria established in Section 4.2.1 are MTCA remediation levels that specify D/F concentrations at which dredging and capping will be

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[2] Text adapted from WAC 173-340-355(2) for application to sediment.

[3] This value was calculated using the 95 percent upper confidence limit on the mean of 10 samples in Fidalgo Bay collected away from the site, assuming a gamma distribution and substituting one-half the detection limit for non-detected values. It was not derived in consideration of PQLs, as discussed later in this memorandum.

employed. The preferred alternative uses remediation levels of 10 ppt TEC and 25 ppt TEC to trigger capping and dredging, respectively.

It is the intent of the preferred alternative to remove existing contamination within the interim action area to a level that approaches background levels where practicable. This will reduce exposure and provide adequate protection for people using the area, but may not reach the standards of a final cleanup action. It is, therefore, useful to understand the derivation of the sediment cleanup level and its relationship to the remediation levels in the preferred alternative.

3.2 How Sediment Cleanup Levels Are Established

MTCA describes a cleanup level for D/F as the concentration in sediment that is determined to be protective of human health and the environment under specified exposure conditions. The RI provided information on several exposure scenarios, and that analysis will be revisited later in this memorandum.

The primary constraint on establishing a MTCA cleanup level for D/F at the site is that cleanup levels are set at the *highest* of natural background, practical quantitation limits (PQLs), and risk-based levels and other applicable, relevant, and appropriate requirements (ARARs), as described below.[4] The rationale for setting cleanup levels at the highest of these concentrations is that, in some cases, cleanup levels calculated using the risk/ARAR requirements specified in MTCA and SMS would be less than natural background levels or levels that can be reliably measured. In those situations, the cleanup level is established at a concentration equal to the practical quantitation limit or natural background concentration, whichever is higher. In this way, cleanup levels are set at potentially sustainable concentrations, rather than concentrations that either cannot be reliably measured or are lower than globally distributed sources of contamination that cannot be controlled.

3.2.1 Natural Background

As defined in WAC 173-340-200, natural background is "the concentration of hazardous substance consistently present in the environment that has not been influenced by localized human activities." Low concentrations of particularly persistent organic compounds, like D/F, are found in sediment throughout much of the state (and elsewhere) due to global distribution. These low concentrations are considered "natural background" because they are not influenced by localized sources.

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[4] WAC 173-340-700(6)(d).

Background refers to levels of contamination, in this case D/F, that are present in the environment and are not due to releases from sources at the site. MTCA defines two types of background concentrations: natural background and area background.

Natural background, as discussed above, is considered in setting cleanup levels, whereas area background is not. Area background is defined as "the concentrations of hazardous substances that are consistently present in the environment in the vicinity of a site which are the result of human activities unrelated to releases from that site."

Conceptually, the difference between these two background concentrations is the nature and location of the sources of hazardous substances: Natural background excludes all localized sources; area background excludes *only* releases from the site and may include known releases from other sites or point sources.

Ecology has determined that 1.3 ppt TEC is representative of natural background concentrations of D/F in Fidalgo Bay (SAIC 2010).

3.2.2 Practical Quantitation Limits (PQLs)

MTCA requires use of accredited laboratories using approved methods. The sensitivity of these methods in reliably quantifying analytes is reflected, among other quality assurance requirements, by the PQLs. Laboratories must achieve the lowest practical quantitation limits consistent with the selected method.

The PQLs for D/F in sediment are the lowest concentrations that can be reliably measured by standard analytical chemistry methods, in this case EPA Method 1613B. Supporting Ecology's effort to revise SMS guidance documents, Hart Crowser surveyed laboratories that analyze a variety of hazardous substances, including D/F in sediment, in 2011. Using this information together with other work, Ecology determined that PQLs for D/F in sediment ranged from approximately 2 to 11 ppt TEC and median values for PQLs were approximately 5 ppt TEC (Ecology 2012).

3.2.3 Risk-Based Cleanup Levels and Applicable, Relevant, and Appropriate Requirements (ARARs)

Cleanup levels for individual hazardous substances, like D/F,[5] are established using applicable state and federal laws and the risk equations and other requirements specified in WAC 173-340-720 through 173-340-760. Pursuant to RCW 70.105D.030(2)(d) and WAC 173-340-700(6)(a), cleanup standards must be at least as stringent as all applicable state and federal laws. Thus, the most stringent (lowest) value from ARARs and risk calculations determines this concentration. These human health risk-based calculations are revised from what was presented in the RI in the following section.

3.3 Human Health Risk Analysis

Human health risk calculations, taken together with applicable or relevant and appropriate requirements (ARARs) are the foundation of cleanup levels. When such calculations result in levels that are less than background or PQLs, cleanup levels increase as described above.

Several comments were received by Ecology relating to how risk was characterized in the RI, particularly in how risks to subsistence fishers were calculated. This section revisits the human health risk analysis presented in the RI. The results of this revised analysis will be used along with background concentrations and PQLs in a discussion of potential cleanup levels.

This revision of the human health risk analysis focuses on the human health risk from seafood consumption, updating the parameters in the risk equations based on additional tissue data that were unavailable during preparation of the RI, developments in risk assessment by EPA (EPA 2012) in response to the National Academy of Sciences (NAS 2006), and comments received on the RI and draft FS. The effects of these revisions are discussed with respect to non-cancer risk and excess cancer risk.

Both non-cancer and cancer risk for the seafood ingestion pathway are based on the amount of seafood consumed, called the chronic daily intake (CDI). The CDI is calculated based on human consumption of edible fish and shellfish tissue from the site, as shown in Equation 1.[6]

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[5] Although D/F is a mixture of chemicals, it is considered a single hazardous substance. WAC 173-340-708(8)(d).

[6] Equation 1 is modified from the analysis presented in the RI based on review of risk assessment guidance, comments received on the RI, and policy discussions within the Department of Ecology.

$$CDI = \frac{EPC * IR * FDF * EF * ED * ABS}{BW * AT} \qquad \text{(Eq. 1)}$$

where:

CDI =   Chronic intake of dioxins and furans expressed as the D/F TEQ (mg/kg-day).

EPC =   Exposure point concentration expressed as D/F TEQ (mg/kg tissue)

IR =   Population-specific ingestion rate of fish and shellfish tissue (kg tissue/d)

FDF =   Fish diet fraction – the fraction of the diet obtained or potentially obtained from the site; MTCA default value = 0.5 (unitless)[7]

EF =   Exposure frequency (d/yr)

ED =   Exposure duration (yr)

ABS =   Gastrointestinal absorption factor (unitless); 0.6 for calculating carcinogenic toxicity, otherwise default value is 1. WAC 173-340-740(3)(b).

BW =   Body weight (kg)

AT =   Averaging time – the time over which exposures are measured (d)

3.3.1 Additional Data and Revision of Parameters

Additional clam tissue data at the site provided in the FS (Appendix A) were not available for the RI analysis of human health risk. These new data change the values used to calculate human exposure. Revisions to other parameters and the formulation of the CDI also result in modifications to the estimate of human exposure.

Table 2 shows revised parameters for use in calculating CDI for both non-cancer and cancer risks. Highlighted cells show changes in parameters from the analysis in the RI.

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[7] The FDF is similar in purpose to the Area Use Factor presented in the RI, but the FDF is a conservative default value contained in MTCA that does not rely on calculations of distances, areas, fish behavior, and fishing practices that are difficult to parameterize accurately. WAC 173-340-730(3).

Table 2 - Site-specific Risk Parameters and D/F CDI Values

Parameter	Units	General Public	MTCA Default Fish Consumption	Subsistence Fisher[a]
			Target Population	
Exposure Point (Tissue) Concentrations				
Fish	pg/g (as TCDD TEC)	0.168	0.168	0.168
Crab		0.11	0.11	0.11
Clam[b]		0.894	0.894	0.894
Ingestion Rate				
Fish		16.4	50.7	306.9
Crab	g/d	0.3	1	32.7
Clam		0.8	2.3	243.4
total	g/d	17.5	54	583
Fish Diet Fraction	unitless	0.5	0.5	0.5
Gastrointestinal Absorption Factor[c]	unitless	0.6	0.6	0.6
Exposure Frequency	d/yr	365	365	365
Exposure Duration	yr	30	30	70
Body Weight	kg	70	70	79[d]
Averaging Time[e]	d	10950	10950	25550
CDI	mg/kg-day (as TCDD TEC)	2.5×10^{-11}	7.6×10^{-11}	1.7×10^{-9}

Notes:

Highlighted cells indicate parameters revisions from the RI.

a   The subsistence fisher ingestion rate was unaltered from the RI (95th percentile of the data set, excluding salmon). This rate excludes consumption of salmon, which do not accumulate a significant portion of their D/F burden from the site. Unless the relative contribution from site contamination is factored into exposure, it is not appropriate to include salmon. Because anadromous species take up very little site-related contamination due to their home range being much larger than the site, the most straightforward approach is to exclude such species from consumption rates, as was done in the RI and has been done at other MTCA and CERCLA sites (e.g., the Lower Duwamish Waterway in Seattle).

b   The maximum clam tissue concentration from the six samples (SAIC 2010) was used to calculate the EPC. This is not representative of tissue concentrations throughout the site and provides an estimate of maximum potential human exposure.

c   The gastrointestinal absorption factor of 0.6 is used only in calculating the CDI for carcinogenic toxicity, as prescribed in MTCA for soil. For non-cancer toxicity, the factor is 1. WAC 173-340-740(3)(b).

d   Suquamish, 2000.

e   Corrected from Table 18 in the RI.

3.3.2 Non-Cancer Risk

As mentioned in comments received by Ecology, D/F exposure has been linked to non-cancer human health effects (ATSDR 1998). Ecology agrees that non-cancer effects have been sufficiently

documented (EPA 2012) to warrant discussion in assessing human heath risk at the site. Nevertheless, these risks would change potential cleanup levels only if: (1) these risks are higher than the cancer risk, and (2) these risks would result in a predicted sediment concentration that is greater than both natural background and PQLs.

Chemicals with non-carcinogenic health effects are assumed unlikely to be toxic below a certain threshold, defined as a reference dose (RfD). If the exposure exceeds this threshold, there may be concern for potential non-cancer effects. Generally, this dose must be exceeded before adverse health effects are observed from a particular hazardous substance through a particular exposure pathway. In this case, the dominant pathway is ingestion, so an oral RfD applies. The potential for non-carcinogenic health effects is represented by the ratio of the estimated chemical intake to the RfD, and is defined as the Hazard Quotient (HQ, Equation 2). The greater the value of the HQ, the greater the level of concern, although the HQ is *not* to be interpreted as a probability and risks are not linearly proportional to the HQ (EPA 1989).

$$HQ = CDI/RfD \qquad\qquad (Eq.\ 2)$$

where:

CDI = Chronic daily intake of dioxins and furans expressed as the TEC of 2,3,7,8-tetrachlorodibenzo-p-dioxin [2,3,7,8-TCDD] (mg/kg-day). (See Equation 1.)

RfD = Oral reference dose, determined by EPA to be 7×10^{-10} mg TEC/kg-day (EPA 2012).

The RI did not calculate non-cancer risk, and several comments were received relating to risk parameters. Revised parameters for Equation 1 and a new value for the RfD in Equation 2 allow calculation of non-cancer risk, as shown by Equation 3 and summarized in the Table 3.

$$HQ = \frac{\left(EPC_{fish} * IR_{fish} + EPC_{crab} * IR_{crab} + EPC_{clam} * IR_{clam}\right) * FDF * EF * ED * ABS}{BW * AT * RfD} \qquad (Eq.\ 3)$$

Table 3 - D/F Hazard Quotient Calculations

Tissue Type	Seafood Consumption Scenario		
	General Public	MTCA Default	High Consumers
Fish	2.81E-02	8.69E-02	4.66E-01
Crab	3.37E-04	1.12E-03	3.25E-02
Clam	7.30E-03	2.10E-02	1.97E+00
Total	3.57E-02	1.09E-01	2.47E+00

The D/F HQ exceeds 1 only for high consumers of clams, indicating concern about non-cancer health effects for subsistence fishers consuming clams from the site. All other scenarios resulted in HQ values less than one, indicating non-cancer health effects from site-related dioxin exposure through seafood consumption are unlikely.

3.3.3 Cancer Risk

Using the revised CDI values generated in Table 2, the cancer risks from site-related D/F exposure through seafood consumption can now be calculated using Equation 4.

$$Risk = CDI * SF \qquad\qquad (Eq.\ 4)$$

where:

> Risk = Estimated individual excess lifetime cancer risk (unitless)

> CDI = Chronic daily intake expressed as toxic equivalent concentration of

>> 2,3,7,8-TCDD (mg/kg-day)

> SF = Oral cancer slope factor for 2,3,7,8-TCDD (1×10^6 kg-day/mg)[8]

MTCA allows modification of Equation 1 to include a gastrointestinal absorption factor of 0.6 (unitless) in calculating cancer risk for D/F. The estimated excess lifetime cancer risk for the scenarios presented in the RI is summarized in Table 4.

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[8] US EPA, 2010. EPA's Reanalysis of Key Issues Related to Dioxin Toxicity and Response to NAS Comments. EPA/600/R-10/038A. This document is a draft for review purposes only and does not constitute Agency policy.

Table 4 - D/F Excess Lifetime Cancer Risk Calculations

Tissue Type	Seafood Consumption Scenario		
	General Public	MTCA Default	High Consumers
Fish	1.18E-05	3.65E-05	1.96E-04
Crab	1.41E-07	4.71E-07	1.37E-05
Clam	3.07E-06	8.81E-06	8.26E-04
Total	1.50E-05	4.58E-05	1.04E-03

Note: Values reflect an estimate of the increase in risk of developing cancer over a lifetime. For example, 1E-04 means an estimated increase in probability of 1 in 10,000.

Values in Table 4 show estimated excess cancer risks from D/F exposure related to the site ranging from approximately 1.5 in 100,000 to 1 in 1,000. The MTCA risk threshold is 1 in 1,000,000 (or 1×10^{-6}), so this site presents risks above the acceptable level specified in MTCA for all seafood consumption scenarios.

3.4 Human Health Risk-Based Cleanup Levels

Deriving risk-based target tissue concentrations involves two steps: (1) calculating tissue concentrations for fish, crab, and clam that meet MTCA criteria, and (2) calculating sediment concentrations derived from these target tissue concentrations.

3.4.1 Tissue Concentrations

Equations 3 and 4 can be used to derive tissue concentrations for each consumption scenario that would theoretically meet MTCA requirements (HQ = 1 and excess lifetime cancer risk of 1 in 1,000,000). For the purposes of this analysis, risks are assumed to be linearly proportional to D/F concentration.[9] The exposure point concentration (EPC) for each tissue type can be calculated by assuming EPC dependence on sediment D/F concentration is similar, so that EPCs will retain the same values relative to each other as they did in Table 2. For example, Table 3 shows the HQ for high consumers to be 2.47, so to reduce this to an HQ of 1 we divide the EPC of each tissue type by 2.47. Likewise, the excess cancer risk shown in Table 4 for high consumers is 1.04×10^{-3}, so each target tissue concentration is reduced by approximately 1000 to meet the MTCA risk

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[9] For a more detailed discussion of risk at very low contaminant concentrations and relevant points of departure from linearity, see NAS 2006 and EPA 2012. Because cleanup levels will not be determined by these risk-based concentrations, it is sufficient to assume linear response.

threshold. Table 5 shows the derived risk-based target tissue concentrations for cancer and non-cancer effects.

Table 5 - Calculated Target D/F Tissue Concentrations Meeting MTCA Risk Thresholds

Tissue Type	Seafood Consumption Scenario[a]					
	General Public		MTCA Default		High Consumers	
	HQ= 1	Risk = 1E-06	HQ= 1	Risk = 1E-06	HQ= 1	Risk = 1E-06
Fish	NA[b]	0.0112	NA	0.00367	0.0681	0.0001622
Crab	NA	0.0073	NA	0.00240	0.0446	0.0001062
Clam	NA	0.0595	NA	0.01952	0.3625	0.0008631

Notes:

a   All values expressed as pg TEC/g tissue. Tissue analytical reporting limits are not considered in these theoretical calculations.

b   NA = not applicable because MTCA requirements are already met for this risk parameter.

3.4.2 Sediment Concentrations

To derive the sediment concentrations from the calculated EPCs, the change in sediment concentrations needs to be related to the change in tissue concentrations using a biota–sediment accumulation factor (BSAF), defined in Equation 5. The BSAF is a ratio of D/F found in fatty tissues of organisms to that found in the organic carbon of sediment.

$$BSAF = (EPC/f_{lipid})/(C_s/f_{oc}) \qquad\qquad \text{(Eq. 5)}$$

where:

EPC =   Concentration of D/F TEC in organism tissue (pg/g)

f_{lipid} =   Fraction of lipid in organism tissue (unitless)

C_s =   Concentration of D/F TEC in co-located sediment (pg/g)

f_{oc} =   Fraction of organic carbon in co-located sediment (unitless)

BSAFs for Fidalgo Bay were reported by SAIC (2010) for some D/F congeners in clam tissue to be approximately 0.0673.[10] Tables 3 and 4 show risks from clam tissue to be significantly higher than

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[10] Average value for all reported congeners in Table 3-7 in SAIC 2010. Note that D/F concentrations in tissue are frequently below reporting limits, and this contributes to high uncertainty in establishing BSAFs. Nevertheless, because we are primarily interested in deriving an estimate of relative risk reduction (before and after the interim action is implemented), the uncertainty of the BSAF is not critical to the comparative risk reduction analysis.

other tissue types for subsistence fishers, so the mean BSAF for D/F in clam tissue will be used to calculate target sediment concentrations to provide a protective remediation solution.[11]

Rearranging Equation 5 to calculate target sediment concentration and using the six co-located sediment and clam tissue samples analyzed by SAIC in 2010,

$$C_s = (f_{oc}/BSAF) * (EPC/f_{lipid}) \qquad\qquad (Eq.~6)$$

Where:

$C_s =$ Target D/F sediment concentration (pg TEC/g)

$f_{oc} =$ Average TOC result: 2.01% (or 0.0201)

BSAF = 0.0673

(EPC/f_{lipid}) =Target D/F concentration in clam tissue from Table 5 (pg TEC/g) divided by (normalized to) the mean tissue lipid fraction

Table 6 shows the calculated target D/F sediment concentration for each of the three seafood consumption scenarios presented in the RI.

Table 6 - Calculated Target D/F Sediment Concentrations Meeting MTCA Risk Thresholds

	Seafood Consumption Scenario					
	General Public		MTCA Default		High Consumers	
	HQ= 1	Risk = 1E-06	HQ= 1	Risk = 1E-06	HQ= 1	Risk = 1E-06
Sediment Concentration (pg TEC/g)[a]	NA[b]	1.23	NA	0.402	7.47	0.0178

Notes:

a   Sediment concentrations derived only from co-located sediment and clam tissue data (SAIC, 2010), disregarding probable analytical chemistry method limitations.

b   NA = not applicable because MTCA requirements are already met for this risk parameter.

Table 6 shows that the human health risk-based concentration that would be used to derive a MTCA cleanup level is 0.0178 ppt TEC, determined by excess lifetime cancer risk for high seafood consumers.

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[11] Clams have the most site fidelity, the best site-specific data set, and are most relevant to the population with the highest estimated risk.

As discussed in the section above on cleanup level development, both PQLs and MTCA natural background concentrations are approximately two orders of magnitude higher than these calculated risk-based concentrations. Nevertheless, the estimated risk values can be useful in evaluating relative risk reduction under the proposed interim action alternative, as discussed in the following section.

4.0 RISK REDUCTION COMPARISON ANALYSIS

Analysis of the reduction in risk due to the proposed interim action alternative requires two elements: an estimate of existing risks and an estimate of predicted risks after the completed interim action. The above discussion of human health risk, including revised parameters and inclusion of non-cancer risk, provides an estimate of the existing excess cancer and non-cancer risks (see Tables 3 and 4). Estimating post-interim action risk requires predicting post-construction surface sediment concentrations, deriving tissue concentrations from the sediment values, and then calculating risks from the predicted tissue concentrations.

4.1 Predicted Sediment Concentrations

The first step is to predict the change in sediment concentration at the site for the proposed alternative.[12] Figure 1 shows the interpolation of existing D/F concentrations within the proposed interim remedial action boundary. The average of the interpolated data concentrations within the interim action boundary is 24.5 ppt TEC. All sediment within this boundary (approximately 19.2 acres) will have a clean post-construction surface sediment layer, but it is reasonable to expect that this surface will approach Fidalgo Bay natural background concentrations over time if all site-related sources and any other sources of D/F identified in the area have been addressed. As discussed in section 3.2.1 of this memo, Ecology has determined this concentration is 1.3 ppt TEC for Fidalgo Bay.

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[12] As described in Section 8.3 of the FS (Hart Crowser 2011), all aquatic remediation alternatives address the same lateral extent of contamination and would place clean fill material in the biologically active zone of the sediment bed. Similar risk reduction results would, therefore, be expected for all alternatives presented in the FS, assuming the long-term effects of dredging residuals are negligible and capping is effective.

4.2 Predicted Clam Tissue Concentrations

The second step is to use Equation 6 to calculate the predicted difference in clam tissue concentrations (EPC), using the same BSAF value cited above and assuming mean sediment TOC[13] and mean tissue lipid fraction remain the same.

$$C_s = (f_{oc}/BSAF) * (EPC/f_{lipid}) \qquad\qquad (Eq. 6)$$

$$1.3 \text{ pg/g TEC} = (0.0201/0.0673) * (EPC/0.0145)$$

$$EPC = 0.0617 \text{ pg TEC/g of Tissue}$$

4.3 Estimated Post-Remediation Human Health Risks

The third step is to use the calculated clam tissue D/F concentration to estimate post-remediation human health risks.

Equation 3 can now be used to estimate the non-cancer risk from this clam tissue concentration, using the parameters in Table 2. For the high consumer scenario, we have

$$HQ = \frac{\left(EPC_{clam} * IR_{clam}\right)* FDF * EF * ED * ABS}{BW * AT * RfD} \qquad\qquad (Eq. 3)$$

$$HQ = \frac{\left(0.0617\,pgTEC/g * 243.4g/d\right)*0.5*365d/yr*70yr*1.0\left(\dfrac{10^{-9}mg}{pg}\right)}{79kg*25550d*7x10^{-10}mgTEC/kg \cdot d}$$

$$HQ = 0.136$$

Compared to the existing non-cancer risk conditions shown in Table 3, where the HQ for high consumers of clams exceeds 1, this represents an order of magnitude HQ reduction (from HQ = 1.97 to an HQ of 0.136) and meets MTCA requirements for non-cancer risk from D/F. HQs are not

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[13] While initial TOC values would be expected to be significantly lower than existing values, it is reasonable to assume that TOC values will rise to reflect fine-grained sediment found nearby in Fidalgo Bay (SAIC 2008). These Fidalgo Bay TOC values are sufficiently close to the mean TOC values reported in the co-located sediments samples used previously in Equation 6.

linearly proportional to risk (EPA 1989), so the risk reduction analysis is limited to the observation of the large decrease in HQ and compliance with MTCA requirements rather than a percent reduction.

A similar calculation using Equation 4 predicts an excess lifetime cancer risk of 5.7×10^{-5}. Compared to the calculated risk in Table 4 for high consumers of clams (8.26×10^{-4}), this represents a 93 percent reduction within the interim remedial action boundary (Equation 7). Assuming the EPCs for fish and crab behave similarly after remediation, the risk within the interim remedial action boundary from seafood consumption will be decreased by 93 percent.

$$\frac{(8.26x10^{-4} - 5.7x10^{-5})}{8.26x10^{-4}} * 100 = 93\% \qquad \text{(Eq. 7)}$$

Assuming risk is proportional to the area of D/F-contaminated surface sediment and using the site area of approximately 480 acres together with D/F concentrations outside the interim remedial action boundary,[14] the interim remedial action yields a 26 percent decrease in human health risk from clam consumption, as shown in Table 7. Assuming the reduction in site-related risk from consumption of fish and crab is analogous, the overall seafood consumption risk also decreases by 26 percent.

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[14] See Table 3-5 of SAIC 2010.

Table 7 - Site Cancer Risk Reduction From the Interim Action[a]

	Before Remediation		After Remediation	
Acreage	**Surface Sediment D/F Concentration (ppt TEC)**	**Risk[b]**	**Surface Sediment D/F Concentration (ppt TEC)**	**Risk**
258	1.65		1.65	
177	3.5		3.5	
22.6	7.5		7.5	
19.2	24.5		1.3	
Average[c]	3.53	1.58×10^{-4}	2.60	1.17×10^{-4}
Calculated Risk Reduction		$\dfrac{1.58 \times 10^{-4} - 1.17 \times 10^{-4}}{1.58 \times 10^{-4}} = 25.9\%$		

Notes:

a) Risk reduction is calculated as the site-wide difference in excess lifetime cancer risk before and after remediation of the 19.2-acre proposed interim remedial action.

b) Risk is calculated using Equation 6 to derive clam tissue EPC and substituting this value into Equation 4. Calculations use average sediment concentration values for clam consumption only using the high consumer scenario (243.4 g/d).

c) Average sediment concentration is calculated on an area-weighted basis: Site average D/F sediment concentration = Σ (Acreage tract x D/F concentration) / Total Site Acreage.

5.0 CONCLUSION

Average surface sediment D/F concentrations within the interim action boundary will significantly decrease under the proposed alternative. The average existing surface sediment concentration of 24.5 ppt TEC within the interim remedial action boundary is predicted to decrease and approach background in Fidalgo Bay, estimated at 1.3 ppt TEC.

Based on updated site-specific parameterization of human health risk equations, the predicted reduction in sediment D/F concentration yields a substantial decrease in predicted non-cancer and cancer risks. The HQ is predicted to decrease by an order of magnitude result in acceptable non-cancer HQ of less than 1 for all seafood consumption scenarios. Excess lifetime cancer risk is predicted to decrease by 93 percent within the 19.2-acre interim remedial action boundary and 26 percent for the site overall. These risks will still exceed the MTCA risk threshold of 1×10^{-6}.

All calculated risk-based surface sediment D/F target concentrations are lower than natural background concentrations. Target concentrations for the high consumer scenario are nearly two orders of magnitude below natural background. The natural background D/F concentrations in Fidalgo Bay are lower than commonly achieved PQLs.

6.0 REFERENCES

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Legend

- ✛ Sample Point
- —— Interim Remedial Action Boundary

Dioxin Concentrations in ppt
- 5 to 10 ppt
- 10 to 25 ppt
- 25 to 50 ppt
- > 50 ppt

Note: Area weighted mean Dioxin/Furan Concentration: 24.5 ppt. Calculation completed using the inverse distance weighted (IDW) techinique.

Sample point labels:
ST-27, ST-19, HC-SS-14, ST-3, ST-11, HC-SS-10, HC-SS-13, HC-SS-9, ST-26, HC-SS-8, SS-20, HC-SS-11, SS-16, ST-2, SS-19, ST-22, SS-17, HC-SS-12, ST-10, SC-50A, ST-14, ST-18, CT-03, SS-22, A3-32, HC-SS-7, SS-21, ST-6, SC-51, SC-50, SC-49, SS-18, SC-42, SC-46, CT-02, SC-59, SS-15, HC-SS-2, HC-SC-15, SC-45, HC-SS-5, SC-58, SS-23, SC-39, ST-21, HC-SS-1, SC-43, SC-44, SC-47, SC-41, SC-40, HC-SS-3, HC-SS-4, SC-48, ST-1, CT-01A, CT-01B

0   75   150   300
Feet

Custom Plywood Mill
Anacortes, Washington

Dioxin/Furan Interpolation

17800-05   7/12

HARTCROWSER   Figure

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