DEVELOPMENT OF HUMAN HEALTH WATER QUALITY CRITERIA FOR THE STATE OF IDAHO

REVISED

Prepared for

State of Idaho
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Table of Contents

Tables

Figures

Acronyms

BAF	bioaccumulation factor
BCF	bioconcentration factor
BW	body weight
COI	chemical of interest
CSF	cancer slope factor
DEQ	Department of Environmental Quality
DI	drinking water intake
EPA	US Environmental Protection Agency
FDEP	Florida Department of Environmental Protection
HCH	hexachlorocyclohexane
HI	hazard index
HQ	hazard quotient
NCI	National Cancer Institute
NHANES	National Health and Nutrition Examination Survey
NRWQC	National Recommended Water Quality Criteria
PAWQCC	Probabilistic Ambient Water Quality Criteria Calculator
PPRTV	Provisional Peer-Reviewed Toxicity Value
RfD	reference dose
RSC	relative source contribution
WQC	water quality criteria
WQS	water quality standards

1 Introduction

This report presents the human health water quality criteria (WQC) developed for the State of Idaho on behalf of the Idaho Department of Environmental Quality (DEQ), along with the methods and parameter values used to calculate these WQC.

1.1 Report Objectives and Intended Audience

WQC were developed for a total of 104 chemicals of interest (COIs), including the 88 COIs identified in the US Environmental Protection Agency's (EPA's) letter of disapproval for WQC developed by the State of Idaho (EPA 2012). Only those COIs identified by Idaho DEQ as COIs were evaluated as part of this report, and thus some chemicals are not addressed herein.

This report is not intended to be a stand-alone document, but rather to allow Idaho DEQ to document the methods used to probabilistically calculate WQC for the selected COIs. Many of the policy decisions and background on the fish consumption rates are provided in other documents referenced throughout this report.

The intended audience of this report is not the general public, but rather a small subset of individuals who are interested in the details of WQC development. Thus, only a brief discussion of background information is included herein. Individuals reading this report will generally be familiar with the methods and equations used to develop WQC, but may be less familiar with the details of how WQC can be calculated probabilistically and/or the advantages of this approach. Thus, an overview of this approach and its advantages is presented in Section 1.2.

1.2 Overview of Approach

WQC are typically calculated using deterministic methods, whereby single values are selected to represent parameters such as the fish consumption rate (FCR) and drinking water intake (DI) rate. Rather than using this approach, Idaho DEQ elected to use a probabilistic approach (i.e., Monte Carlo analysis) whereby distributions (rather than single values) can be used for parameters. This probabilistic approach allows for the variability and/or uncertainty of a parameter to be incorporated into the calculations, thus providing more information about the resulting criteria values or risk estimates. The primary disadvantage of this approach is the increased complexity of the calculations, which makes a probabilistic approach more time intensive and thus generally more expensive to conduct. More information regarding the use of probabilistic methods to calculate risks and/or WQC can be found in documents such as EPA's risk assessment guidance on this topic (EPA 2001).

For each of the COIs evaluated in this report, WQC were calculated based on two types of exposure: 1) fish1-only intake, and 2) fish + water intake. WQC were calculated probabilistically to better characterize the range of potential risks to the exposed populations than would have been possible using deterministic calculation methods. Distributions were used for select input parameters (i.e., FCR, DI rate, and body weight [BW]); point estimates were used for all other inputs. When available, input values (e.g., the FCR) were developed based on data specific to Idaho to better reflect site-specific exposure. Thus, Idaho-specific survey data were used to develop distributions for the FCR and BW and were used to develop Idaho-specific weighting factors by trophic level for the determination of bioaccumulation. Other parameter values were based on national studies, and were generally in keeping with EPA default values or based on EPA guidance.

2 Methods and Parameter Values

This section presents the populations considered for the development of WQC (Section 2.1), the methods used to calculate WQC for Idaho (Section 2.2), and the development of parameter values for these calculations (Section 2.3). A summary of the methods and parameter values is presented in Section 2.4.

2.1 Populations Evaluated and Acceptable Risk Thresholds

The populations of interest considered for the development of Idaho human health WQC included the following:

- **General population in Idaho** – This population includes all individuals who consume fish and shellfish.
- **Higher-level consumer populations –** Three populations that consume fish at higher rates than the general population were also considered:
    - Angler-only population in Idaho (this group is a subset of the general population that includes all individuals who identify themselves as anglers)[2]
    - Nez Perce tribal members
    - Shoshone-Bannock tribal members

[1] For the purposes of this document, the term "fish" was used to describe criteria types (rather than the term "organism," which is commonly used in other WQC documents). This is consistent with EPA's use of FI for "fish intake" in their human health WQC equations.

[2] The "angler only" population is a subset of the general population that includes only those individuals who indicated in the survey that they were licensed Idaho anglers. These individuals are typically known to consume fish at a rate higher than does the general population. More information is available in Idaho DEQ's fish consumption survey report (NWRG 2015).

WQCs were developed using probabilistic methods and focused on an evaluation of the general Idaho population and on an evaluation of the higher-level consumer populations (i.e., the angler-only population in Idaho, the Nez Perce tribe, and the Shoshone-Bannock tribes). Fish consumption rates were compared by Idaho DEQ across the three higher-level consumer populations to determine which of these groups was the most highly exposed (Idaho DEQ 2015b). Based on this comparison Idaho DEQ provided direction that the Nez Perce tribe would be used to represent the higher-level consumer populations for the purpose of calculating WQC.

Acceptable risk thresholds for the development of WQC are presented in Table 2-1. For the general Idaho population, the intent was to protect an upper percentile of the population (i.e., the 95th percentile of exposure) (Idaho DEQ 2015a). For the higher-level consumer populations (represented by the Nez Perce tribe), the intent was to ensure that the WQC would be protective of the average individual.

Table 2-1. Risk thresholds and population levels

Population	Population Level to Protect	Evaluation Type	Target Risk	
			Lifetime Excess Cancer Risk	Non-Cancer HI
General population in Idaho	95th percentile	probabilistic	1×10^{-6}	1
Higher-level consumer populations:				
Angler-only population in Idaho	average individual	probabilistic	1×10^{-6}	1
Nez Perce tribal members				
Shoshone-Bannock tribal members				

HI – hazard index

2.2 Calculation of WQC

As discussed in Section 1, the Idaho human health WQC were calculated using probabilistic methods for the general Idaho population and the Nez Perce Tribal population. For each population, two WQC were developed for each COI: one based on fish-only intake, and the other based on fish + water intake. The final selected WQC for each COI-criteria type combination was the more stringent (i.e., lower) of the WQC calculated for the general population and the Nez Perce tribal population.

Each COI was evaluated based on either cancer or non-cancer toxicity values. When both types of toxicity values were available for a given chemical, the WQC was developed based on the toxicity value (i.e., cancer or non-cancer) that resulted in the more stringent (i.e., lower) WQC. Equations 2-1 through 2-4 in Table 2-2 are the equations used to calculate WQC using deterministic calculation methods and are presented in here for informational purposes (they were not used in the calculation of WQC using probabilistic methods). For the probabilistic approach, it was necessary to use equations that calculate risk estimates at a given water concentration; these are presented as Equations 2-5 through 2-8 in Table 2-2. Using @RISK software, Monte

Carlo simulations were conducted to produce distributions of incremental cancer risks and non-cancer hazard quotients (HQs.) Distributions were defined for three input parameters: body weight, DI rate, and FCR. Point estimates were entered for all other parameter values. The development of these distributions and values for these parameters are described in Section 2.3.

Table 2-2. Equations used to calculate WQC and risk estimates

Basis	Equations Used to Calculate WQC		Equations Used to Calculate Risk Estimates	
Non-Cancer Approach (Using Reference Dose)				
Fish-only intake	$WQC = HQ_{target} \times RfD \times RSC \times \left(\frac{BW}{FCR \times BAF}\right)$	*Equation 2-2*	$HQ = \frac{(C_w \times FCR \times BAF) \times ED}{BW \times AT_{nc} \times RSC \times RfD}$	*Equation 2-6*
Fish + water intake	$WQC = HQ_{target} \times RfD \times RSC \times \left(\frac{BW}{DI + (FCR \times BAF)}\right)$	*Equation 2-1*	$HQ = \frac{((C_w \times DI) + (C_w \times FCR \times BAF)) \times ED}{BW \times AT_{nc} \times RSC \times RfD}$	*Equation 2-5*
Cancer Approach (Using Cancer Slope Factor)[a]				
Fish-only intake	$WQC = \frac{ELCR_{target} \times BW}{CSF \times (FCR \times BAF)}$	*Equation 2-4*	$ELCR = \frac{(C_w \times FCR \times BAF) \times ED \times CSF}{BW \times AT_c}$	*Equation 2-8*
Fish + water intake	$WQC = \frac{ELCR_{target} \times BW}{CSF \times (DI + (FCR \times BAF))}$	*Equation 2-3*	$ELCR = \frac{((C_w \times DI) + (C_w \times FCR \times BAF)) \times ED \times CSF}{BW \times AT_c}$	*Equation 2-7*

Source: EPA (2000, 2002).

Note: In the equations in this table, WQC are shown in mg/kg. In subsequent tables in this report, WQC are reported in µg/kg. Conversion from mg/kg to µg/kg is done by multiplying WQC values by 1,000; this conversion was done at the request of Idaho DEQ.

Where:

AT_c = averaging time, cancer (years)
AT_{nc} = averaging time, non-cancer (years)
BAF = bioaccumulation factor (L/kg)
BW = body weight (kg)
CSF = cancer slope factor $(mg/kg\text{-}day)^{-1}$
C_w = chemical concentration in water (mg/L); equal to candidate WQC
DEQ = Department of Environmental Quality
DI[b] = drinking water intake rate (L/day)
ED = exposure duration (years)
ELCR = excess lifetime cancer risk
$ELCR_{target}$ = target excess lifetime cancer risk (equal to 1×10^{-6})
EPA = US Environmental Protection Agency
FCR = fish consumption rate (kg/day)
HQ = hazard quotient
HQ_{target} = target hazard quotient (equal to 1)
POD = point of departure
RfD = reference dose (mg/kg-day)
RSC = relative source contribution (fraction)
UF = uncertainty factor
WQC = water quality criteria (mg/kg)

a For select carcinogens, a nonlinear approach is considered the most appropriate method for calculating cancer risks (EPA 2000). For these chemicals, the equations used to calculate the WQC are as follows:

fish-only intake: $WQC = POD / UF \times RSC \times \left(\frac{BW}{FCR \times BAF}\right)$; fish + water intake: $WQC = POD / UF \times RSC \times \left(\frac{BW}{DI + (FCR \times BAF)}\right)$

b To use a body-weight normalized DI rate, the total DI rate is calculated using the following equation: DI_{TOTAL} (L/day) = BW (kg) × $DI_{NORMALIZED}$ (L/kg-day).

2.2.1 Probabilistic model runs

The Probabilistic Ambient Water Quality Criteria Calculator (PAWQCC) model developed by Arcadis (2014) was used to calculate WQC.[3] The model was parameterized using the values and distributions described in Section 2.3. For probabilistic calculations, an initial estimate of the WQC for each COI (based on the WQC deterministically calculated by the model) was entered into the section of the model devoted to probabilistic results. A Monte Carlo simulation was run (the number of runs per simulation is discussed in Section 2.2.2), and the results were evaluated relative to the target excess cancer risk or non-cancer HQ. This process was repeated iteratively using different water concentrations until the WQC for a given chemical resulted in a distribution of risks in which the target risk was achieved for the target population (as defined Table 2-1). For example, for the general population, the 95th percentile of the distribution was equal to either an HQ of 1 or an excess cancer risk of 1×10^{-6}.

2.2.2 Determination of number of model runs

As discussed in the work plan (Windward 2015), it was important to run a sufficient number of model simulations to ensure that the resulting risk estimate distributions would be stable (i.e., that successive simulation runs would yield the same results) prior to running the probabilistic model to calculate WQC. For this exercise, three simulations were run using the same input values and the same number of model runs per simulation. The results of these simulations were evaluated using two metrics to determine whether the model runs were stable: 1) whether the model runs produced the same risk estimate to two significant figures (plus or minus one significant figure) across all three simulations, and 2) whether the variability in results for a given chemical was less than 5% across all three simulations. The following process was used to determine the appropriate number of model runs:[4]

- **Run probabilistic simulations** – Three probabilistic simulations were conducted (starting with 100 model runs per simulation) using the general population parameterization. Simulations were conducted using ten COIs that were selected to cover a range of input values (e.g., varying BAFs) and for COIs for which WQC would be based on both cancer and non-cancer risks.

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[3] A copy of the PAWQCC model is available online here: http://www.deq.idaho.gov/media/60176866/58-0102-1201-probabilistic-ambient-wq-criteria-calculator-0715.xlsm

[4] The parameterization for the general population was used for this evaluation, except that EPA's default BAF values were used for this evaluation (Idaho-specific BAFs had not yet been developed when this evaluation was conducted). The small changes in BAFs would not impact the results of this evaluation.

- **Evaluation of results** – The resulting risk estimate distributions were compared across the three simulations. The number of model runs was determined to be sufficient if the resulting risk estimates at the 95th percentile were stable to two significant figures (plus or minus one digit) for each chemical, and/or if the resulting risk estimates for each chemical varied by less than 5%.
- **Continued evaluation until stable results were obtained** – If these criteria were not met, additional probabilistic simulations were conducted with a higher number of model runs per simulation until stable results were achieved. This included verification of this evaluation for an additional eight COIs.

Following this process, Monte Carlo simulations were conducted for ten COIs first using 100 runs, followed by 500 and then 1,000 runs; none of these simulations produced stable results, indicating that a larger number of runs would be needed. Ultimately, Monte Carlo simulations using 5,000 runs produced generally stable results to two significant figures and had results that varied by less than 5% for each chemical, and thus 5,000 runs were used in simulations for the calculation of WQC. Monte Carlo simulations were conducted for 500 and 5,000 model runs for eight additional COIs to verify the results of this evaluation. A summary of these results are presented in Table 2-3, and the complete results are provided in Appendix A.

Table 2-3. Evaluation of model stability

Metric of Comparison	Model Stability by Number of Iterations per Model Run			
	100	500	1,000	5,000
Evaluation of primary set of 10 chemicals				
Stability of results to two significant figures, plus or minus one digit (number of chemicals with stable results out of the 10 chemicals evaluated)	5 / 10	5 / 10	6 / 10	9 / 10
Range of variability (expressed as the range of relative percent standard deviation across each of the 10 chemicals evaluated)	1 to 27%	1 to 5%	0 to 11%	0 to 4%
Evaluation of 8 additional chemicals				
Stability of results to two significant figures, plus or minus one digit (number of chemicals with stable results out of the 8 chemicals evaluated)	ne	0 / 8	ne	6 / 8
Range of variability (expressed as the range of relative percent standard deviation across each of the 8 chemicals evaluated)	ne	5 to 13%	ne	2 to 3%

ne – not evaluated

2.3 Parameter Values

This section discusses the development of parameter values for the calculation of WQC. Idaho survey data were used when available and appropriate. Otherwise parameter values derived from guidance were used. An overview of the methods and parameter values discussed in this section is presented in Section 2.4.

2.3.1 Body Weight

As discussed in the work plan (Windward 2015), Idaho survey data were available for the BW parameter (i.e., combined male and female data) (NWRG 2015), and thus the these data were evaluated to determine their suitability for developing a distribution for the BW parameter. Because the BW data from the Idaho survey are self-reported values (meaning that participants provide their BW), BW data for adults (male and female) from EPA's *Exposure Factors Handbook* (EPA 2011; Table 8-1) were compared with the Idaho survey data to ensure that the self-reported data from the Idaho survey were reasonable. As presented in Table 2-4, the Idaho survey data closely matched the national EPA data, and thus was considered to be a reliable source of BW data for the development of WQC.

Table 2-4. Comparison of BW data from Idaho's survey and EPA's *Exposure Factors Handbook*

Source and Population	No. of Participants	BW (kg)							
		Mean	Min	Max	Percentile				
					25th	50th	75th	90th	95th
General population in Idaho (from survey data)	4,168	80	27	181	66	77	91	107	115
National data from EPA's *Exposure Factors Handbook* (EPA 2011)	18,161	80	nr	nr	66	78	91	105	115

Note: All data are for adults and include both males and females.
EPA – US Environmental Protection Agency
nr – not reported

Based on the Idaho BW survey data, @RISK software was used to fit a distribution to the available data for the general population in Idaho (Table 2-4), which resulted in the development of a logarithmic distribution for BW for the calculation of probabilistic WQC (Figure 2-1). This distribution was applied to all populations evaluated in for this effort.

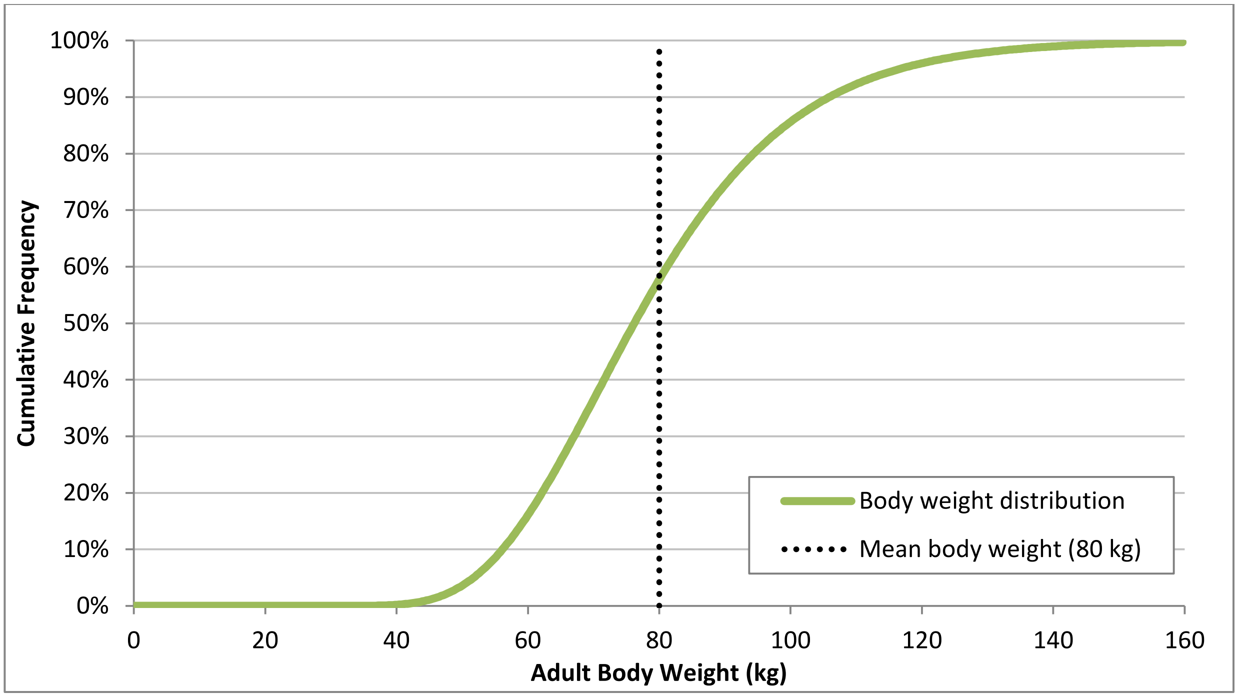


Figure 2-1. BW distribution based on the general Idaho population

2.3.2 Drinking Water Intake Rate

As described in the work plan (Windward 2015), no Idaho-specific DI rate data were available. Thus, DIs for the calculation of WQC were based on the National Health and Nutrition Examination Survey (NHANES) 2003 to 2006 data, as presented in EPA's *Exposure Factors Handbook* (EPA 2011) and reproduced in Table 2-5. The specific dataset that was used to develop DI rates was the per-capita estimates of direct and indirect intake of community water for individuals aged 21 and over (which includes consumers and non-consumers of this water source).[5] These data were taken from Table 3-23 (total daily rates) and Table 3-33 (body weight-normalized daily rates) in the *Exposure Factors Handbook* (EPA 2011). The 90th percentile of 2.4 L/day corresponds to the DI value used in EPA's 2015 updated criteria (EPA 2015).

[5] It should be noted that the Florida Department of Environmental Protection (FDEP) used the same study (i.e., NHANES data, as presented by EPA (2011)) to develop the water quality distribution in their 2013 draft WQC document (FDEP 2013). However, FDEP based their distribution on the "all sources" dataset (which includes both community and bottled water). The decision to use intake rates for community water sources alone was based on direction from Idaho DEQ because this source more realistically represents the drinking water consumption that is relevant to the development of WQC.

Table 2-5. NHANES DI rates for individuals aged 21 and older

Type	Unit	DI Rate							
			Percentile						
		Mean	10th	25th	50th	75th	90th	95th	99th
Total daily rate	mL/day	1,043	0	227	787	1,577	2,414	2,958	4,405
Body weight-normalized daily rate	mL/kg-day	13	0	3	10	20	32	40	59

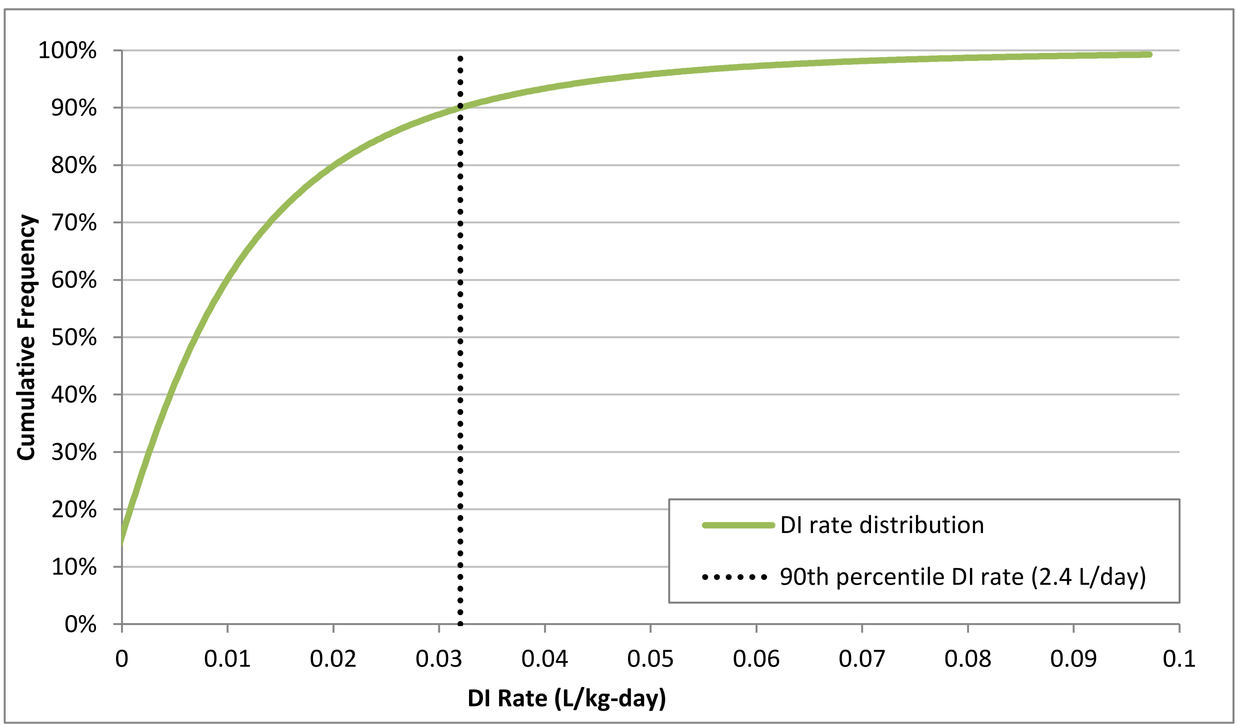
Source: EPA's *Exposure Factors Handbook* (EPA 2011; Tables 3-23 and 3-33). Rates were based on total per-capita estimates for community water sources.

DI – drinking water intake

EPA – US Environmental Protection Agency

NHANES – National Health and Nutrition Examination Survey

For the probabilistic WQC calculations, a distribution was developed to reflect the variability in the DI rate for individuals. Rather than using the overall daily intake rate, a distribution was fit to the body-weight normalized DI rate values to ensure an appropriate correlation with body weight (which was also allowed to vary probabilistically; Section 2.3.1). This distribution, which was developed using @RISK software (using the same methodology as for the BW parameter), is presented in Figure 2-2. This distribution was applied to all populations evaluated in this report. When calculating the WQC for fish-only intake, the DI rate was set to 0.



Note: Distribution was truncated to avoid the selection of negative DI rate values.

Figure 2-2. DI rate distribution

2.3.3 Fish Consumption Rate

As described in the work plan (Windward 2015), FCR information from the Idaho survey (NWRG 2015) and the National Cancer Institute (NCI) analysis (Buckman et al. 2015) was used as the basis for the development of the FCR distributions and point estimates for the general population and the angler-only population. Idaho-specific data for the Nez Perce Tribe and the Shoshone-Bannock Tribe (Ridolfi and Pacific Market Research 2015; Author Unknown 2015) (adjusted by Idaho DEQ to account for the exclusion of certain salmon species, estuarine species, and tilapia (Idaho DEQ [in prep])) were used to develop a distribution for the tribal population. A summary of these FCRs is presented in Table 2-6 (a complete table of percentiles is provided in Appendix A).

Table 2-6. Idaho fish consumption rate data

Population	No. of Individuals	FCR							
		Mean (g/day)	Percentile						
			10th	25th	50th	75th	90th	95th	99th
General population in Idaho[a]	2,959	2.3	0.00077	0.0079	0.093	0.84	4.7	11.2	40.5
Angler-only population in Idaho[a]	1,175	4.5	0.025	0.11	0.59	2.9	10.8	21.4	62.4
Nez Perce Tribe[b]									
Overall rate	446	66.5	6.8	15.1	36.0	81.7	159	234	nr
Adjusted rate	446	16.1	1.6	3.7	8.7	19.8	38.6	56.6	nr
Shoshone-Bannock Tribe[c]									
Overall rate	225	18.6	0.7	2.1	6.5	20.0	48.9	80.0	nr
Adjusted rate	225	5.6	0.2	0.6	2.0	6.0	14.7	24.1	nr

a Percentiles based on NCI analysis of dietary recall data from Idaho's survey (Buckman et al. 2015) (complete table of percentiles is presented in Appendix A).

b Percentiles were based on the Nez Perce Tribe in Idaho, as reported in Table E-2 of Ridolfi and Pacific Market Research (2015) and Author Unknown (2015). Per Idaho DEQ, percentiles were adjusted by multiplying the percentages by 24.2% to determine rates for the Nez Perce Tribe excluding certain salmon species, estuarine species, and tilapia (Idaho DEQ [in prep]).

c Percentiles were based on the Shoshone-Bannock Tribe in Idaho, as reported in Table E-2 of Ridolfi and Pacific Market Research (2015) and Author Unknown (2015). Per Idaho DEQ, percentiles were adjusted by multiplying the percentages by 30.1% to determine rates for the Shoshone-Bannock Tribe, excluding certain salmon species, estuarine species, and tilapia (Idaho DEQ [in prep]).

FCR – fish consumption rate

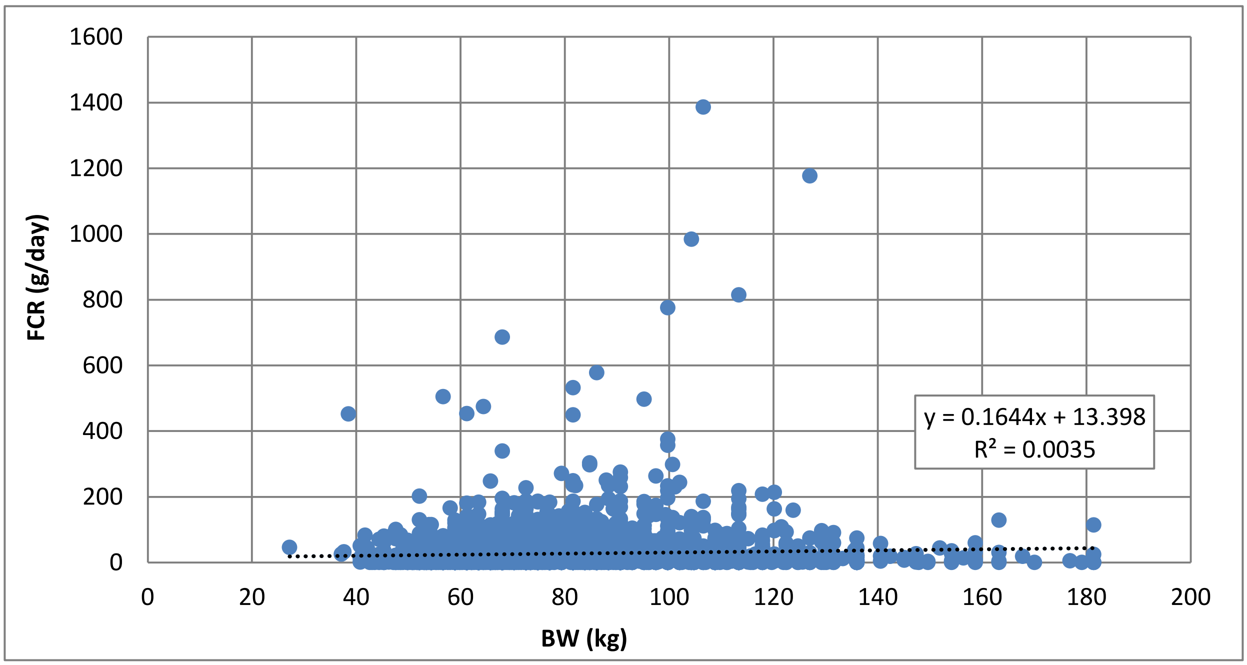
NCI – National Cancer Institute

nr – not reported

Details regarding the development of a distribution or point estimate for each population are provided in the subsections that follow.

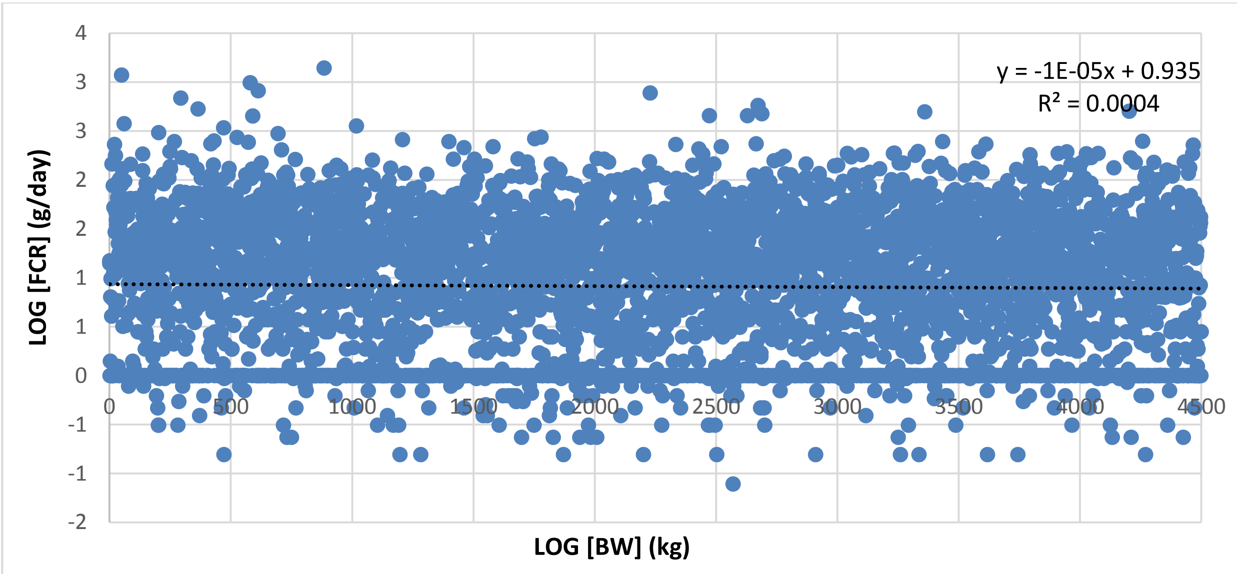
2.3.3.1 Consideration of correlation with body weight data

As discussed in the work plan (Windward 2015), before developing the FCR distributions/values for the WQC calculations, paired body weight and FCR data from the Idaho survey were evaluated to determine the appropriate correlation factor between these two parameters. For this evaluation, FCRs for the general population were graphed as a function of body weight using both untransformed data (Figure 2-3) and log-transformed data (Figure 2-4). As shown in these figures, it was determined that there was no relationship between these two parameters, and thus the two parameters were allowed to vary independently in the calculation of WQC (i.e., no correlation factor was applied).



Note: Blue dots represent the individual sample points from the Idaho survey data. The black dotted line is the trend line fitted by Microsoft Excel®. The low r^2 associated with the trend line (less than 0.05) indicates that no relationship exists between these parameters.

Figure 2-3. Paired FCR and BW data for the general population from the Idaho survey



Note: Blue dots represent the individual sample points from the Idaho survey data. The black dotted line is the trend line fitted by Microsoft Excel®. The low r^2 associated with the trend line (less than 0.05) indicates that no relationship exists between these parameters.

Figure 2-4. Log-transformed paired FCR and BW data for the general population from the Idaho survey

2.3.3.2 General population in Idaho

Summary percentiles for each integer percentage (e.g., 0%, 1%, 2%, 3%) were available from the NCI analysis of dietary recall data from the Idaho survey for the general Idaho population (Buckman et al. 2015). Unlike for the datasets used to develop the BW and DI distributions, the available information provided a good picture of the overall distribution of the data. Thus, rather than using @RISK software to develop a distribution, a linear interpolation was used between each percentile to estimate the FCR at each tenth-of-a-percentile increment (see Appendix A). The resulting values were used to parameterize a discrete distribution in which each of the tenth-of-a-percentile increments had an equal likelihood of being selected during the Monte Carlo simulation. This distribution is shown in Figure 2-5.

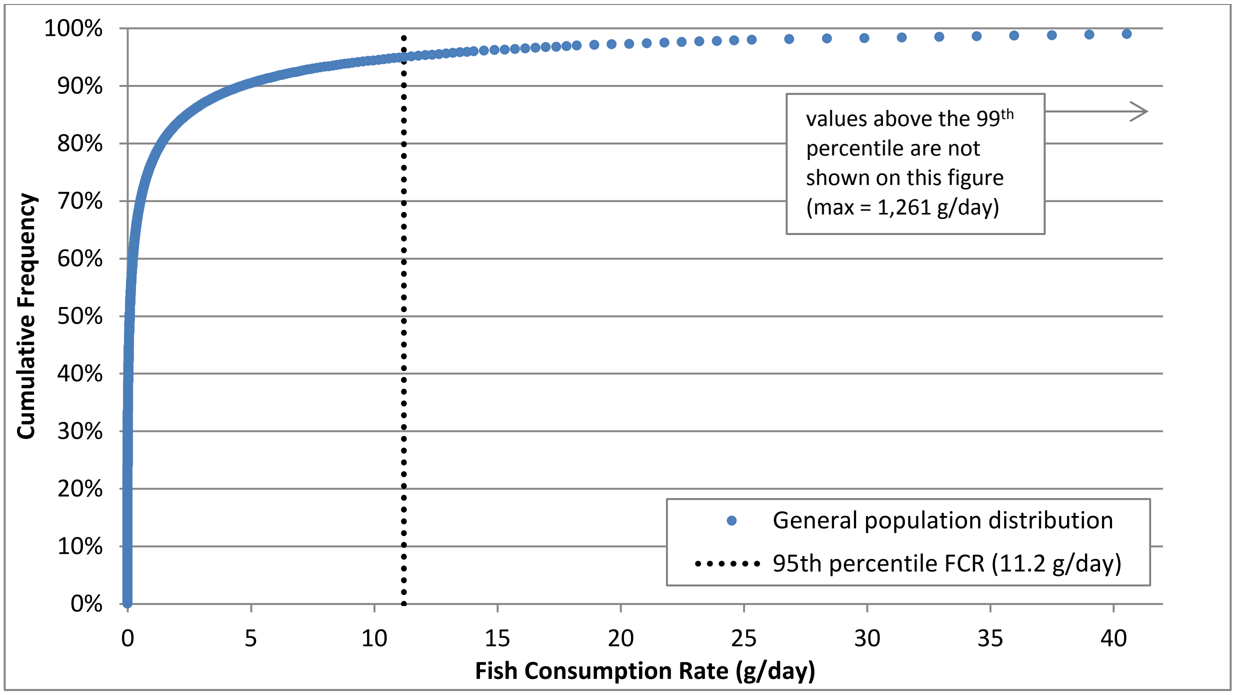


Figure 2-5. Fish consumption rate distribution for general population in Idaho

2.3.3.3 Nez Perce tribal population in Idaho

At the time that the WQC were calculated, only limited percentile data were available from the NCI analysis of FCR data for the Nez Perce Tribe (Ridolfi and Pacific Market Research 2015; Author Unknown 2015). These data included all fish species, and thus an adjustment factor was developed by Idaho DEQ to account for the exclusion of select species (specifically tilapia, estuarine species, and select species of salmon) (Idaho DEQ [in prep]). Thus, as was presented in Table 2-6, the overall FCR for the Nez Perce Tribe was multiplied by a factor of 0.242; this new calculated rate was used to develop the FCR distribution for the calculation of WQC.

Percentile data were available for every 5th percentile, beginning with the 5th percentile and continuing to the 95th percentile. Similar to the process used to determine the distribution to represent the FCR for the general population, a linear interpolation was used between each of the available percentiles to estimate the FCR at each tenth-of-a-percentile increment (see Appendix A). Per direction from Idaho DEQ, all increments below the 5th percentile were assumed to be equal to the 5th percentile value. Above the 95th percentile, a maximum (i.e., 100th percentile) value of 306 g/day was estimated,[6] and a linear interpolation was used to fill in the percentile values between the 95th and 100th percentiles. The resulting distribution is shown in Figure 2-6.

[6] Per direction from Idaho DEQ, the estimated maximum value for the Nez Perce Tribe was assumed to be equal to the maximum rate from the general population (equal to 1,261 g/day), multiplied by the 0.242 adjustment factor used for the rest of the Nez Perce distribution.

The assumptions at the tails of the FCR distribution had limited impact on the shape of the resulting WQC distribution. However, it is important to recognize that these changes resulted in an increase in the mean value of the distribution (approximately 19.2 g/day), about 3 g/day higher than the Idaho-translated mean value for the Nez Perce Tribe of 16.1 g/day. This change in the mean value results in WQC that are lower (i.e., more health-protective) than if the distribution more closely matched the FCR of 16.1 g/day. As shown in the figure, the mean value of 16.1 g/day for the Nez Perce tribal population corresponds to approximately the 70th percentile of the distribution for this population.

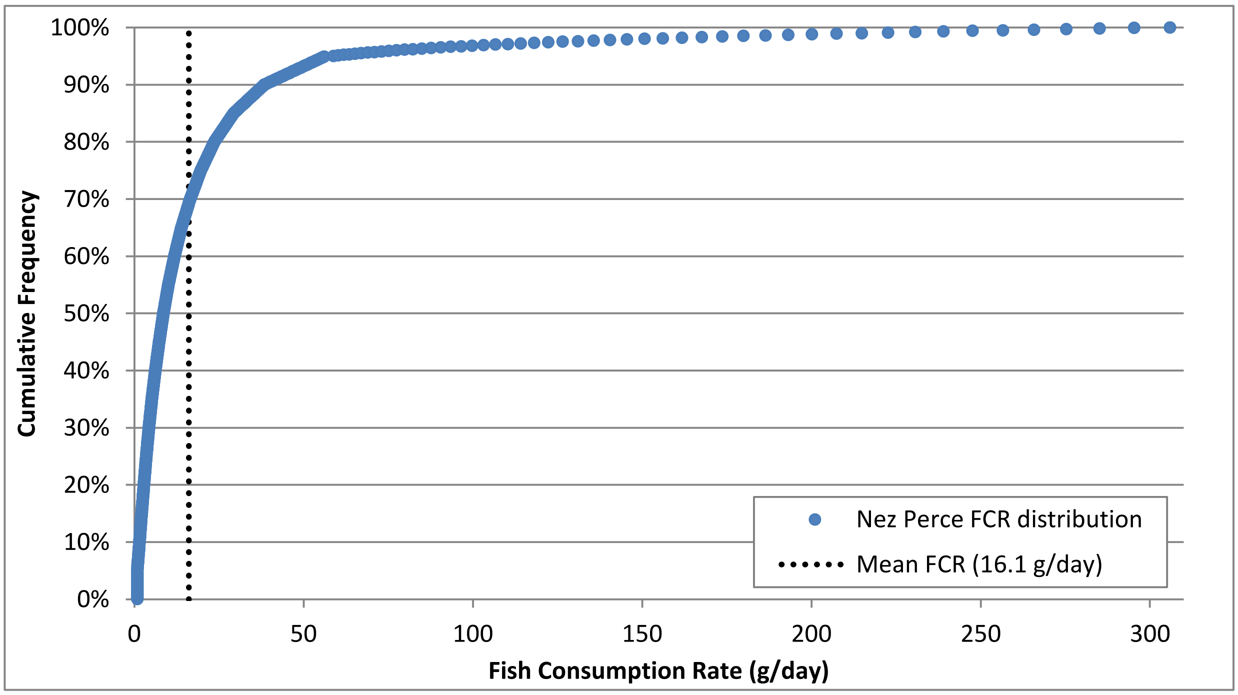


Figure 2-6. FCR distribution for the Nez Perce Tribe based on adjusted consumption data

2.3.3.4 Angler-only population in Idaho

Although a full probabilistic evaluation was not conducted for the angler-only population, a distribution was developed for informational purposes and for use in the sensitivity analysis presented in Section 3.3.2.[7] Summary percentiles were available from the NCI analysis of dietary recall data from the Idaho survey in the same format as for the general population. Thus, the same process used for the general population was used for the angler-only population to estimate a distribution. As shown in Figure 2-7, the mean value of 4.5 g/day for the angler-only population corresponds to approximately the 80th percentile of the distribution for this population.

[7] A distribution was not developed for the Shoshone-Bannock Tribe because no probabilistic evaluation was conducted for this population.

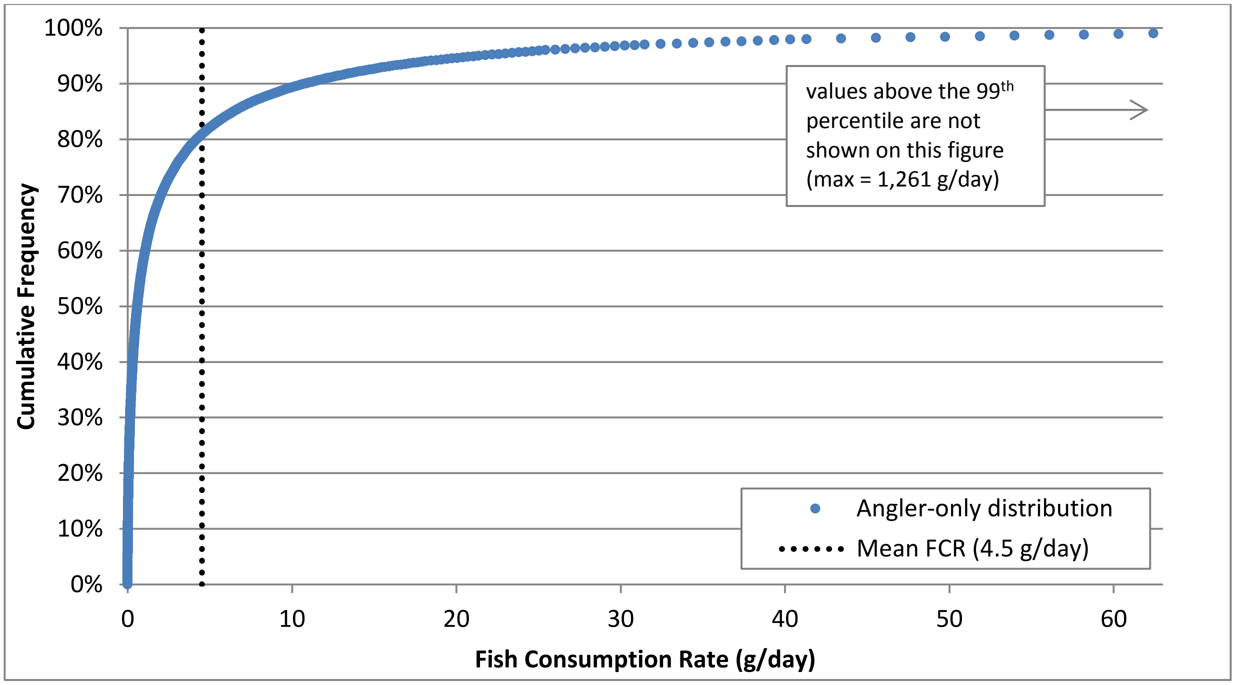


Figure 2-7. Fish consumption rate distribution for angler-only population in Idaho

2.3.4 Relative source contribution

As shown in the equations presented in Table 2-2, relative source contributions (RSCs) were used to calculate WQC (or risk estimates) when non-cancer toxicity values were used. As described in the work plan (Windward 2015), the RSC was treated as a static value (i.e., no distribution was used). The approach used to select RSC values was altered from that outlined in the work plan (Windward 2015) because of the publication of EPA's Final 2015 Updated National Recommended Human Health Criteria (EPA 2015). The RSC values in EPA's final criteria, rather than the values in EPA's 2014 draft updated National Recommended Water Quality Criteria (NRWQC) (EPA 2014) were used as the RSC values for calculation of HH WQC for Idaho.

In general, the 2015 criteria (EPA 2015) were based on the default RSC of 0.2 for most of the COIs evaluated in this report. However, in several cases, EPA's updated criteria used alternative RSC values. These alternative values (i.e., those other than 0.2) were adopted for the calculation of Idaho's WQCs as follows:

- An RSC of 0.4 was used for one chemical (i.e., antimony).
- An RSC of 0.5 was used for one chemical (i.e., gamma-hexachlorocyclohexane [HCH])
- An RSC of 0.8 was used for five chemicals (i.e., 2-chloronaphthalene, chlorophenoxy herbicide [also called 2,4,5-TP or silvex], endrin, endrin aldehyde, and methoxychlor).

RSCs for all chemicals used in the calculation of Idaho's WQC are presented in Appendix A.

Because of the uncertainty associated with the selected RSCs, a sensitivity evaluation was conducted to evaluate the impact of alternative RSC values on the resulting WQC (see Section 3.3).

2.3.5 Bioaccumulation or Bioconcentration Factors

The work plan (Windward 2015) also specified that EPA's 2014 draft updated NRWQC (EPA 2014) would be the primary source of bioaccumulation factors (BAFs). As with the RSC, the methods used to select BAFs/bioconcentration factors (BCFs) for use in the calculation of Idaho's WQC were revised to instead use the BAFs presented by EPA in the Final 2015 Updated National Recommended Human Health Criteria (EPA 2015). The process for selecting the BAFs/BCFs for use in the calculation of Idaho's WQC was as follows:

- When available for a given chemical, the BAFs or BCFs from EPA's 2015 updated criteria (EPA 2015) were used for the calculation of Idaho's WQC. For chemicals with BAFs, the individual trophic-level BAFs were weighted for use in the calculation of WQC as described in Idaho DEQ's technical support document (Idaho DEQ [in prep]). This process is described as follows (and is summarized in Appendix A):
  - **General population and angler-only population in Idaho –** Idaho-specific weighting factors were developed based on FCRs from Idaho's survey data.
  - **Tribal population –** Idaho-specific weighting factors were developed based on FCRs for the Nez Perce Tribe.
- For chemicals not evaluated by EPA in the 2015 updated criteria, BCFs used by EPA in the 2002 NRWQC (EPA 2002) calculations were selected for use in the calculation of WQC for Idaho.

A table of the BAFs/BCFs used for the calculation of Idaho's WQC is provided in Appendix A.

2.3.6 Toxicity Values

Toxicity values (including a cancer slope factor [CSF] for chemicals identified as carcinogens and a reference dose [RfD] for chemicals with non-carcinogenic effects) were determined for each chemical in consultation with Idaho DEQ. Sources of toxicity values included the following:

- For the 94 chemicals included in EPA's 2015 criteria update, the toxicity values in these updated criteria (EPA 2015) were used for the calculation of WQC for Idaho.

- For thallium, the Provisional Peer-Reviewed Toxicity Value (PPRTV) RfD of 1.0×10^{-5} was used for the calculation of the thallium WQC (rather than the RfD of 6.8×10^{-5} used by EPA in the 2002 NRWQC (EPA 2002)).
- For the remaining nine chemicals, toxicity values used by EPA in the 2002 NRWQC (EPA 2002) calculations were used.

A table of the toxicity values used in the calculation of Idaho's WQC is provided in Appendix A.

2.4 Overview of Selected Methods and Parameter Values

Table 2-7 presents a summary of the methods and parameter values used for the calculation of WQCs for the general population and the Nez Perce tribal population.

Table 2-7. Summary of methods and parameters used for the calculation of probabilistic WQC

Method or Parameter	Basis for Parameter Value	
	General Population	Nez Perce Tribal Population
Methods		
Calculation method	probabilistic (protective of the 95th percentile of the population)	probabilistic (protective of the average individual of the population)
Acceptable risk threshold	non-cancer HQ: 1 excess cancer risk: 1×10^{-6}	non-cancer HQ: 1 excess cancer risk: 1×10^{-6}
Parameter values		
Body weight	distribution developed based on general Idaho population	same as for general population
DI rate[a]	distribution developed based on body-weight-normalized rates for adults[b]	same as for general population
FCR	distribution developed based on general Idaho population	distribution developed based on fish consumption rate data for the Nez Perce Tribe
RSC	in general, a default value of 0.2 was used for all chemicals for non-carcinogenic effects, except when alternative values were used by EPA in their 2015 updated criteria (EPA 2015)	same as for general population
BAF/BCF	when available, values from EPA's 2015 criteria update (EPA 2015) were used (BAFs were adjusted with Idaho-specific weighting factors); in other cases, BCFs from EPA's 2002 NRWQC (EPA 2002) were used	same as for general population (except that tribal-specific weighting factors were used to adjust EPA's BAFs)
Toxicity value	primary source was values from EPA's 2015 updated criteria (EPA 2015); otherwise, values from EPA's 2002 NRWQC (EPA 2002) were generally used	same as for general population

a For the calculation of the fish-only intake WQC, the DI rate was set equal to zero.
b Body weight-normalized data was used to ensure an appropriate correlation with body weight distribution.

BAF – bioaccumulation factor
BCF – bioconcentration factor
EPA – US Environmental Protection Agency
DI – drinking water intake
FCR – fish consumption rate
NRWQC – National Recommended Water Quality Criteria
RSC – relative source contribution
WQC – water quality criteria

3 Water Quality Criteria

This section presents the WQC developed for the State of Idaho.

3.1 Probabilistic WQCs for the General Idaho Population

As described in Section 2, two sets of probabilistic WQCs were calculated as follows:

- **General population in Idaho** – WQCs protective of the 95th percentile of the population were calculated using a FCR based on the general Idaho population.
- **Higher-level consumer populations in Idaho** – WQCs protective of the mean individual of the Nez Perce tribal population were calculated using an adjusted FCR based on data from the Nez Perce Tribe. WQC calculated based on the Nez Perce Tribe were used to represent WQC for the other higher-level consumer sub-populations evaluated (i.e., the angler-only and Shoshone-Bannock tribal populations) because of the higher FCR for the Nez Perce tribe.

Table 3-1 presents the WQC (for both fish-only consumption and for fish + water consumption) for each of the 104 COIs evaluated as part of this effort. In addition to presenting the WQC for the general population and the Nez Perce tribal population, this table also presents the "selected WQC," which is equal to the lower of the WQC calculated for these two populations. Table 3-1 also indicates whether the WQC for each chemical were based on cancer or non-cancer toxicity values. A complete summary of these WQC, along with the input parameter values used for each chemical is provided in Appendix B.

Table 3-1. Probabilistic WQC calculated for the state of Idaho

Chemical	Idaho WQS Number	Risk Basis	WQC (µg/L)				Selected WQC (µg/L)[a]	
			General Population		Nez Perce Tribal Population			
			Fish Only	Fish + Water	Fish Only	Fish + Water	Fish Only	Fish + Water
Antimony	1	non-cancer	1,100	3.2	640	10	640	3.2
Nickel	9	non-cancer	540	75	330	150	330	75
Selenium	10	non-cancer	1,400	20	800	59	800	20
Thallium	12	non-cancer	0.13	0.038	0.075	0.050	0.075	0.038
Zinc	13	non-cancer	8,300	1,100	4,800	2,200	4,800	1,100
Cyanide	14	non-cancer	810	2.4	460	7.3	460	2.4
2,3,7,8-TCDD	16	cancer	1.0×10^{-8}	1.0×10^{-8}	6.1×10^{-9}	5.8×10^{-9}	6.1×10^{-9}	5.8×10^{-9}
Acrolein	17	non-cancer	650	2.0	400	6.1	400	2.0
Acrylonitrile	18	cancer	12	0.036	7.0	0.12	7.0	0.036
Benzene[b]	19	cancer	27 – 100	0.35 – 1.3	16 – 58	1.1 – 3.9	16 – 58	0.35 – 1.3
Bromoform	20	cancer	200	4.3	110	13	110	4.3
Carbon tetrachloride	21	cancer	7.8	0.28	4.3	0.72	4.3	0.28
Chlorobenzene	22	non-cancer	1,400	75	780	190	780	75
Chlorodibromomethane	23	cancer	35	0.48	20	1.5	20	0.48
Chloroform	26	cancer[c]	3,900	39	2,300	120	2,300	39
Dichlorobromomethane	27	cancer	46	0.56	26	1.7	26	0.56
1,2-Dichloroethane	29	cancer	1,100	6.2	640	19	640	6.2
1,1-Dichloroethylene	30	non-cancer	27,000	200	16,000	610	16,000	200
1,2-Dichloropropane	31	cancer	53	0.56	30	1.7	30	0.56
1,3-Dichloropropene	32	cancer	20	0.17	11	0.48	11	0.17
Ethylbenzene	33	non-cancer	210	70	120	89	120	70
Methyl bromide	34	non-cancer	20,000	80	12,000	240	12,000	80
Methylene chloride	36	cancer	2,200	1.0	1,300	32	1,300	1.0
1,1,2,2-Tetrachloroethane	37	cancer	4.6	0.10	2.5	0.28	2.5	0.10

Chemical	Idaho WQS Number	Risk Basis	WQC (µg/L)				Selected WQC (µg/L)[a]	
			General Population		Nez Perce Tribal Population			
			Fish Only	Fish + Water	Fish Only	Fish + Water	Fish Only	Fish + Water
Tetrachloroethylene (perchloroethylene)	38	cancer	49	8.6	28	15	28	8.6
Toluene	39	non-cancer	880	36	500	99	500	36
trans-1,2- DCE	40	non-cancer	6,500	81	3,700	240	3,700	81
1,1,1-Trichloroethane	41	non-cancer	300,000	7,800	170,000	22,000	170,000	7,800
1,1,2-Trichloroethane	42	cancer	15	0.34	8.2	0.99	8.2	0.34
TCE	43	cancer	11	0.39	6.7	1.1	6.7	0.39
Vinyl chloride	44	cancer	2.7	0.013	1.6	0.040	1.6	0.013
2-Chlorophenol	45	non-cancer	1,400	19	810	57	810	19
2,4-Dichlorophenol	46	non-cancer	93	11	55	22	55	11
2,4-Dimethylphenol	47	non-cancer	4,200	80	2,400	230	2,400	80
2-Methyl-4,6-dinitrophenol	48	non-cancer	44	1.1	26	3.3	26	1.1
2,4-Dinitrophenol	49	non-cancer	600	8.0	350	24	350	8.0
3-Methyl-4-chlorophenol	52	non-cancer	3,900	360	2,200	790	2,200	360
Pentachlorophenol	53	cancer	0.054	0.031	0.027	0.023	0.027	0.023
Phenol	54	non-cancer	460,000	2,500	270,000	7,200	270,000	2,500
2,4,6-Trichlorophenol	55	cancer	4.6	1.5	2.6	1.8	2.6	1.5
Acenaphthene	56	non-cancer	160	110	94	78	94	78
Anthracene	58	non-cancer	660	520	370	340	370	340
Benzidine	59	cancer	0.018	9.0×10^{-5}	0.011	2.6×10^{-4}	0.011	9.0×10^{-5}
Benzo(a)anthracene	60	cancer	0.0024	0.0023	0.0014	0.0013	0.0014	0.0013
Benzo(a)pyrene	61	cancer	2.4×10^{-4}	2.3×10^{-4}	1.4×10^{-4}	1.3×10^{-4}	1.4×10^{-4}	1.3×10^{-4}
Benzo(b)fluoranthene	62	cancer	0.0024	0.0023	0.0014	0.0013	0.0014	0.0013
Benzo(k)fluoranthene	64	cancer	0.024	0.023	0.014	0.013	0.014	0.013
Bis(2-Chloroethyl) ether	66	cancer	3.8	0.019	2.2	0.055	2.2	0.019
Bis(2-chloro-1-methylethyl) ether	67	non-cancer	6,000	150	3,500	430	3,500	150
Bis(2-ethylhexyl) phthalate	68	cancer	0.70	0.55	0.39	0.36	0.39	0.36

Chemical	Idaho WQS Number	Risk Basis	WQC (µg/L)				Selected WQC (µg/L)[a]	
			General Population		Nez Perce Tribal Population			
			Fish Only	Fish + Water	Fish Only	Fish + Water	Fish Only	Fish + Water
Butyl benzyl phthalate	70	cancer	0.19	0.18	0.11	0.11	0.11	0.11
2-Chloronaphthalene	71	non-cancer	2,000	880	1,100	890	1,100	880
Chrysene	73	cancer	0.24	0.23	0.14	0.14	0.14	0.14
Dibenzo(a,h)anthracene	74	cancer	2.4×10^{-4}	2.2×10^{-4}	1.4×10^{-4}	1.3×10^{-4}	1.4×10^{-4}	1.3×10^{-4}
1,2-Dichlorobenzene	75	non-cancer	5,400	1,100	3,100	1,700	3,100	1,100
1,3-Dichlorobenzene	76	non-cancer	22	6.8	11	7.5	11	6.8
1,4-Dichlorobenzene	77	non-cancer	1,400	250	810	410	810	250
3,3'-Dichlorobenzidine	78	cancer	0.25	0.039	0.14	0.069	0.14	0.039
Diethyl phthalate	79	non-cancer	1,200	1,000	700	620	700	620
Dimethyl phthalate	80	non-cancer	3,400	3,100	2,000	2,000	2,000	2,000
Di-n-Butyl phthalate	81	non-cancer	46	45	27	27	27	27
2,4-Dinitrotoluene	82	cancer	2.8	0.030	1.6	0.088	1.6	0.030
1,2-Diphenylhydrazine	85	cancer	0.35	0.023	0.19	0.056	0.19	0.023
Fluoranthene	86	non-cancer	35	32	20	20	20	20
Fluorene	87	non-cancer	110	81	58	51	58	51
Hexachlorobenzene	88	cancer	1.3×10^{-4}	1.3×10^{-4}	6.0×10^{-5}	6.0×10^{-5}	6.0×10^{-5}	6.0×10^{-5}
Hexachlorobutadiene	89	cancer	0.039	0.038	0.017	0.017	0.017	0.017
Hexachlorocyclopentadiene	90	non-cancer	5.8	5.2	3.9	3.7	3.9	3.7
Hexachloroethane	91	cancer	0.39	0.26	0.15	0.14	0.15	0.14
Indeno(1,2,3-cd)pyrene	92	cancer	0.0022	0.0022	0.0014	0.0014	0.0014	0.0014
Isophorone	93	cancer	3,200	22	1,700	64	1,700	22
Nitrobenzene	95	non-cancer	950	8.1	540	24	540	8.1
N-nitrosodimethylamine	96	cancer	4.9	4.0×10^{-4}	2.8	0.0012	2.8	4.0×10^{-4}
N-Nitrosodi-n-propylamine	97	cancer	0.85	0.003	0.49	0.009	0.49	0.0030
N-Nitrosodiphenylamine	98	cancer	10	3.2	5.8	4.0	5.8	3.2
Pyrene	100	non-cancer	47	40	27	26	27	26

Chemical	Idaho WQS Number	Risk Basis	WQC (µg/L)				Selected WQC (µg/L)[a]	
			General Population		Nez Perce Tribal Population			
			Fish Only	Fish + Water	Fish Only	Fish + Water	Fish Only	Fish + Water
1,2,4-Trichlorobenzene	101	cancer	0.16	0.15	0.11	0.11	0.11	0.11
Aldrin	102	cancer	1.1×10^{-6}	1.2×10^{-6}	5.3×10^{-7}	5.1×10^{-7}	5.3×10^{-7}	5.1×10^{-7}
alpha- HCH	103	cancer	7.5×10^{-4}	6.7×10^{-4}	4.2×10^{-4}	4.0×10^{-4}	4.2×10^{-4}	4.0×10^{-4}
beta- HCH	104	cancer	0.023	0.0084	0.014	0.0099	0.014	0.0084
gamma-HCH	105	non-cancer	6.9	6.5	4.2	3.9	4.2	3.9
Chlordane	107	cancer	4.5×10^{-4}	4.4×10^{-4}	2.4×10^{-4}	2.4×10^{-4}	2.4×10^{-4}	2.4×10^{-4}
4,4'- DDT	108	cancer	5.3×10^{-5}	5.3×10^{-5}	1.7×10^{-5}	1.7×10^{-5}	1.7×10^{-5}	1.7×10^{-5}
4,4'- DDE	109	cancer	2.9×10^{-5}	2.8×10^{-5}	1.2×10^{-5}	1.2×10^{-5}	1.2×10^{-5}	1.2×10^{-5}
4,4’- DDD	110	cancer	1.9×10^{-4}	1.8×10^{-4}	9.8×10^{-5}	9.4×10^{-5}	9.8×10^{-5}	9.4×10^{-5}
Dieldrin	111	cancer	1.8×10^{-6}	1.8×10^{-6}	8.9×10^{-7}	8.8×10^{-7}	8.9×10^{-7}	8.8×10^{-7}
alpha-Endosulfan	112	non-cancer	44	18	26	19	26	18
beta-Endosulfan	113	non-cancer	74	20	40	26	40	20
Endosulfan sulfate	114	non-cancer	67	20	36	24	36	20
Endrin	115	non-cancer	0.046	0.046	0.026	0.026	0.026	0.026
Endrin aldehyde	116	non-cancer	1.9	1.5	1.2	1.1	1.2	1.1
Heptachlor	117	cancer	8.6×10^{-6}	8.6×10^{-6}	4.1×10^{-6}	4.2×10^{-6}	4.1×10^{-6}	4.2×10^{-6}
Heptachlor epoxide	118	cancer	4.5×10^{-5}	4.5×10^{-5}	2.6×10^{-5}	2.7×10^{-5}	2.6×10^{-5}	2.7E-05
PCBs	119	cancer	1.1×10^{-4}	1.1×10^{-4}	6.3×10^{-5}	6.1×10^{-5}	6.3×10^{-5}	6.1×10^{-5}
Toxaphene	120	cancer	0.0010	9.8×10^{-4}	6.7×10^{-4}	6.4×10^{-4}	6.7×10^{-4}	6.4×10^{-4}
1,2,4,5-Tetrachlorobenzene	na	non-cancer	0.10	0.10	0.050	0.049	0.050	0.049
2,4,5-Trichlorophenol	na	non-cancer	990	310	560	380	560	310
Bis(chloromethyl) ether	na	cancer	0.03	9.0×10^{-5}	0.018	2.8×10^{-4}	0.018	9.0×10^{-5}
Chlorophenoxy herbicide (2,4,5-TP) [silvex]	na	non-cancer	730	110	420	210	420	110
Chlorophenoxy herbicide (2,4-D)	na	non-cancer	22,000	800	13,000	2,200	13,000	800
Dinitrophenols	na	non-cancer	1,700	8.0	1,000	24	1,000	8.0
HCH-technical	na	cancer	0.017	0.0077	0.0096	0.0075	0.0096	0.0075

Chemical	Idaho WQS Number	Risk Basis	WQC (µg/L)				Selected WQC (µg/L)[a]	
			General Population		Nez Perce Tribal Population			
			Fish Only	Fish + Water	Fish Only	Fish + Water	Fish Only	Fish + Water
Methoxychlor	na	non-cancer	0.025	0.024	0.016	0.016	0.016	0.016
Pentachlorobenzene	na	non-cancer	0.20	0.19	0.089	0.085	0.089	0.085

[a] The selected WQC is the lower of the WQC for the general population or the Nez Perce tribal population.

[b] The range of WQC for benzene is the result of evaluating two different cancer slope factors for this chemical, as was done by EPA in their *Final 2015 Updated National Recommended Human Health Criteria* (EPA 2015).

[c] The WQC for chloroform was developed using the nonlinear cancer equation (Idaho DEQ [in prep]).

DCE – dichloroethylene
DDD – dichlorodiphenyldichloroethane
DDE – dichlorodiphenyldichloroethylene
DDT – dichlorodiphenyltrichloroethane
EPA – US Environmental Protection Agency
HCH – hexachlorocyclohexane
TCDD – tetrachlorodibenzo-*p*-dioxin
TCE – trichloroethylene
WQC – water quality criteria
WQS – water quality standard

3.2 DETERMINISTIC WQC CHECK FOR THE ANGLER-ONLY POPULATION AND THE SHOSHONE-BANNOCK TRIBAL POPULATION

After WQC were calculated probabilistically for the general population and the Nez Perce tribal population, the protectiveness of the selected WQC was evaluated for the other two higher-level consumer populations (i.e., the angler-only population and the Shoshone-Bannock tribal population). As noted in Section 2.1, the intent of this evaluation was to ensure that the probabilistically calculated WQC would be protective of the average individual in these populations.

To conduct this check, risk estimates were calculated using Equations 2-5 through 2-8 in Table 2-2. In addition to the probabilistically calculated WQC (Table 3-1), parameter values used in these equations are shown in Table 3-2. For the angler-only population, all chemical-specific parameter values (i.e., RSC, BAF/BCF, and toxicity values) remained unchanged from those used in the calculation of WQC for the general population. For the Shoshone-Bannock tribal population, all chemical-specific parameter values (i.e., RSC, BAF/BCF, and toxicity values) remained unchanged from those used in the calculation of WQC for the Nez Perce tribal population.

Table 3-2. Parameters used for the calculation of risks for the angler-only population

Parameter	Value	Notes
BW (kg)	80	mean BW value from Idaho survey (see Table 2-4)
DI rate (L/day)	2.4	90^{th} percentile value (see Table 2-5)
FCR for the angler-only population (g/day)	4.5	mean value; risks were also calculated based on the 90^{th} percentile FCR (10.8 g/day) and the 95^{th} percentile FCR (21.4 g/day) of the angler-only population (see Table 2-6)
FCR for the Shoshone-Bannock tribal population (g/day)	5.6	mean value; risks were also calculated based on the 90^{th} percentile FCR (14.7 g/day) and the 95^{th} percentile FCR (24.1 g/day) of the Shoshone-Bannock tribal population (see Table 2-6)

BW – body weight
DI – drinking water intake
FCR – fish consumption rate

Table 3-3 presents a summary of the excess cancer risk and non-cancer HQs calculated as a result of this evaluation (complete results are presented in Appendix B). As presented in Table 3-3, no excess cancer risks were greater than the threshold of 1×10^{-6}, and no HQs were greater than the threshold of 1. This indicates that the WQCs calculated based on the general and tribal populations were protective of the angler-only population and the Shoshone-Bannock tribal population, based on the average individual in these populations and based on both the 90^{th} and 95^{th} percentile individuals. This was expected because the FCRs at these levels of the distribution (4.5 g/day, 10.8 g/day, and 21.4 g/day for the angler-only population, and 5.6 g/day, 14.7 g/day, and 24.1 g/day for the Shoshone-Bannock population) were below or similar to the 95th percentile FCR for the general population (11.8 g/day) and the mean FCR for the tribal population (16.1 g/day).

Table 3-3. Summary of risks calculated for the angler-only population

Population and FCR	Risk Estimates Based on Fish-Only WQC[a]		Risk Estimates Based on Fish + Water WQC[a]	
	Non-Cancer HQs	Range of Excess Cancer Risks	Non-Cancer HQs	Range of Excess Cancer Risks
Angler-Only Population				
Average FCR (4.5 g/day)	0.2 to 0.3	1×10^{-7} to 3×10^{-7}	0.2 to 0.6	6×10^{-8} to 6×10^{-7}
90th percentile FCR (10.8 g/day)	0.4 to 0.6	3×10^{-7} to 6×10^{-7}	0.4 to 0.8	6×10^{-8} to 8×10^{-7}
95th percentile FCR (21.4 g/day)	0.8 to 1	6×10^{-7} to 1×10^{-6}	0.6 to 1	6×10^{-8} to 1×10^{-6}
Shoshone-Bannock Tribal Population				
Average FCR (5.6 g/day)	0.3	3×10^{-7}	0.3 to 0.7	6×10^{-8} to 6×10^{-7}
90th percentile FCR (14.7 g/day)	0.7	7×10^{-7}	0.6 to 1	6×10^{-8} to 1×10^{-6}
95th percentile FCR (24.1 g/day)	1	1×10^{-6}	0.6 to 1	6×10^{-8} to 1×10^{-6}

[a] Excess cancer risks and non-cancer HQs were calculated based on the WQC presented in Table 3-1. Complete results are presented in Appendix B.

FCR – fish consumption rate HQ – hazard quotient WQC – water quality criteria

3.3 FURTHER EVALUATION

As was discussed in the work plan (Windward 2015), several additional analyses were conducted to further evaluate the probabilistically calculated human health WQC values. These included an evaluation of the RSC (Section 3.3.1) and an evaluation of the protectiveness of the probabilistic method (Section 3.3.2).

3.3.1 Evaluation of RSC

There is considerable uncertainty associated with the use of default RSC values, particularly with variable fish consumption and DI rates. To further evaluate this uncertainty, alternative RSCs were investigated for three chemicals using model parameterization for the general population to quantify the impact of changing these default values. Table 3-4 presents a summary of the resulting probabilistically calculated WQC based on the original default RSC of 0.2, as well as the WQC that resulted when the two alternative RSCs were used (0.4 and 0.8).

Table 3-4. Evaluation of alternative RSCs on calculated WQC

Chemical	WQC (µg/L)					
	Fish-Only Intake			Fish + Water Intake		
	RSC = 0.2	RSC = 0.4	RSC = 0.8	RSC = 0.2	RSC = 0.4	RSC = 0.8
Diethyl phthalate	1,200	2,400	4,700	1,000	2,000	4,200
Ethylbenzene	230	450	900	70	140	290
Toluene	970	1,900	3,700	36	72	150

Note: WQC presented in this table are based on the general population and thus were calculated using the same model parameterization as that used for the general population. It should be noted that EPA's default BAFs were used for this evaluation.

BAF – bioaccumulation factor
EPA – US Environmental Protection Agency
RSC – relative source contribution
WQC – water quality criteria

As presented in Table 3-4, and as would be expected based on a review of the WQC equations (Table 2-2), there is approximately a linear relationship between changes in the RSC and changes in the WQC. In other words, increasing the RSC by a factor of two resulted in an increase in the WQC by approximately the same factor; similarly, an increase in the RSC by a factor of four resulted in approximately the same increase in the WQC. The changes in the WQC were not perfectly linear because of the slight variability introduced in the input values when probabilistic calculation methods are used.

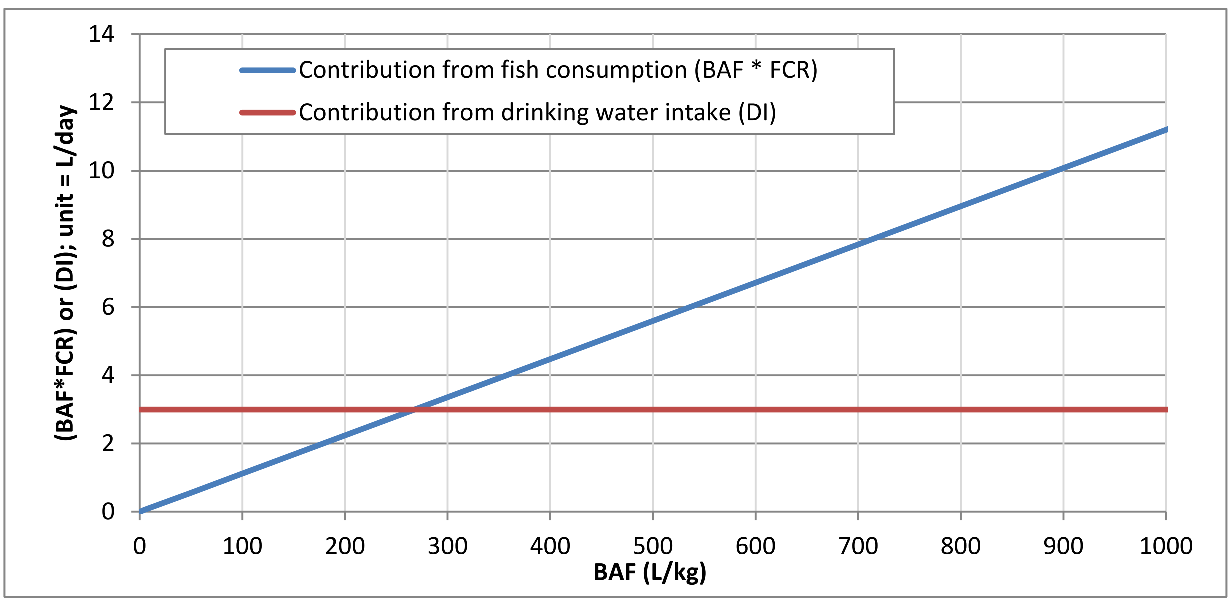
3.3.2 Relative importance of fish consumption and drinking water intake rates on the WQC

In reviewing the selected WQC in Table 3-1, it becomes apparent that the BAF/BCF value for a given chemical is important in determining whether the lowest fish + water WQC is based on the general population or the Nez Perce tribal population. Understanding this relationship involves two key pieces of information, which are described as follows:

1. The BAF/BCF value for each chemical impacts whether the selected WQC is based primarily on the intake of drinking water or fish.
    - For chemicals with low BAFs/BCFs (i.e., for which the bioaccumulation of chemicals in fish tissue is low), the drinking water intake rate has a greater influence on the selected WQC.
    - For chemicals with higher BAFs/BCFs (i.e., chemicals that bioaccumulate at a higher rate in fish tissue), the fish consumption rate has a greater influence on the selected WQC.

2. There are important differences in the DI rates and FCRs at the percentile of the population upon which the WQC are based.
   - **General population –** WQC for the general population are based on the 95th percentile of the population, which roughly corresponds to an FCR of 11.2 g/day and a DI of 3.0 L/day.
   - **Nez Perce Tribe –** WQC for the Nez Perce tribal population are based on the mean of the population, which roughly corresponds to an FCR of 16.1 g/day and a DI of 1.0 L/day.

Together, this information means that for chemicals with lower BAFs, the DI rate is the key factor driving the WQC, and thus the selected WQC is based on the general population. Conversely, for chemicals with higher BAFs, the FCR is the key factor driving the WQC, and thus the selected WQC is based on the Nez Perce tribal population. Figure 3-1 illustrates this relationship. Based on the approximate parameterization at the 95th percentile for the general population, this figure shows that at BAFs above approximately 300 L/kg, the FCR drives the WQC, while at BAFs below approximately 250 L/kg, the DI rate drives the WQC (between these values, both factors influence the WQC).



Note: Figure is based on an FCR or 11.2 g/day and DI of 3.0 L/day (i.e., roughly the values expected at the 95th percentile for the general population).

Figure 3-1. Relative importance of the FCR and DI rate as a function of BAF/BCF

3.3.3 Calculation of probabilistically-calculated WQC for the angler-only population

To further evaluate the protectiveness of the WQC for the other higher-level consumer populations, an evaluation of WCQ using probabilistic methods was conducted for the angler-only population for approximately 10% of the COIs (i.e., 10 chemicals). The list of COIs selected for inclusion in this evaluation captured a range of BAF/BCF values and included COIs for which the WQC were based on both cancer and non-cancer risks.

Table 3-5 presents the comparison of these probabilistically calculated WQC for the angler-only population with the selected WQC. As can be seen in the table, the selected WQC are lower than the WQC calculated for the angler-only population for all 10 chemicals. These results indicate that the methods used to calculate the selected WQC are sufficiently health-protective of the average individual from the angler-only population and thus provide added confidence in the selected WQC.

Table 3-5. Probabilistically calculated WQC for the angler-only population

Chemical Name	Idaho DEQ Number	BAF/BCF (L/kg)	Fish + Water WQC (µg/L)		Selected WQC Lower than WQC Calculated based on Angler-Only Population?
			Selected WQC from Table 3-1	WQC Calculated Based on Angler-Only Population	
Chemicals for which WQC are based on cancer risks					
N-nitrosodimethylamine	96	0.026	4.0×10^{-4}	0.0013	yes
Trichloroethylene (TCE)	43	11	0.39	1.2	yes
Chrysene	73	3,900	0.14	0.24	yes
PCBs	119	31,200	6.1×10^{-5}	1.1×10^{-4}	yes
4,4'- DDE	109	1,300,000	1.2×10^{-5}	3.0×10^{-5}	yes
Chemicals for which WQC are based on non-cancer hazards					
Cyanide	14	1	2.4	7.6	yes
Selenium	10	4.8	20	61	yes
Ethylbenzene	33	130	70	130	yes
Dimethyl Phthalate	80	4,000	2,000	3,500	yes
Endrin	115	27,000	0.026	0.049	yes

BAF – bioaccumulation factor
BCF – bioconcentration factor
DDE – dichlorodiphenyldichloroethylene
WQC – water quality criteria

4 References

Arcadis. 2014. Probabilistic ambient water quality criteria calculator (PAWQCC). Arcadis. Available from: https://www.deq.idaho.gov/media/1117234/58-0102-1201-probabilistic-ambient-wq-criteria-calculator-presentation-040214.pdf.

Author Unknown. 2015. A Fish Consumption Survey of the [Shoshone-Bannock Tribes] [Nez Perce Tribe] Combination Draft Final Report. Volume II—Current Fish Consumption Survey. Available from: http://www.deq.idaho.gov/media/60177033/58-0102-1201-vol-ii-shoshone-bannock-nez-perce-report-0815.pdf.

Buckman DW, Parsons R, Kahle L. 2015. NCI method estimates of usual intake distributions for fish consumption in Idaho. Information Management Services, Inc. Available from: http://www.deq.idaho.gov/media/60177036/58-0102-1201-nci-method-estimates-final.pdf.

EPA. 2000. Methodology for deriving ambient water quality criteria for the protection of human health (2000). EPA-822-B-00-004. US Environmental Protection Agency, Washington, DC.

EPA. 2001. Risk assessment guidance for Superfund: volume 3—part A, process for conducting probabilistic risk assessment. EPA 540-R-02-002. Office of Solid Waste and Emergency Response, US Environmental Protection Agency, Washington, DC.

EPA. 2002. National recommended water quality criteria: 2002. Human health criteria calculation matrix. EPA-822-R-02-012. US Environmental Protection Agency, Washington, DC.

EPA. 2011. Exposure factors handbook: 2011 edition. EPA/600/R-09-052F. National Center for Environmental Assessment, US Environmental Protection Agency, Washington, DC.

EPA. 2012. EPA disapproval of new and revised human health water quality criteria for toxics, Idaho Docket 58-0102-0503. US Environmental Protection Agency, Seattle, WA.

EPA. 2014. Draft: updated national recommended water quality criteria - human health [online]. US Environmental Protection Agency, Washington, DC. [Cited 2015.] Available from: http://water.epa.gov/scitech/swguidance/standards/criteria/current/hhdraft.cfm.

EPA. 2015. Final 2015 updated national recommended human health criteria [online]. US Environmental Protection Agency, Washington, DC. [Cited 2015.] Available from: http://water.epa.gov/scitech/swguidance/standards/criteria/current/hhfinal.cfm.

FDEP. 2013. Technical support document: derivation of human health-based criteria and risk assessment. Draft. Florida Department of Environmental Protection, Division of Environmental Assessment and Restoration, Tallahassee, FL.

Idaho DEQ. 2015a. Human health criteria - fish consumption rates. DEQ recommendations on criteria evaluation. Idaho Department of Environmental Quality. Available from: http://www.deq.idaho.gov/media/60160094/58-0102-1201-recommendations-on-criteria-calculation-presentation-042115.pdf.

Idaho DEQ. 2015b. Summary and comparison of fish consumption rates, g/day. Idaho Department of Environmental Quality. Available from: http://www.deq.idaho.gov/media/60177028/58-0102-1201-summary-and-comparison-of-fcrs-0815.pdf

Idaho DEQ. [in prep]. Idaho human health criteria: technical support document. State of Idaho department of Environmental Quality.

NWRG. 2015. IDEQ fish consumption survey final report. Northwest Research Group, LLC. Available from: http://www.deq.idaho.gov/media/60176884/58-0102-1201-nwrg-fish-consumption-survey-final-report.pdf

Ridolfi, Pacific Market Research. 2015. A fish consumption survey of the [Shoshone-Bannock Tribes] [Nez Perce Tribe]. Combination draft final report. Volume III (Appendices to Volume II, current fish consumption survey). Ridolfi and Pacific Market Research. Available from: http://www.deq.idaho.gov/media/60177034/58-0102-1201-shoshone-bannock-nez-perce-report-0815.pdf

Windward. 2015. Work plan for the development of water quality criteria for the State of Idaho using probabilistic methods. Windward Environmental, LLC, Seattle, WA.