April 1, 2022

Idaho Association of Commerce & Industry

Employers Advocating Economic Opportunity in Idaho®

Sent via email to paula.wilson@deq.idaho.gov

Ms. Paula Wilson
Idaho Department of Environmental Quality
1410 North Hilton
Boise, ID 83706

Dear Ms. Wilson:

On March 2, 2022, the Department of Environmental Quality published a notice for establishing new human health water quality criteria (HHWQC) for inorganic arsenic (Proposed Rule). This "notice" is the result of nearly four years of rulemaking meetings to derive this proposed criteria.

The Idaho Association of Commerce and Industry (IACI) is the leading trade association of Idaho businesses and represents hundreds of employer members of all sizes engaged in diverse commercial and industrial enterprises through the state. The HHWQC for arsenic are used to set requirements for wastewater discharge permits and for cleanup/remedial objectives. Thus, these criteria will have direct impact on the IACI membership. Because of the importance of these criteria to the IACI membership, extensive comments on the regulatory, technical and implementation aspects of this proposed rulemaking have been submitted by IACI throughout the rulemaking.

The attached comments respond to the March 2, 2022, Proposed Rule. Specifically, these comments address the following topics: (a) review of the regulatory history and framework for arsenic HHWQC in Idaho; (b) arsenic concentrations (and relationships) in Idaho waters and fish; (c) utilization of the environmental data to develop arsenic HHWQC; and finally (d) comments and recommendations for the Proposed Rule.

IACI appreciates the considerable work that the Department has done on this rulemaking. The investigation of arsenic in Idaho surface water and fish tissues that the Department conducted provided high quality scientific information for the basis of this rulemaking. The negotiated rulemaking process allowed a thorough examination of this information and the ability to work through regulatory issues associated with developing the proposed criteria. Please contact us if you have any questions.

Sincerely,

Alex LaBeau
President

cc: Alan Prouty, Chair
IACI Environment Committee

IACI
Idaho Association of Commerce & Industry
Employers Advocating Economic Opportunity in Idaho®

Idaho Association of Commerce and Industry (IACI) Comments on Proposed Arsenic Human Health Water Quality Standards

April 1, 2022

Contents

EXECUTIVE SUMMARY

The Department of Environmental Quality initiated in 2018 a rulemaking to update Idaho's human health water quality criteria (HHWQC) for inorganic arsenic (As). This rulemaking was prompted by a settlement that the Environmental Protection Agency (EPA) had entered into with Northwest Environmental Advocates in which EPA revoked its prior approval of Idaho's inorganic arsenic HHWQC. The settlement required new HHWQC for inorganic arsenic to be set.

The Department's rulemaking was buttressed by an extensive scientific investigation of arsenic concentrations in surface waters and fish throughout Idaho. The goal was to ***"…help to ensure that DEQ uses appropriate, Idaho-specific, scientifically defensible inputs"*** to derive the criteria. This scientific information is key to the rulemaking as arsenic is naturally prevalent through Idaho's surface waters.

Based on this best available, scientific data the Department proposed the following criteria for inorganic arsenic:

For the domestic water supply designated use:

- Water column criterion of 10 micrograms per liter.

For the primary or secondary recreation designated use:

- Water column criterion of 4.3 micrograms per liter.
- Fish tissue criterion of 8.0 micrograms per kilogram (wet weight) with the fish tissue value superseding the water column criteria.

IACI supports the proposed domestic water supply water column criterion of 10 micrograms per liter. IACI also believes that the domestic water supply criteria should include a fish tissue value of 8.0 micrograms per kilogram (wet weight). For the primary or secondary recreation designated use, IACI believes water column screening value would be most appropriate, but if the Department chooses to include a water column criterion, IACI supports a water column criterion of 13 micrograms per liter and a fish tissue criterion value of 8.0 micrograms per kilogram (wet weight).

1. INTRODUCTION

The Idaho Department of Environmental Quality (Department) initiated in 2018, a rulemaking to update Idaho's human health water quality criteria (HHWQC) for arsenic (As). The proposed revisions are found in IDAPA 58.01.02 subsections 210.01.a. and b., 210.03.d. and e., and 210.05.b. This rulemaking was commenced to address a May 2016, the U.S Environmental Protection Agency (EPA) Consent Decree with Northwest Environmental Advocates to reconsider EPA's 2010 approval of Idaho's HHWQC for arsenic. Though EPA had approved in 2010 Idaho's HHWQC for arsenic of 10 micrograms per liter (μg/L), in September 2016 EPA reversed is prior approval.[1] The Consent Decree requires that EPA propose new HHWQC for arsenic by November 15, 2018, and that EPA either approve Idaho's submittal of revised HHWQC for arsenic or promulgate federal criteria by July 15, 2019. In June 2018, the Court granted the Unopposed Motion to Modify Consent Decree, extending the November 15, 2018, and July 15, 2019, deadlines to November 15, 2022, and November 15, 2023, respectively. This rulemaking will enable Idaho to adopt HHWQC for arsenic under state rulemaking and may prevent federal promulgation of criteria for Idaho by EPA.

The March 2, 2022 notice by the Department proposed the following HHWQC for inorganic arsenic (Proposed Rule):

Table 1
Proposed Water Quality Criteria

Designated Use	Water Column Criterion (μg/L)	Fish Tissue Criterion (μg/kg – wet)	Notes
Domestic water supply use (water and fish consumption)	10		Dissolved, inorganic forms only.
Primary or secondary recreation use (fish only)	4.3	8.0	Water column element is based on dissolved inorganic arsenic; fish tissue element is based on total recoverable inorganic arsenic in muscle or fillet. Fish tissue element supersedes water column element.[2]

The Idaho Association of Commerce and Industry (IACI) is the leading trade association of Idaho businesses and represents hundreds of employer members of all sizes engaged in diverse commercial and industrial enterprises through the state. The HHWQC for arsenic are used to set requirements for wastewater discharge permits and for

[1] The 10 μg/L arsenic criteria was for both consumption of fish only and consumption of fish & water.

[2] Proposed rule has additional clarifications and requirements applicable to the fish tissue element.

cleanup/remedial objectives. Thus, these criteria will have direct impact on the IACI membership.

IACI, throughout the history of this rulemaking, has submitted extensive comments on the regulatory, technical and implementation aspects of this proposed rulemaking. This comment letter responds to the March 2, 2022 Proposed Rule. Specifically, these comments address the following topics: (a) review of the regulatory history and framework for arsenic HHWQC in Idaho; (b) arsenic concentrations (and relationships) in Idaho waters and fish; (c) utilization of the environmental data to develop arsenic HHWQC; and finally (d) comments and recommendations on the Proposed Rule.

2. BACKGROUND

The State of Idaho has wrestled for over three decades with reconciling the uncertainty in the science on the toxicity of arsenic, how to account for naturally occurring high concentrations of arsenic in Idaho groundwater and surface water, the utilization of that science in establishing appropriate and protective regulatory HHWQC, and conflict with the EPA over the appropriate criteria. This uncertainty and conflict continues today. Reconciling these issues was well illustrated in a 2007 letter from then Department Director Hardesty in which she discussed the use of the Safe Drinking Water Act (SDWA) Maximum Contaminant Level (MCL) as the HHWQC for arsenic:[3]

> "….Second was the concern for cities with a ground water based public water supply that exceeds 10 μg/L arsenic criterion and the associated arsenic concentration in the NPDES wastewater discharge, a situation not uncommon in Idaho. This is made even more difficult by the fact the efforts to treat water supplies to achieve the new drinking water requirement will likely leave even higher concentrations of arsenic to be discharged by public wastewater systems."

This current rulemaking is the Department's fourth effort in establishing arsenic HHWQC, a process that began in 1997.

[3] Idaho DEQ. 2007. Idaho's Human Health Arsenic Water Quality Criteria, reply to ICL Letter of April 5, 2007.

2.A. Regulatory History

Idaho's history with the HHWQC for arsenic has been one of almost constant flux and disagreement with EPA on appropriate values (see Table 2). When EPA promulgated the National Toxics Rule (NTR) in 1992, it was made applicable to Idaho. Those values were 0.14 μg/L inorganic arsenic ($As_{(in)}$) for consumption of fish only and 0.018 μg/L $As_{(in)}$ for fish and water consumption. In 1994, Idaho adopted the NTR by reference. However, the Idaho Legislature in 1995 revised the Idaho arsenic HHWQC. It is not clear that EPA ever acted on this legislative change. However, since Idaho had adopted the NTR by reference, EPA removed Idaho from the NTR in 1997.

In 1997, the Department initiated a new rulemaking on the HHWQC for arsenic. The negotiated rulemaking value proposed by the Department to the Idaho Board of Environmental Quality (Board) was 25 μg/L; however, the Board adopted a temporary rule of 50 μg/L for both fish consumption only and water and fish consumption combined. This change in the HHWQC was approved by the Idaho legislature in 1999. EPA took no immediate action on the new criterion.

In 2005, the Department commenced a new rulemaking on the arsenic HHWQC. The focus of the rulemaking was to change the HHWQC to the new (2001) MCL for arsenic of 10 μg/L. However, due to a number of questions/issues raised, no change in the HHWQC was proposed.

In 2008, Advocates for the West, representing the Idaho Conservation League filed against EPA a Notice of Intent to Sue over EPA's failure to act on the 1999 submittal by Idaho. This led to another Idaho rulemaking in 2009 and resulted in HHWQC of 10 μg/L $As_{(in)}$ (for both fish consumption only and water and fish consumption combined). These HHWQC were approved by the Idaho legislature in 2010 and approved by EPA later that year.

Northwest Environmental Advocates (NWEA) filed a complaint against EPA in 2015 challenging EPA's 2010 approval of Idaho's arsenic HHWQC. The primary rationale for the complaint was that EPA's approval of the MCL (10 μg/L) was not consistent with EPA's own guidance that recommends states *not* adopt SDWA MCLs as HHWQC for Clean Water Act (CWA) purposes.

EPA reached an agreement with NWEA in 2016 to take new action on Idaho's 2010 criteria submittal and to essentially have new arsenic HHWQC in place for Idaho by July 15, 2019. EPA's new action revised its prior approval of Idaho's 10 μg/L HHWQC; EPA also disapproved the 50 μg/L HHWQC that had been submitted in 1999. The 10 μg/L HHWQC is still in place for purposes of the CWA.

The settlement agreement with NWEA was modified in 2018 to allow EPA to finish the Integrated Risk Information System (IRIS) Toxicological Review of Inorganic Arsenic in 2021. It is EPA's intent that information from this review would be helpful in establishing a new arsenic HHWQC for Idaho. The date for taking action on a new arsenic HHWQC for Idaho was moved to November 15, 2023.

The current rulemaking by the Department was initiated to utilize state-specific information on $As_{(in)}$ concentrations in fish and state waters to develop new arsenic HHWQC. The utilization of state-specific information would allow the best science and most relevant environmental data to be used to develop arsenic HHWQC for Idaho.

2.B. Regulatory Framework and Issue

The goal of HHWQC is to protect designated beneficial uses. For purposes of the arsenic criteria, the applicable designated beneficial uses are recreation and water supply. These lead to the development of two criteria:

- A criterion for the consumption of fish only (recreation use); and
- A criterion for the consumption of fish and water (water supply and recreation uses).

Often HHWQC adopted by the states are based on EPA's own CWA section 304(a) recommended criteria. States can develop their own criteria as long as such criteria protect the designated use and are based on sound scientific rationale.[4] EPA developed section 304(a) criteria for arsenic in 1992 (Table 3).

[4] 40 CFR § 131.11(a).

Table 2
Arsenic Human Health Water Quality Criteria History

Year	Action	Criteria: recreation (µg/L)$_{(in)}$	Criteria: recreation and water supply (µg/L)$_{(in)}$	Notes
1992	EPA: NTR applicable to Idaho	0.14	0.018	
1994	Idaho: adopts NTR by reference	0.14	0.018	
1995	Idaho: Legislature revises criteria	6.2	0.02	It is not clear that EPA ever acted on these criteria.
1997	EPA: finalizes removing Idaho from NTR	0.14	0.018	
1997/1999	Idaho: DEQ Board approves temporary rule changing standard. Approved by legislature in 1999.	50	50	EPA did not act on this change until 2016, in which it was denied.
2005	Idaho: new negotiated rulemaking on As criteria; no consensus reached on changes to criteria.			
2008	ICL files intent to sue over EPA's failure to act on 1999 submittal.			
2010	Idaho: changes criteria to be consistent with MCL.	10	10	EPA approved these criteria in 2010.
2015	Northwest Environmental Advocates files complaint over EPA's 2010 approval of Idaho's			
2016	EPA: (a) settles complaint by agreeing to take *new* action and adopt replacement criteria by November 15, 2019. (b) disapproves both the 1999 and 2010 Idaho criteria.			
2018	EPA: reaches a modified agreement with plaintiffs; will adopt new Idaho criteria by November 15, 2023.			EPA also discusses finishing IRIS assessment for $As_{(in)}$ in 2021.
2018	Idaho: starts a new negotiated rulemaking on As criteria.			

Table 3
EPA CWA § 304(a) Arsenic$_{(in)}$ Criteria

	Criteria[5] (µg/L)
Water and organisms	0.018
Organisms only	0.14

Application of EPA's section 304(a) recommended HHWQC for arsenic to Idaho is problematic for several reasons. First, there has been considerable debate on the scientific basis of the assumptions about the toxicity of $As_{(in)}$ used to develop EPA's recommended HHWQC. Second, more than 25 years have passed since EPA developed the recommended HHWQC shown in Table 3. During that time new information affecting exposure assumptions used to develop the 1992 HHWQC has also become available. For example, new information about the bioaccumulation and speciation of arsenic in fish indicates EPA's 1992 HHWQC are based on overestimated bioaccumulation of $As_{(in)}$ in fish and that the methodology EPA uses to estimate bioaccumulation does not apply to arsenic. Third, especially for Western states, arsenic is prevalent in the natural landscape, often resulting in surface and groundwater having concentrations greatly exceeding EPA's recommended 304(a) WQC.

Because of these complicating factors, several states have developed different approaches to setting arsenic HHWQC. These approaches have included:

- Derivation of state-specific HHWQC using state-specific values for parameters such as bioaccumulation factors (BAFs), speciation of arsenic in fish tissue, and allowable risk, among other factors;
- Background or natural concentrations of arsenic; and
- Use of SDWA MCLs.

Western states have a large range of arsenic HHWQC. Six of the fourteen states have either a water and organism criterion or an organism only criterion equal to 10 µg/L or higher (Table 4). Four states use the EPA 304(a) HHWQC, one of which was imposed by EPA.[6] States in other areas of the country also have adopted a range of HHWQC for arsenic including the 10 µg/L MCL (Table 5).[7]

[5] Criteria assume an allowable excess lifetime cancer risk level of $1x10^{-6}$. Assuming Idaho's allowable risk level of $1x10^{-5}$, the criteria would be 0.18 and 1.4 µg/L respectively.
[6] The State of Washington, like Idaho, finalized arsenic HHWQC of 10 µg/L. EPA disapproved those criteria in 2016 and substituted the National Toxics Rule (NTR) criteria, which for arsenic are the same as the Section 304(a) recommended criteria.
[7] The criteria in Table 5 were obtained using a EPA's relatively new WQS Search Tool, which provides access to a compilation of state-specific water quality standards that are either approved by EPA or are

Table 4
Summary of Arsenic Wate Quality Criteria - Western States

State	Most Recent Update/Effective Date	Drinking Water (µg/l)	Water and Organism (µg/l)	Organism only (µg/l)	Notes
Alaska	2008	10	--	--	Alaska drinking water criterion is based on the federal maximum contaminant level (Safe Drinking Water Act). The reference column in the Alaska Water Quality Criteria for Toxics and Other Deleterious Substances Table for arsenic human health refers to federal code 63 FR 10140, which states that EPA withdraws the applicability to Alaska's waters of the federal human health criteria for arsenic. Alaska does not appear to have established it's own state-specific human health surface water quality criteria for arsenic.
Oregon	2021	--	2.1	2.1 (freshwater) 1.0 (saltwater)	Oregon human health water criteria are given for consumption of water and organisms and consumption of organisms only. The organism only freshwater criterion is based on a risk level of approximately 1 x 10^{-5}, and the water and organism criterion is based on a risk level of 1 x 10^{-4}.
Washington	2016	--	0.018	0.14	EPA disapproved of Washington's proposed 2016 water quality criteria for consumption of water and organisms (10 µg/l) and organisms only (10 µg/l). Therefore, the Clean Water Act-effective criteria are those that EPA originally promulgated for Washington in the National Toxics Rule for consumption of water and organisms (0.018 µg/l) and organisms only (0.14 µg/l).
California	2008	10	0.018	0.14	California drinking water criterion is based on the federal maximum contaminant level (Safe Drinking Water Act). The human health surface water quality criteria for consumption of water and organisms and organisms only are based on the federal National Toxics Rule.
Arizona	2016	10	--	80	Arizona human health water quality criterion is based on the federal maximum contaminant level (Safe Drinking Water Act) for drinking water (called "domestic water source" and defined as the use of a surface water as a source of potable water in Arizona administrative code). The fish consumption value of 80 µg/l is defined in Arizona administrative code as the use of a surface water by humans for harvesting aquatic organisms for consumption. Harvestable aquatic organisms include, but are not limited to, fish, clams, turtles, crayfish, and frogs.
Nevada	2021	50	--	--	Nevada water quality criterion is the maximum contaminant level (Safe Drinking Water Act) for drinking water and contact recreation uses. No values are given for consumption of water and organisms or consumption of organisms only. 50 µg/l is the federal maximum contaminant level for arsenic prior to 2001. 10 µg/L is the new federal maximum contaminant level standard.
Utah	2020	10	10	10	Utah human health water quality criteria for drinking water, the consumption of water and organisms, and the consumption of organisms only are based on the federal maximum contaminant level (Safe Drinking Water Act) for drinking water (called "domestic source uses" in Utah administrative code).
New Mexico	2020	10	--	9	New Mexico drinking water criterion is based on the federal maximum contaminant level (Safe Drinking Water Act) for drinking water (called "domestic water supply" in New Mexico administrative code). A human health surface water criteria is provided for consumption of organisms only but not for consumption of water and organisms.
Texas	2021	--	10	--	Texas human health water quality criterion is for the consumption of water and organisms and is based on the federal maximum contaminant level (Safe Drinking Water Act) for drinking water. No separate value is given for drinking water only or consumption of organisms only.
Montana	2019	10	10	--	Montana drinking water and human health surface water quality criteria are based on the federal maximum contaminant level (Safe Drinking Water Act) for drinking water. Montana assumes that surface water criteria are for the consumption of water and organisms. No organism only criteria are provided.
Wyoming	2018	--	10	10	Wyoming human health surface water quality criteria for consumption of fish and organisms or consumption of organisms only are based on the federal maximum contaminant level (Safe Drinking Water Act).
Colorado	2020	0.02 - 10	0.02	7.6	The Colorado drinking water criterion (called "domestic water supply" in Colorado administrative code) is a range of values. The first number in the range is a strictly health-based value, based on the Colorado Water Quality Control Commission's established methodology for human health-based standards. The second number in the range is a maximum contaminant level, established under the federal Safe Drinking Water Act that has been determined to be an acceptable level of this chemical in public water supplies, taking treatability and laboratory detection limits into account. Human health surface water criteria are provided for consumption of water and organisms and consumption of organisms only.
South Dakota	2021	--	0.018	0.14	South Dakota human health surface water quality criteria for the consumption of water and organisms and consumption of organisms only are provided and based on the federal National Toxics Rule.
North Dakota	2018	--	10	--	North Dakota human health surface water quality criterion is for the consumption of water and organisms and is based on the federal maximum contaminant level (Safe Drinking Water Act) for drinking water. No separate value is given for consumption of organisms only.

otherwise in effect for CWA purposes (https://www.epa.gov/wqs-tech/state-specific-water-quality-standards-effective-under-clean-water-act-cwa).

Notes:
The table contains three sets of HHWQC including Drinking Water, Water and Organism and Organism Only. Several states have a designated use of domestic (or drinking) water supply and have developed HHWQC for that designated use in addition to or instead of having HHWQC for Water and Organism and Organism Only. In many cases the Drinking Water HHWQC is equal to the Maximum Contaminant Level developed as part of the Safe Drinking Water Act.

Table 5
Summary of Arsenic Water Quality Criteria – Nation Wide

State	Domestic Water Supply (µg/L)	Organism Only (µg/L)	Water and Organism (µg/L)	Notes	Last Updated
Alabama	--	See equation	See equation		7/24/2017
Arkansas	--	--	--		6/4/2020
Connecticut	--	0.021	0.011		10/10/2013
Delaware	10	--	10		12/11/2017
Florida	10	50	--	10 µg/l = drinking water; 50 µg/l = class iii fish coı	3/27/2018
Georgia	10	--	--	10 µg/l = drinking water; 50 ug/L = all other classi	8/16/2016
Illinois	50	--	--		6/24/2019
Indiana	10	--	--	0.022 µg/l = point of water intake, but not clear what the intake is used for; 10 ug/L is the drinking water class ground water criteria	9/28/2021
Iowa	--	50	0.18		1/19/2017
Kansas	10	--	--		5/7/2018
Kentucky	10	--	--		6/2/2020
Louisiana	10	--	--		8/10/2021
Maine	--	3.7 2.6 (sustenance fishing waters)	1.3 1.1 (sustenance fishing waters)		6/23/2020
Maryland	10	1.4	0.18		7/11/2018
Massachusetts	--	0.14	0.018		9/19/2007
Michigan	10				2/1/2020
Minnesota	10	--	--		10/8/2021
Mississippi	--	24	0.078		12/17/2021
Missouri	50	--	--		4/6/2021
Nebraska	0.18	--	--	0.18 µg/l = drinking water (public drinking water)	9/5/2019
New Hampshir	--	0.14	0.018		4/1/2015
New Jersey	0.017	--	--	0.017 µg/l = human health criteria (not specified if organism only or organism plus water)	7/29/2020
New York	50	--	--	50 µg/l = drinking water (municipal or domestic sı	3/7/2018
North Carolina	--	--	10		9/17/2021
Ohio	10	--	--	10 µg/l = drinking water (municipal or domestic sı	6/11/2021
Oklahoma	40	205	--	40 µg/l = drinking water (municipal or domestic sı	10/9/2020
Pennsylvania	10	--	--	10 µg/l = drinking water (municipal or domestic sı	7/4/2014
Rhode Island	--	1.4	0.18		2/26/2020
South Carolina	10	10	10		4/22/2021
Tennessee	10	10	10		12/19/2019
Texas	--	--	10		3/18/2021
Vermont	--	1.5	0.02		2/12/2020
Virginia	10	--	--		11/10/2021
Washington DC	--	0.14	0.018	Use federal standards	8/5/2020
West Virginia	--	10	10		8/11/2021
Wisconsin	0.2	--	--	0.2 µg/l = drinking water (municipal or domestic s	7/1/2010

Notes:
The table contains three sets of HHWQC including Drinking Water, Water and Organism and Organism Only. Several states have a designated use of domestic (or drinking) water supply and have developed HHWQC for that designated use in addition to or instead of having HHWQC for Water and Organism and Organism Only. In many cases the Drinking Water HHWQC is equal to the Maximum Contaminant Level developed as part of the Safe Drinking Water Act.

3. ARSENIC IN IDAHO'S WATER AND FISH

3.A. Arsenic in Idaho Waters

Arsenic occurs naturally in soils and waters in the West, including Idaho. The Idaho Department of Water Resources (IDWR) published a very comprehensive review of the geological origin of arsenic in Idaho.[8] This study includes data from measurements of arsenic in groundwater at 255 sites. Fifteen percent (15%)of the sites sampled had arsenic concentrations greater than 10 μg/L. Previous studies conducted by the IDWR and the Department have shown total arsenic ($As_{(total)}$) concentrations in surface water that range from less than 1 μg/L up to 17 μg/L.[9] The Department began a targeted monitoring program in August 2019 of 40 different sampling locations. Those locations have arithmetic mean $As_{(in)}$ concentrations ranging from 0.06 to 12 μg/L with an overall state-wide arithmetic mean of 1.7 μg/L (Table 6).

At virtually all targeted monitoring stations the majority of total arsenic in surface water is comprised of $As_{(in)}$ (Figure 1). In contrast to the water column, in fish tissue, virtually all of the arsenic is present in organic forms and only a small portion is present as $As_{(in)}$, the form or arsenic that is assumed to be toxic to humans (Figure 2).

[8] Idaho Department of Water Resources. 2002. Technical Summary Arsenic Results from the Statewide Program, 1991-2001.
[9] Essig. D. 2010. Arsenic, Mercury and Selenium in Fish Tissue and Water from Idaho's Major Rivers: A Statewide Assessment. Idaho Department of Environmental Quality. March 2010.

Table 6
Summary of August 2019 to May 2020 $As_{(in)}$ Surface Water Monitoring Results

Sample Location ID	Sample Size	Stream/River ID	Frequency of Detects (%)	Min Detect	Max Detect	Arithmetic Mean	Harmonic Mean	Median	10th Percentile	90th Percentile
AST001	8	Kootenai River	100	0.184	0.268	0.209	0.207	0.205	0.188	0.232
AST002	8	SF Coeur d'Alene River	100	0.287	0.975	0.514	0.438	0.421	0.32	0.813
AST003	8	Priest River	100	0.221	1.67	0.625	0.408	0.435	0.255	1.292
AST004	8	NF Coeur d'Alene River	100	0.11	0.191	0.149	0.144	0.148	0.118	0.18
AST005	8	St. Maries River	100	0.044	0.152	0.0943	0.079	0.095	0.0489	0.142
AST006	8	Palouse River	100	0.141	0.39	0.221	0.201	0.193	0.158	0.32
AST007	8	Potlatch River	87.5	0.047	0.143	0.079	0.066	0.077	0.0449	0.135
AST008	8	Paradise Creek	100	0.18	1.11	0.438	0.328	0.38	0.198	0.712
AST009	8	Snake River	100	1.18	3.55	3.125	2.750	3.45	2.496	3.508
AST010	8	MF Clearwater River	62.5	0.044	0.089	0.055	0.051	0.064	0.04	0.0785
AST011	8	Threemile Creek	100	0.05	0.215	0.0984	0.085	0.0825	0.0696	0.139
AST012	8	NF Payette River	87.5	0.047	0.105	0.060	0.056	0.056	0.0449	0.0763
AST013	8	Little Salmon River	100	0.089	0.257	0.183	0.162	0.186	0.117	0.251
AST014	6	Gold Fork River	100	0.053	1.24	0.424	0.177	0.251	0.142	0.88
AST015	8	Weiser River	100	0.049	0.314	0.187	0.128	0.207	0.0693	0.295
AST016	8	Mann Creek	100	4.21	19.8	12.35	9.817	13.45	6.114	17.35
AST017	8	Squaw Creek	100	0.087	0.379	0.16	0.134	0.127	0.104	0.252
AST018	8	Deadwood River	100	0.192	0.408	0.332	0.308	0.373	0.209	0.395
AST019	8	MF Boise River	100	1.49	3.03	2.281	2.203	2.23	1.952	2.666
AST020	8	Mores Creek	100	1.65	3.7	3.226	3.024	3.49	2.539	3.679
AST021	8	Bruneau River	100	2.34	11.9	7.426	5.993	7.295	4.734	10.21
AST022	8	Big Wood River	100	0.512	0.689	0.597	0.590	0.592	0.518	0.674
AST023	7	Rock Creek	100	2.39	4.82	3.867	3.680	4.08	2.906	4.706
AST024	8	Salmon River	100	1.91	2.35	2.153	2.140	2.185	1.938	2.329
AST025	8	Salmon River	100	0.934	2.33	1.388	1.242	1.2	0.935	2.232
AST026	7	Snake River	100	1.34	3.53	2.057	1.841	1.75	1.412	3.02
AST027	9	Portneuf River	100	1.52	2.77	2.352	2.282	2.45	1.984	2.746
AST028	4	Bear River	100	0.507	2.25	1.201	0.904	1.024	0.612	1.932
AST029	9	Blackfoot River	100	1.08	2.02	1.414	1.336	1.19	1.08	1.852
AST030	8	Bitch Creek	100	0.101	1.08	0.626	0.380	0.686	0.311	0.904
AST031	8	Henrys Fork	100	1.06	1.58	1.336	1.318	1.32	1.172	1.51

Notes:
All non-detects had a detection limit of 0.04 ug/L.
Arithmetic mean - calculated with ND=DL for non-detects

Figure 1
Plot of Inorganic and Total Arsenic Concentrations in Surface Water from 2019

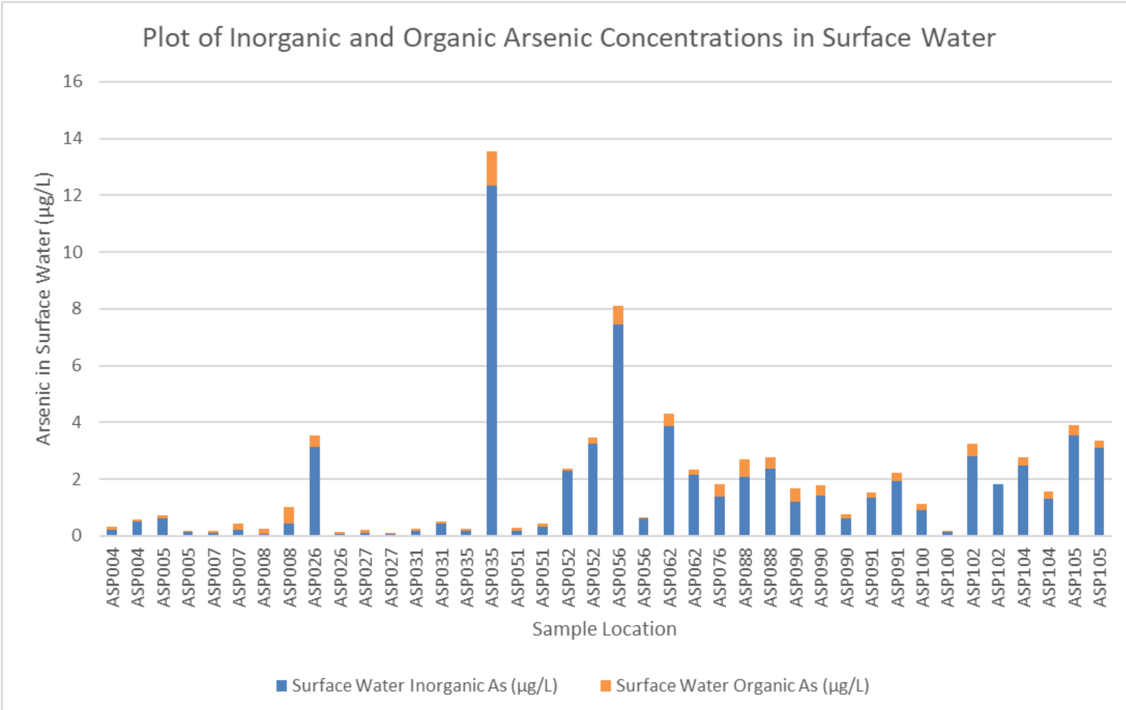


Figure 2
Plot of Inorganic and Total Arsenic Concentrations in Fish Tissue from 2019

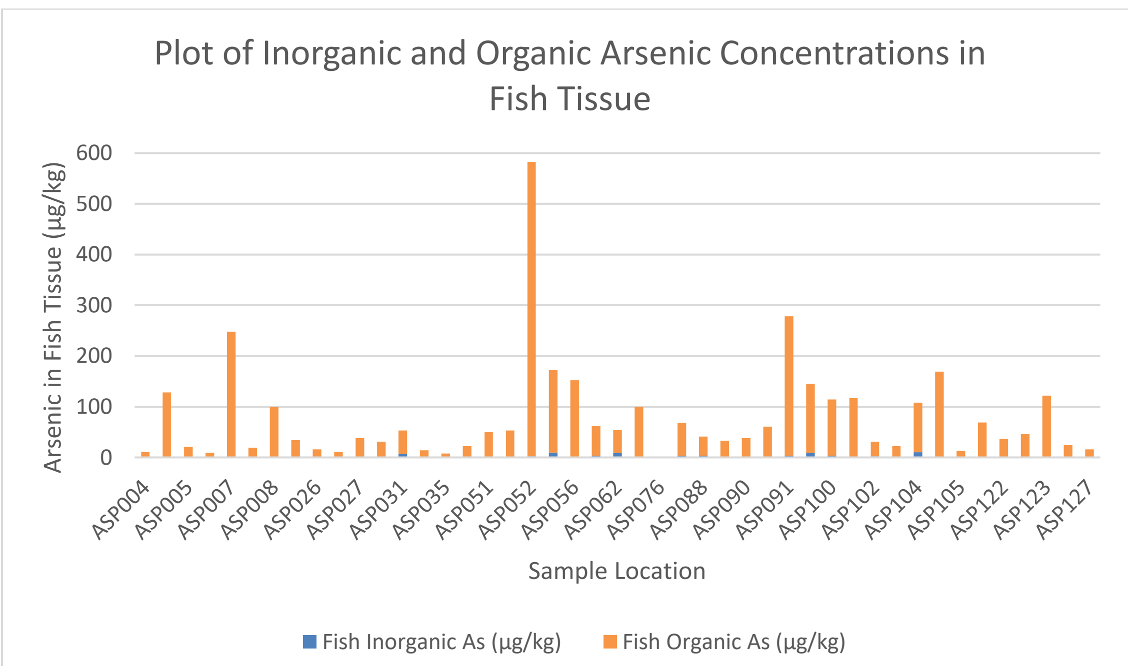
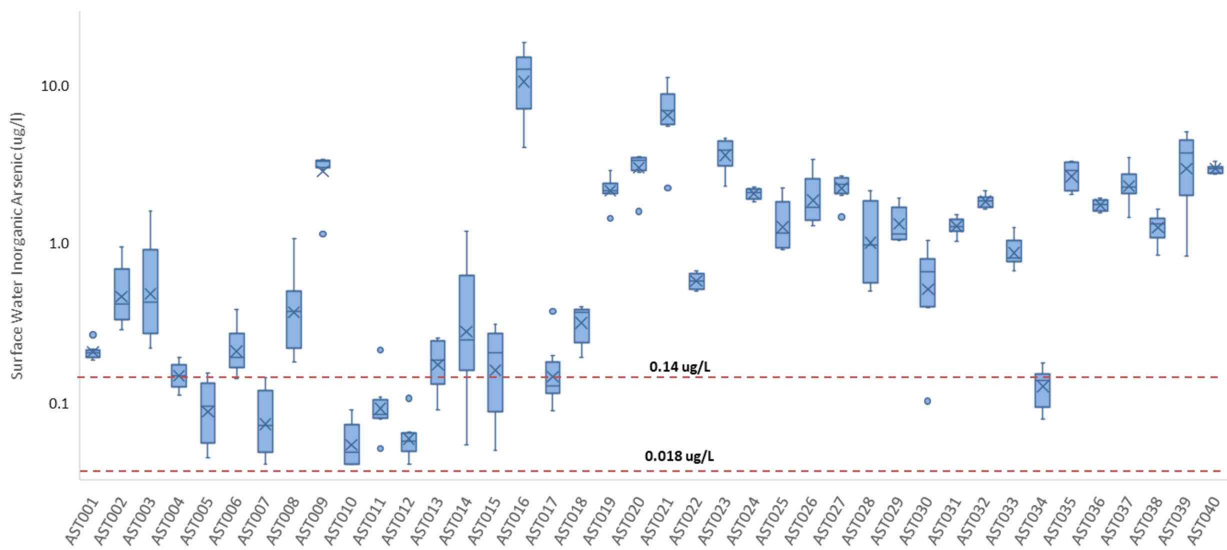


Figure 3
August 2019 to May 2020 $As_{(in)}$ Surface Water Monitoring Results Compared to USEPA CWA § 304(a) Arsenic Criteria



Notes:
0.14 µg/L = EPA CWA 304(a) HH WQC (organism only)
0.018 µg/L = EPA CWA 304(a) HH WQC (water + organism)
Middle line = median
X = arithmetic mean
Bottom line of the box represents the median of the bottom half or 1st quartile.
Top line of the box represents the median of the top half or 3rd quartile.
Whiskers = minimum and maximum values
Dots = outliers (a data point is considered an outlier if it exceeds a distance of 1.5 times the IQR below the 1st quartile or above the 3rd quartile)

3.B. Background Concentrations of Arsenic in Idaho Surface Waters

Arsenic occurs naturally in the environment in several valences (e.g., arsenic III, arsenic V) and many forms (e.g., organic and inorganic). $As_{(in)}$ is acknowledged by the scientific community to be the most toxic form of arsenic that poses the greatest risk to human health. As a result, the Department's sampling and monitoring programs have focused on measuring concentrations of $As_{(in)}$ in surface water and fish tissue for the purpose of gathering data that could be used for the establishment of new arsenic HHWQC.

The results collected to date from the Department's targeted state-wide surface water monitoring program provide an excellent empirical dataset regarding the range of $As_{(in)}$ background concentrations in Idaho surface waters. Concentrations of $As_{(in)}$ range from non-detect with a detection limit of 0.04 µg/L to 19.8 µg/L (Table 7). Arithmetic mean concentrations of $As_{(in)}$ at the 40 targeted surface water monitoring locations range from 0.055 µg/L to 12.35 µg/L (Table 6, Figure 3). The Department also collected inorganic As surface water concentration data as part of the 2019 probabilistic fish tissue sampling program. The range of inorganic arsenic surface water concentrations from those 24 locations is similar to the ongoing monitoring program (Table 7) providing further evidence of the widespread presence of inorganic arsenic in Idaho surface waters.

Table 7
Comparison of $As_{(in)}$ Surface Water Concentrations from the 2019 Targeted and Probabilistic Monitoring Programs

Dataset	Sample Size	Detects	Non-Detects	Minimum Detect	Maximum Detect	Arithmetic Mean	Harmonic Mean	Median	10th Percentile	90th Percentile
Targeted Surface Water (Aug 2019 - May 2020)	309	304	5	0.044	19.8	1.68	0.25	1.01	0.08	3.5
Probabilistic Surface Water/Fish Tissue (Aug - Oct 2019)	48	46	2	0.076	8.1	1.53	0.31	1.01	0.13	4.2

3.C. Bioaccumulation of Arsenic in Fish Tissue

The results of the comprehensive state-wide sampling program can be used to better understand the relationship between concentrations of $As_{(in)}$ in surface water and concentrations of $As_{(in)}$ in fish tissue. These results inform development of a BAF for use in establishing HHWQC for arsenic in Idaho waters. The 2019 dataset is exceptionally robust and represents a one-of-a-kind study given the large number of sampling locations and their geographic coverage. Moreover, the similarity of $As_{(in)}$ surface water concentrations in the probabilistic paired fish tissue/surface water sampling program and the more expansive targeted ongoing surface water monitoring program (Table 7) indicates that the $As_{(in)}$ fish tissue concentrations measured as part of the probabilistic fish tissue sampling program are representative of $As_{(in)}$ fish tissue concentrations in most Idaho surface waters.

Historically, BAFs have often been calculated simply as the *ratio* of the concentration of a substance in fish to the concentration of that substance in water. If only a single paired sample was available, the fish to water concentration ratio from that sample was assumed to be the BAF. If more than one paired sample was available, an overall BAF was estimated by taking the mean of all the BAFs calculated for each sample, as the Department did when developing the BAF of 1.18 liters per kilogram (L/kg) used to develop the proposed fish consumption only HHWQC of 4.3 µg/L. However, even though a BAF can be calculated in this manner, it may not be an accurate or appropriate predictor of bioaccumulation. *Regression analysis* represents a superior method to determine whether a relationship exists between water and fish tissue concentrations.[10] If a statistically significant relationship exists, that relationship represents the BAF. The absence of a statistically significant relationship, as is the case in Idaho, indicates that the

[10] Arcadis. 2018. Idaho Arsenic Human Health Criteria: Comments Prepared in Response to the April 19, 2018 Rulemaking Meeting. April 30, 2018.

concentration of a substance in fish tissue is not related to the concentration of the substance in surface water and therefore, a meaningful biologically-based BAF cannot be derived. Consequently, based on the existing data, a BAF should not be used to predict fish tissue concentrations based on surface water concentrations.

Three regression analyses were conducted using the 2019 paired fish tissue/surface water data collected by the Department. The analyses differed based on the treatment of surface water and fish tissue samples with non-detect $As_{(in)}$ concentrations. One regression analysis assumed non-detects have an $As_{(in)}$ concentration equal to the detection limit. Another assumed non-detects have an $As_{(in)}$ concentration equal to the one half the detection limit. The third regression analysis used only paired samples in which $As_{(in)}$ was detected in both surface water and fish tissue. All of the regression analyses confirmed the key finding presented by the Department.[11,12] Namely that a statistically significant relationship between the concentration of $As_{(in)}$ concentrations in surface water and the concentration of $As_{(in)}$ in fish tissue does not exist (Table 8, Figure 4).

Table 8
Summary of $As_{(in)}$ Surface Water/Fish Tissue Regression Analyses with Varying Treatment of Non-detects

Treatment of Non-Detects	Sample Size	Regression Equation	R^2	P-Value
Non-detects = Detection Limit	48	y = 0.1845x + 1.5487	0.013	0.44
Non-detects = 1/2 Detection Limit	48	y = 0.1908x + 1.5069	0.014	0.42
Non-detects Excluded	34	y = 0.0854x + 2.3312	0.003	0.77

[11] Idaho Department of Environmental Quality. 2020a. 2019 Arsenic Accumulation in Fish Tissue. Preliminary Monitoring Results. March.
[12] Idaho Department of Environmental Quality. 2020b. Revision of Idaho's Human Health Criteria for Arsenic. Docket No. 58-0102-1801. July 15, 2020. PowerPoint presentation by Jason Pappani.

Thus, based on the state-wide 2019 dataset, the concentration of $As_{(in)}$ in fish tissue appears to be independent of the concentration of $As_{(in)}$ in surface water. As a result, a scientifically defensible BAF (defined as a statistically significant BAF that can be used to predict fish tissue concentrations from a water concentration) cannot be established. That means in the "aggregate" regulating the $As_{(in)}$ concentration in surface water will not affect concentrations of $As_{(in)}$ in fish; for very specific site conditions such a relationship may exist but at this time a data set for such a site/conditions has not been found (developed). The state-wide data set shows that lower $As_{(in)}$ surface water concentrations do not lead to lower fish concentrations (and lower fish consumption exposures).[13] Though it does not preclude the possibility of specific sites where such a relationship does exist.

3.D. Potential Risk From Inorganic Arsenic Concentrations in Fish

As noted above, the geographic breadth (i.e., targeted state-wide sampling) and large size (i.e., 172 individual fish divided into 48 composites samples) of the 2019 Idaho-wide fish dataset makes it unique and robust. It can be used to evaluate the potential for fish in Idaho surface waters to pose a potential risk to human health associated with consumption of Idaho fish containing $As_{(in)}$. To derive HHWQC for other substances, the Department has already identified the key assumptions necessary for deriving allowable concentrations of substances in surface water allowable fish tissue concentrations. Assuming a bodyweight of 80 kilograms, a fish consumption rate of 66.5 grams per day for a lifetime, an acceptable excess lifetime cancer risk of $1x10^{-5}$, and using the current EPA cancer slope factor of 1.5 $(mg/kg\text{-}day)^{-1}$ for arsenic, the allowable $\underline{As_{(in)}}$ fish tissue concentration is 8 micrograms per kilogram (μg/kg)[14].

Based on the Department's 2019 data, 44 of 48 composite fish samples had $As_{(in)}$ concentrations below an allowable fish tissue concentration of 8 μg/kg (Figure 5). Only four of 48 tissue samples had an $As_{(in)}$ concentration slightly (no more than 25%) greater than 8 ug/kg (Figure 4). Because the exceedances of the allowable concentration are small and infrequent, the potential excess lifetime cancer risk associated with all four of these samples meets the allowable risk goal of $1x10^{-5}$. The comparison of measured inorganic As fish tissue concentrations to the allowable concentration indicates that potential excess lifetime cancer risks associated with daily consumption of fish from Idaho surface waters over a lifetime are at or below Idaho's allowable risk level and that the fish are safe to eat.

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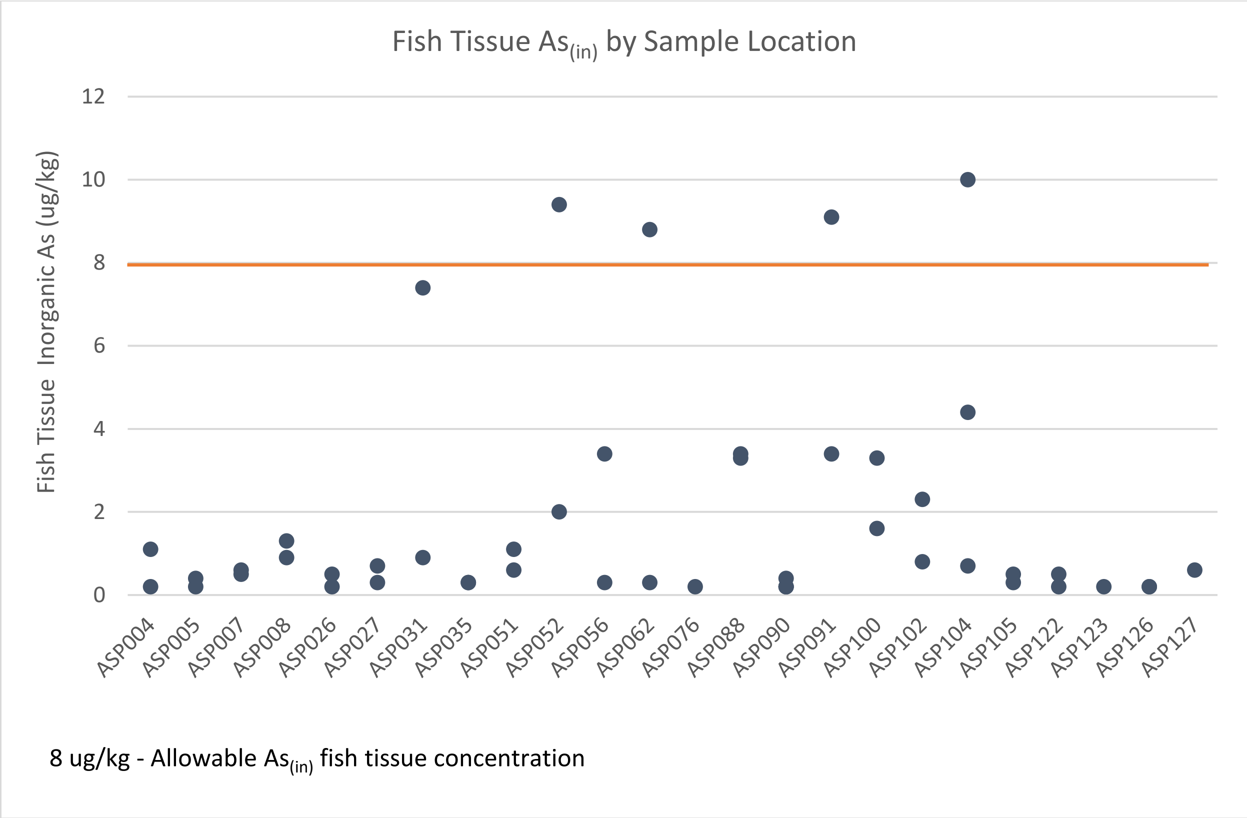
[13] The same conclusions exist for inorganic arsenic in fish tissue and total arsenic concentrations in surface water.

[14] Allowable concentration (ug/kg) = (Allowable Risk ($1x10^{-5}$) x Bodyweight (80 kg/person)) ÷ (Fish consumption rate (0.0665 kg/person-day) x Cancer Slope Factor (1.5 kg-day/mg) x Conversion factor (1,000 ug/1 mg) = 8 ug/kg. Use of an allowable risk of $1x10^{-4}$ would result in a higher allowable concentration in fish tissue.

Figure 4

Plot of 2019 Fish Tissue Data by Sampling Location with 8 ug/kg $As_{(in)}$ Allowable Fish Tissue Concentration also Shown



4. APPLICATION OF SCIENTIC FINDINGS FOR ARSENIC HUMAN HEALTH WATER QUALITY CRITERIA

As described in the introduction, $As_{(in)}$ HHWQC are being developed to protect two beneficial uses: recreational (fish consumption exposures only); and, recreational and domestic water supply (fish consumption and potable water exposures). Approximately 96,490 stream miles are designated or presumed to have recreational use only. Approximately 22,957 stream miles are currently designated for domestic water supply and recreational use.[15] There are several different approaches to setting an arsenic HHWQC for Idaho for these two beneficial uses.

One approach would be to use the EPA CWA 304(a) criteria (see Table 3). As discussed in Section 2.B. these criteria are problematic for several reasons. When comparing these criteria to Idaho monitoring data, only six monitoring sites had $As_{(in)}$ concentrations less than the EPA CWA 304(a) organism only HHWQC of 0.14 µg/L $As_{(in)}$; no monitoring sites had an arsenic concentration that met the water and organism HHWQC of 0.018 µg/L $As_{(in)}$ (Figure 3).[16] It is doubtful that water with less than18 parts per trillion (0.018 µg/L) can be found in Western surface waters. The conclusion from comparing concentrations of arsenic in Idaho waters shows that the 304(a) criteria are inappropriate and unattainable for all major surface waters sampled in Idaho and such criteria were derived using overly conservative assumptions and assumptions not representative of conditions in Idaho.

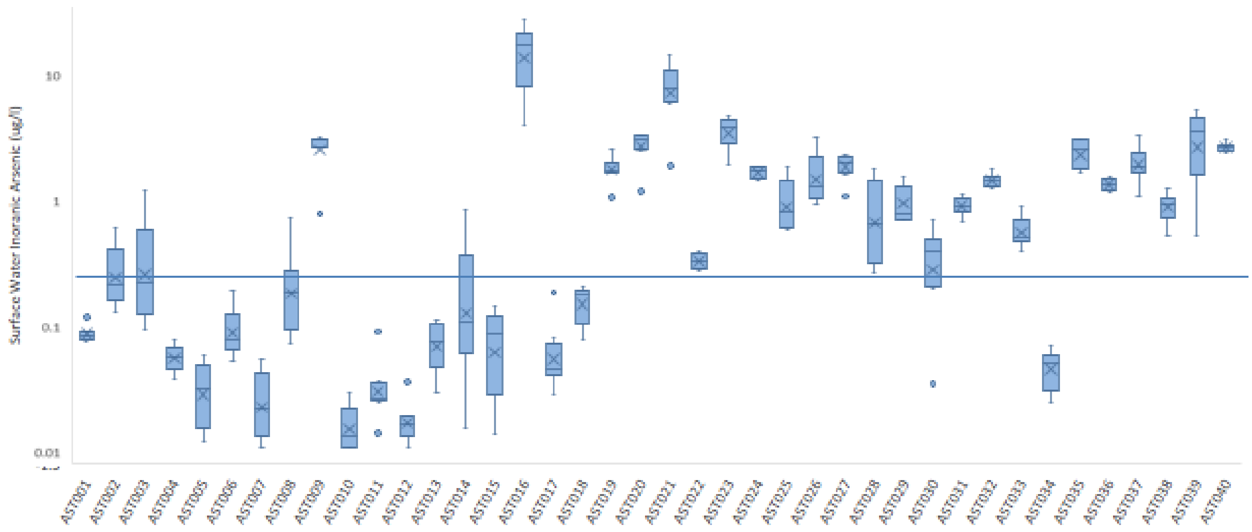
A second approach would be using default Department and EPA assumptions to derive potential HHWQC protective of drinking water exposures. This methodology would result in a value of 0.22 µg/L $As_{(in)}$. Such a value is lower than the arithmetic mean[17] background $As_{(in)}$ concentration in most Idaho surface waters monitored to date (Figure 5). Adoption and implementation of such potential HHWQC creates numerous practical limitations, beyond the obvious problem of promulgating an unattainable criteria. Two examples of such limitations are listed below.

[15] Idaho Department of Environmental Quality. 2019. Docket No. 58-0102-1801. Revision of Idaho's Human Health Criteria for Arsenic. Negotiated Rulemaking. PowerPoint presentation by Jason Pappani. July 23, 2019.

[16] 40 CFR § 131.36(b)(1).

[17] When comparing the receiving water concentration of a substance to a human health WQC based on chronic exposures, the arithmetic mean concentration, not the geometric or harmonic mean concentration, is the appropriate measure of central tendency to use in the comparison (Appendix E).

Figure 5
August 2019 to May 2020 $As_{(in)}$ Surface Water Monitoring Results Compared to Hypothetical $As_{(in)}$ Human Health Water Quality Criteria



Note: Blue line indicates an $As_{(in)}$ concentration of 0.22 µg/L.

The first example consists of a hypothetical drinking water utility that extracts groundwater with a natural occurring $As_{(in)}$ concentration of 1 µg/L. That groundwater concentration is greater than a hypothetical drinking water HHWQC of 0.22 µg/L $As_{(in)}$ but meets the MCL of 10 µg/L $As_{(total)}$. Because the $As_{(in)}$ concentration is less than the MCL, the utility is able to distribute the groundwater without treatment for the $As_{(in)}$ concentration as potable water to the community it serves. Following use of the water by the community, the water is collected by the wastewater utility serving that community. The water continues to have an $As_{(in)}$ concentration of 1 µg/L because the community did not add any $As_{(in)}$ to the water during use. If Idaho were to adopt a hypothetical HHWQC of 0.22 µg/L $As_{(in)}$, the wastewater utility might need to treat the water before discharging it to a surface water designated for drinking water use. Treatment might not be necessary if the $As_{(in)}$ receiving water concentration is less than the HHWQC but would likely be required if the $As_{(in)}$ receiving water concentration is greater than the HHWQC.

In the first case where the background concentration in the receiving water is less than the HHWQC, as long as the concentration of the receiving water remains below the HHWQC following release of the wastewater utility's effluent, treatment would not be required. However, in the second case, where the $As_{(in)}$ background concentration in the receiving water exceeds the HHWQC, treatment would likely be required such that the $As_{(in)}$ concentration in the receiving water does not exceed the naturally occurring $As_{(in)}$ concentration. Given the state-wide monitoring data collected to date, about two thirds of Idaho rivers will have a naturally occurring $As_{(in)}$ background concentration higher than the hypothetical HHWQC used in this example.

The second hypothetical example of the practical implications of a HHWQC that is lower than naturally occurring background $As_{(in)}$ concentrations consists of a drinking water utility that uses the receiving water as the source of potable water. The naturally occurring $As_{(in)}$ concentration in the receiving water is 1 μg/L. As in the above scenario, the drinking water utility can distribute that as potable water without treatment for arsenic because it meets the MCL of 10 ug/L $As_{(inl)}$. However, if consideration of naturally occurring background is not allowed, the wastewater utility will likely need to treat that water before discharging it because it exceeds the HHWQC by nearly 10-fold. Because Idaho rules do allow use of naturally occurring background as the HHWQC when the background concentration is higher than the HHWQC, it may be possible for the wastewater utility to discharge its effluent without treatment. This assumes that the use of the water by the community did not add a measurable amount of arsenic to the wastewater. If the community were to add a measurable amount of arsenic to the wastewater stream, even if that amount is very small (e.g., 0.1 μg/L $As_{(in)}$, or 10% of the background), the wastewater utility would need to treat the water such that the receiving water does not exceed the natural background of 1 μg/L $As_{(in)}$.

Beyond the issue of community use of the water potentially causing a small increase in the $As_{(in)}$ concentration that would necessitate potentially expensive treatment, as the Department's targeted monitoring data show, naturally occurring background concentrations vary. Given that variation, establishing naturally occurring background on a site-specific basis has the potential to be a resource intensive process. Further, given that variation, a background-based HHWQC would also need to have in place a process for determining whether an exceedance of naturally occurring background is the result of an addition by the community of $As_{(in)}$ to the wastewater stream or is it simply, natural variation, unless the hypothetical $As_{(in)}$ HHWQC allowed for a nominal exceedance of background.

Finally, from a public policy standpoint, the hypothetical drinking water criteria of 0.22 μg/L $As(_{in})$ makes no sense in Idaho. According to the Department's website approximately 95% of Idaho's population obtain their drinking water from groundwater. Both the Department and EPA have determined that it is safe for Idaho citizens to consume drinking water with a concentration of arsenic that does not exceed 10 μg/L. A third approach is to develop HHWQC based on the relationship between $As_{(in)}$ concentrations in water and in fish tissue. However, the concept of a BAF is not applicable due to the absence of a biologically meaningful and statistically significant relationship between $As_{(in)}$ concentration in Idaho surface waters and fish tissue. Thus, the traditional numeric surface water column-based criteria that rely on a BAF are not defensible because requiring a lower $As_{(in)}$ surface water concentration will not lead to lower fish concentrations (and lower fish consumption exposures). If the $As_{(in)}$ concentration in fish tissue is determined to pose an unacceptable risk, exposure to such $As_{(in)}$ concentrations will need to be reduced through a mechanism other than numeric HHWQC and dealt with on a site by site basis.

5. RECOMMENDATIONS ON PROPOSED ARSENIC HUMAN HEALTH CRITERIA

Though the relationship between inorganic arsenic concentrations in the surface water and fish tissue is not statistically significant and highly variable across fish species and sizes, the Department believes it needs to include a HHWQC for recreational waters. This is so the proposed HHWQC is consistent with EPA guidance for developing/setting water quality criteria for chemicals.

5.A. Recreational Designated Use (fish only exposure)

The Department has proposed a two-element criteria:

- Water column concentration of 4.3 μg/L
- Fish tissue concentration of 8.0 μg/kg (wet weight) with the fish tissue element (value) superseding the water column element (value).

Comments are provided for each of these elements, including recommendations regarding the criteria and aspects of the implementation.

5.A. 1 Water Column Element

The proposal by the Department incorporates the following elements:[18]

- The Department uses a TL-weighted BAF derived using a procedure that is mathematically consistent with the BAFs used by the Department to derive HHWQC for other toxic substances.
- This approach is consistent with EPA's derivation of BAFs when setting national HHWQC.
- The TL-weighted BAF used in the proposed rule uses Idaho-specific fish tissue and water column data collected by the Department in 2019.
- The calculation utilizes EPA national fish consumption rates by tropic level specific consumption rates where the weighting is equal to the proportion the 95th percentile of TL-specific consumption of freshwater + estuarine fishes comprised of the total consumption rate from the national estimated fish consumption study as presented in *EPA. 2014. Update of Human Health Ambient Water Quality Criteria*.

As discussed in these comments (and prior comments submitted by IACI), the Department's comprehensive dataset does not support using ratios of $As_{(in)}$ in paired fish tissue and surface water samples to derive a meaningful biologically-based BAF[19]. The

[18] Idaho Department of Environmental Quality. 2021. Rulemaking Document 58-0102-1801, Arsenic Human Health Criteria, Discussion Paper #3. August 13, 2021.

[19] See: IACI's August 21, 2020 comment letter, pages 15-17, including Table 7 and Figure 4; and IACI's July 14, 2021 comment letter, page 2.

findings of the 2019 Idaho study are consistent with information from the literature: the relationship between $As_{(in)}$ concentrations in the surface water and fish tissue is not statistically significant and highly variable across fish species and sizes. IACI recognizes that the Department believes it needs to include a water column-based HHWQC for recreational waters in a proposed rule for $As_{(in)}$, as the EPA has not updated and revised their process or guidance for developing/setting HHWQC for chemicals to which traditionally-derived BAFs are not applicable.

The best representation of the relationship between the concentration of $As_{(in)}$ in the water column and fish tissue is determined using regression analysis. Consistent with the use of the BAF in the proposed rule, regression analysis can be used to define the relationship between water and tissue concentrations of $As_{(in)}$ for each of the trophic levels used by the Department to derive its TL-weighted BAF. The results of the TL-specific regression analyses are presented in Figures 6-8. The TL-specific BAFs are 1.36 L/kg, 0.31 L/kg and -0.6 L/kg for TLs 2, 3 and 4, respectively. The scatter of the individual data points provides a visual indication of the lack of a meaningful relationship between $As_{(in)}$ in water and in fish tissue.

Figure 6
Tropic Level 2 Regression Analysis.

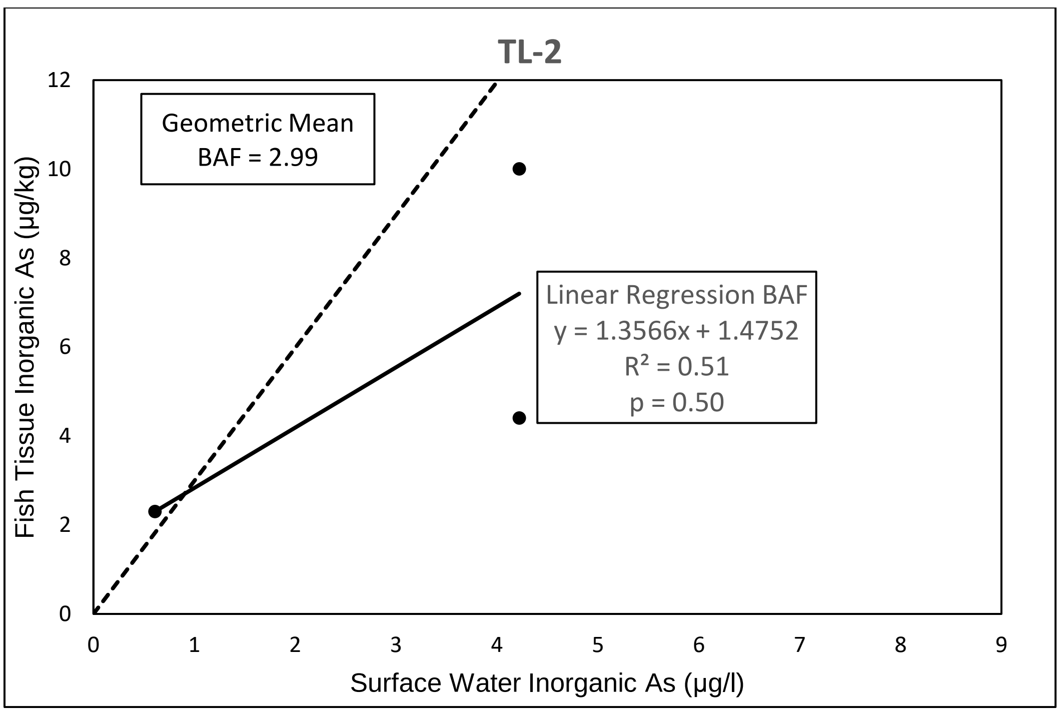


Figure 7
Tropic Level 3 Regression Analysis

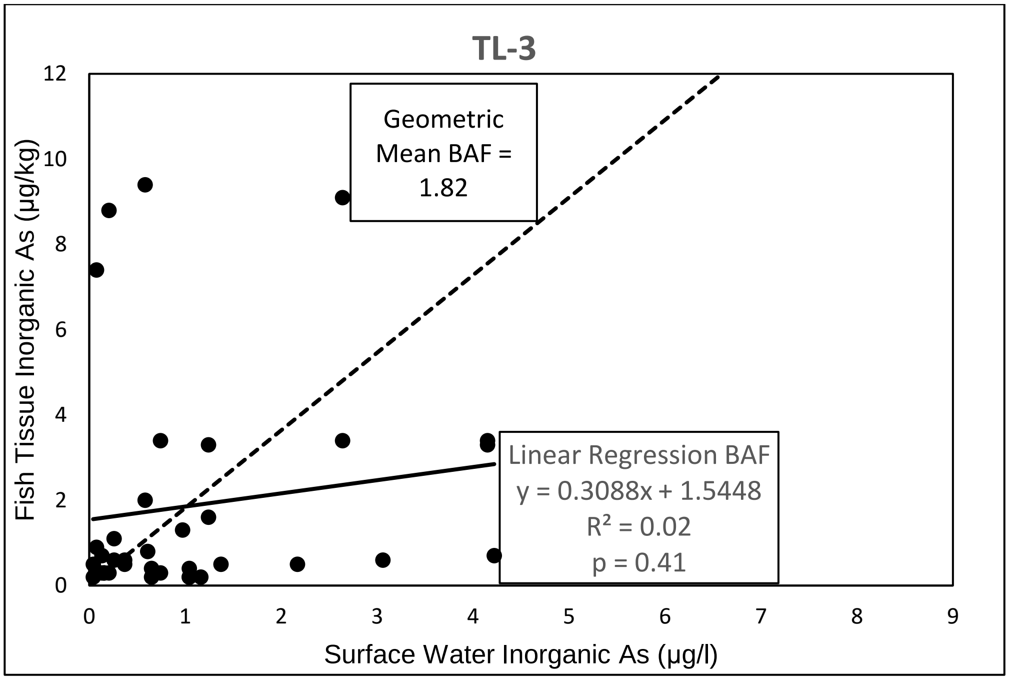
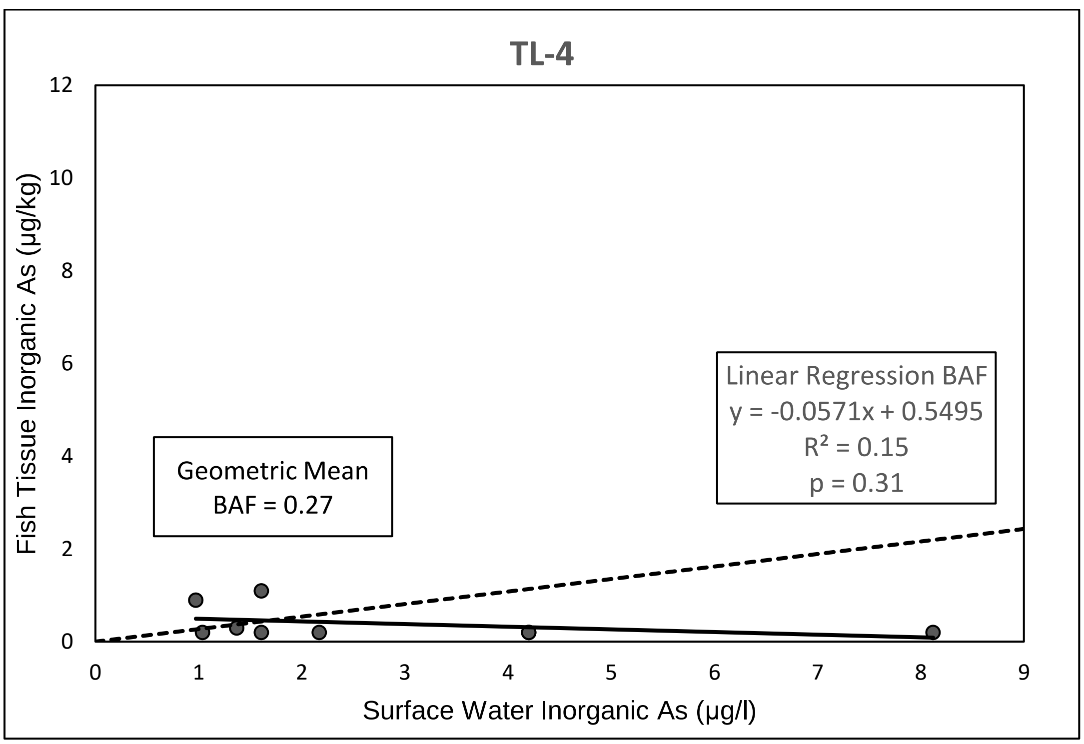


Figure 8
Tropic Level 4 Regression Analysis



While none of the TL-specific regressions are statistically significant ($p>0.05$), the slope of regression equations is the best representation of $As_{(in)}$ bioaccumulation by Idaho fish. Figures 6, 7 and 8 show both the TL-specific BAFs using regression analysis (solid lines) and the TL-specific BAFs based on the geometric mean of individual paired sample points (dotted lines), the BAFs based on regression analysis better fit the measured data. This is in particular true at higher concentrations of $As_{(in)}$ in surface water, where the geometric mean BAFs substantially overpredict measured $As_{(in)}$ concentrations in fish tissue.

The TL-specific regression-based BAFs can be incorporated in the process used by the Department to derive an Idaho-specific the TL-weighted BAF of 0.6 L/kg as shown below.

TL-based BAF = $(BAF_{TL2}\ x\ P_{TL2}) + (BAF_{TL3}\ x\ P_{TL3}) + (BAF_{TL4} x\ P_{TL4})$

Where:
TL-Based BAF = The trophic level weighted BAF;
BAF_{TLi} = the regression-based BAF for all species assigned to trophic level *i*; and
P_{TLi} = the proportion of the national fish consumption rate for TLi.

Substituting the regression-based TL-specific BAFs has shown above and the national fish consumption rate proportions used by the Department and EPA to derive TL-weighted BAFs results in a TL-weighted BAF of 0.61 L/kg.

TL-based BAF = [(1.36 L/kg x 0.36) + (0.31 L/kg x 0.4) + (-0.06 L/kg x 0.24)] = 0.61 L/kg).

Using this weighted BAF of 0.61 L/kg leads to a water column HHWQC of 13 µg/L as calculated below:

$$HHWQC = RSD\ x\ \frac{BW}{FCR\ x\ BAF}\ x\ CF$$

HHWQC = Human Health Water Quality Criterion;
RSD = risk-specific dose for cancer effects (acceptable cancer risk level divided by cancer slope factor, CSF), assuming an acceptable cancer risk level of $1x10^{-5}$ and CSF of 1.5 kg-day/mg;
BW = body weight of 80 kg;
FCR = fish consumption rate of 0.0665 kg/day;
BAF = TL-weighted bioaccumulation factor of 0.61 L/kg; and
CF = unit conversion factor of 1,000 µg/mg.

$$HHAWQC = \frac{1x10^{-5}}{1.5}\ x\ \frac{80}{0.0665\ x\ 0.61}\ x\ 1{,}000 =\ 13\ \mu g/L$$

As discussed in our September 22, 2021 comments, the 4.3 µg/L concentration was derived by calculating the geometric mean of the ratio BAF for each of the paired water quality/fish tissue concentrations by tropic level and then deriving trophic level weighted BAF. The ratio based geometric mean of the BAFs is purely a mathematical calculation to provide a single value from several values while minimizing the extremes of an arithmetic average. This singular derived BAF assumes a direct relationship exists between the $As_{(in)}$ concentration in fish tissue and in the water column. Based on the monitoring data (as well as data from other studies reported in the literature) we know that is not the case. Moreover, calculating a single BAF using a geometric mean does not test whether a direct relationship between water and tissue is actually present or whether the calculated BAF based on the geometric mean is a good predictor of measured concentrations.

The regression analysis methodology used to derive the BAF of 0.61 L/kg presented in IACI's earlier comments[20] does not assume *a priori* that a direct relationship exists between $As_{(in)}$ in the water column and fish tissue. Instead, it is a methodology that identifies the best relationship, determines whether the relationship is statistically significant, and how much of the observed range of $As_{(in)}$ in fish tissue concentrations can be explained by the $As_{(in)}$ concentration in surface water. In this case, consistent with previous findings reported in the literature, the regression analysis identified a weak, not statistically significant relationship, with the concentration in water explaining relatively little of the range of concentrations observed in fish tissue. However, given one of the outputs of the regression methodology is the best available relationship, that relationship does indeed provide the best mathematical representation of the relationship between fish tissue and water column concentrations.

The relative ability of the geometric mean of the ratio-based BAFs and the regression-based BAF to predict measured $As_{(in)}$ tissue concentrations can be compared using a statistical test. The relative performance of the two alternative BAFs was analyzed using the Aikake Information Criterion (AICc) statistic, an estimation of prediction error. The findings of the statistical comparison of the relative predictive ability of the two BAFs provide clear evidence that the regression-based BAF is better supported by the data than the geometric mean of the ratio-based BAFs (see Table 9 and Attachment A).

Table 9
Statistical Comparison of Relative Predictive Ability of the Two BAFs

Model	AICc	Log Likelihood	Probability
Regression-based BAF	231.33	-144.62	0.9999984
Geomean-based BAF	258.06	-127.99	0.0000016

[20] See IACI's September 22, 2021 comment letter for the details on the use of the regression analysis method and associated calculations.

This statistical comparison demonstrates that the 4.3 μg/L water column value in the proposed rule is a "conservative value" and it is appropriate that the fish tissue criterion of 8.0 micrograms per kilogram (μg/kg) be the primary standard.[21] Based on the clear demonstration that the regression-based BAF is a better predictor of tissue concentrations than the geometric mean of the ratio-based BAFs, IACI continues to recommend that the fish consumption only HHWQC be based on the scientifically more defensible regression-based BAF of 0.61 L/kg presented in IACI's previous comments resulting in a water column criterion of 13 μg/L.[22] Given that the Department's goals for undertaking the statewide paired fish tissue and water column sampling program was to "….help to ensure that DEQ uses appropriate, Idaho specific, scientifically defensible inputs to the HHC equation."[23] The regression-based TL-weighted BAF better meets the stated goals than the geometric mean-based TL-weighted BAF. This approach is also consistent with the EPA and the Department's implementation of the selenium criterion elements for water.

5.A.2. Fish Tissue Element

For the fish tissue element of the HHWQC, the Department has proposed a concentration of 8 μg/kg (wet weight). As discussed in Section III.D of these comments, this concentration is obtained by using the standard equation and standard inputs for calculating the allowable concentration of a substance in fish tissue to be protective of human health.

5.A.3. Implementation of Fish Tissue Element

The proposed rule has detail on: (a) how to apply the proposed HHWQC when $As_{(in)}$ concentrations are increasing due to new arsenic sources; (b) how to apply the proposed HHWQC to fishless waters; and, (c) how to demonstrate compliance with the proposed HHWQC using fish sampling.

<u>Increasing Arsenic Concentrations or New Arsenic Sources</u>

The Department has proposed language in the rule that restricts the use of the fish tissue element to when:

> "...there is no new or increasing point source discharges of arsenic, …"

IACI recommends that the language be changed (see Section 5.A.4 of the comments for specific language changes) because the underlying technical issue is: how quickly do fish

[21] The 8.0 μg/kg is based upon the standard equation for calculating a human health criterion which utilizes a fish consumption rate, mean adult body weight, cancer slope factor and an allowable lifetime cancer risk of $1x10^{-5}$.

[22] See IACI's September 22, 2021 comment letter.

[23] Rulemaking Docket 58-0102-1801. Statewide Arsenic Monitoring to Support Human Health Criteria Updates. Discussion Paper #2, July 2019.

species respond to (and reach equilibrium with) changes in arsenic inputs to surface water?[24]

The concentration of arsenic in fish tissues essentially represents the "integral" of chemical update and depuration of any arsenic flux that occurs in the surface water. Natural conditions alone provide some change in arsenic concentrations in surface water. First, arsenic concentrations in surface water will fluctuate seasonally or even annually based on hydrological patterns and precipitation trends. For example, surface water flows are typically the highest in spring/early summer from snow melt. This seasonal runoff often (not always) results in lower concentrations of many substances in the water column. Furthermore, as discussed extensively in these comments, there is no demonstrated relationship between surface water arsenic concentrations and fish tissue arsenic relationships. Thus, even if there is an increasing and/or new point source of arsenic (or decreasing concentration), such increasing (or decreasing) water column concentrations may or may not be reflected in the arsenic concentration in fish tissue.

Studies have shown that fish reach a "steady-state" condition for fluxes in arsenic exposure rather quickly. Arsenic speciation studies have revealed that most arsenic in fish muscle is found in organic forms (such as arsenobetaine); researchers have proposed that fish transform $As_{(in)}$ into organic arsenic species found in tissue.[25] Experimental exposure studies suggest that fish rapidly incorporate $As_{(in)}$ in their tissues. Once absorbed from the gastrointestinal tract, $As_{(in)}$ species (AsIII and AsV) are widely distributed throughout the body, where AsV is reduced to AsIII which is in turn methylated (as DMA or MMA; organic forms of As) in the liver.[26] $As_{(in)}$ concentrations in carp (*Carassius auratus)* and tilapia (*Oreochromis spp)* muscle tissue reached steady state

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[24] In other words, this is really about how soon do fish tissues reach a "steady state" with the arsenic flux in surface water? In its 2003 water quality derivation guidance and the revised Implementation guidance for selenium (2021), EPA defined language for "steady state":

> "An organism is in steady state when the rates of chemical uptake and depuration are equal and tissue concentrations remain constant over time." [USEPA. 2003. *Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000) Volume 2: Development of National Bioaccumulation Factors.* EPA-882-R-03-030. U.S. Environmental Protection Agency, Office of Water, Washington, DC. https://nepis.epa.gov/Exe/ZyPDF.cgi/P1005EZQ.PDF?Dockey=P1005EZQ.PDF
>
> For the purposes of the national CWA section 304(a) recommended selenium criterion, steady state refers to conditions where sufficient time has passed after the introduction of a new or increased discharge of selenium into a water body so that fish tissue concentrations of selenium are no longer increasing. [USEPA. 2021. *2021 Revision to: Aquatic Life Ambient Water Quality Criterion for Selenium–Freshwater 2016.* EPA 822-R-21-006. U.S. Environmental Protection Agency, Office of Water, Washington, DC. https://www.epa.gov/system/files/documents/2021-08/selenium-freshwater2016-2021-revision.pdf

[25] Tanamal, C. et al. 2021. Health Risk Assessment of Inorganic Arsenic Exposure Through Fish Consumption in Yellowknife, Northwest Territories, Canada. Human and Ecological Risk Assessment, 27 (4) 1072-1093.

[26] McIntyre, D.O. and T.K. Linton. 2012. Arsenic. In: *Fish Physiology, Volume 31B: Homeostats and Toxicology of Non-Essential Metals* (Eds. C.M. Wood, A.P. Farrell, C.J. Brauner), pp 297-349. London: Academic Press.

after 10-15 days of dietary exposure in the laboratory and then remained constant for the duration of the experiment (22-32 days).[27]

Thus, IACI believes rather than focusing on "new or increasing point source discharges of arsenic", the rule should instead describe the conditions under which fish sampling should be initiated to confirm compliance with the proposed $As_{(in)}$ HHWQC when either new or increased point source discharges of arsenic occur. [Proposed changes to the proposed rule to address this matter are found in Section 5.A.4 of these comments.]

Fishless Waters:

The currently proposed rule language does not include fishless waters for setting precedence of water over fish tissue in waters where fish are not found. It does however state in 210.01.k footnote 1:

> "Fish tissue element is based on total recoverable inorganic arsenic in muscle or fillet. When sufficient fish tissue data are available, and there are no new or increasing point source discharges of arsenic, the fish tissue element supersedes the water column element. Fish tissue element will be applied in accordance with Subsection 210.03.e."

This statement implies that when sufficient fish tissue data are not available, the water column element of the proposed HHWQC applies. However, the question of how to handle "fishless" waters has already been addressed by the Department as a part of the selenium criteria for the Blackfoot River. Section 287.01 footnote 5 states:

> "Water column values are the applicable criterion element in the absence of steady-state condition fish tissue data. In fishless waters, surface water from the fishless waters and fish tissue from the nearest downstream waters are used for bioaccumulation modeling. Fish tissue supersedes any site-specific water column values when fish are sampled downstream of fishless waters"

Given the existence of the above precedent an identical approach should be taken for arsenic. Recommended language changes are found in Section 5.A.4 of these comments.

Fish Sampling

IACI believes that fish species captured and analyzed should, by preference, be gamefish of legal, catchable size. However, the implementation needs to recognize that fish sampling may not result in the capture of gamefish and it may be necessary to collect and analyze non-game species in such instances. Also, in Subsection 210.03.v.(2), the word "representative" is used. It is not clear what is intended by this qualifier. Does the

[27] Cui, D., P. Zhang, H. Liu, Z. Zhang, Y. Song, Z. Yang. 2021. The dynamic changes of arsenic biotransformation and bioaccumulation in muscle of freshwater food fish crucian carp during chronic diet-borne exposure. Journal of Environmental Sciences 100: 74-81.

Department expect that the fish species sampled to include all species present with a BAF calculated for each species or for each tropic level of fish species present?

5.A. 4. Recommendations: Recreation Designated Use

IACI has the following specific recommendations for changes to the proposed standard for the "recreation (fish only) designated use.

1. *If* the decision is made that the proposed rule *must contain a water column criterion for recreational use waters*, IACI believes the trophic level weighted BAF based on regression analyses and the resulting HHWQC of 13 µg/L represents the most scientifically defensible use of the comprehensive Idaho paired tissue and water dataset. Using a TL-weighted BAF to derive HHWQC is consistent with the process the Department and EPA have used to derive BAFs when setting HHWQC for other compounds. The only difference is that the regression-based BAF better represents the fish tissue-water column relationship in Idaho (see Attachment 1) and is, therefore, more scientifically robust. Given that the Department's goal for undertaking the statewide paired fish tissue and water column sampling program was to "…help to ensure that DEQ uses appropriate, Idaho-specific, scientifically defensible inputs to the HHC equation."[28] the regression-based TL-weighted BAF better meets the stated goals than the geometric mean-based TL-weighted BAF.

   Please note the *"if"* a water column criterion is required. As IACI described in our August 2020 comments, using a water column value as a screening trigger for fish tissue sampling for the recreational designated use makes sense as the risk being addressed is from ingestion of inorganic arsenic.

2. If the Department moves forward with a water column HHWQC of 4.3 µg/L based on the geometric mean of TL-specific BAFs, such a criterion is *conservative* as it based on a TL-weighted BAF that generally overpredicts concentrations of $As_{(in)}$ in fish at water concentrations that approach, are similar to, or greater than the proposed water column element HHWQC of 4.3 µg/L.[29]

3. IACI supports the fish tissue element HHWQC of 8.0 µg/kg (wet weight) as its derivation is consistent with the process used to develop other fish tissue criteria.

4. IACI supports the fish tissue "element" superseding the water column "element" value. In particular if 4.3 4.3 µg/L is selected as the water column criterion element HHWQC, this value is based on a combination of conservative exposure and toxicity assumptions including a TL-weighted BAF that overestimates fish concentrations over

[28] Rulemaking Docket 58-0102-1801. Statewide Arsenic Monitoring to Support Human Health Criteria Updates.Discussion Paper #2. July 2019.

[29] It should be noted that promulgating a water column criterion of 4.3 µg/L would constitute the only instance in IDAPA 58.01.02 where a fish-only criterion is more stringent than a corresponding water and fish consumption if the 10 µg/L value proposed by the Department is adopted.

a large range of water column concentrations. If the Department were to adopt a 13 μg/L water column criterion, IACI recommends that the fish tissue "element" still supersede the water column value due to statistical uncertainty in the regression analysis used to derive it.

5. Specific language changes recommended are as follows:

Table 2. Footnote 1: "Fish tissue element is based on total recoverable inorganic arsenic in muscle or fillet. ~~When sufficient fish tissue data are available, and there is no new or increasing point source discharges of arsenic,~~ In fishless waters, surface water from the fishless waters and fish tissue from the nearest downstream waters are used to determine compliance with the fish tissue-based HHWQC. Fish tissue supersedes the water column value when fish are sampled downstream of fishless waters. ~~The fish tissue element supersedes the water column element.~~ The fish tissue element will be applied in accordance with Subsection 210.03.e."

03.e.
i. The fish tissue element for total recoverable inorganic arsenic is based on a single measurement using sufficiently sensitive methods.

ii. (new). For new or increasing point source discharges of arsenic, fish tissue sampling to demonstrate compliance with the fish tissue element of the water quality standard will occur no sooner than 90 days after a permitted increased or new point source discharge has commenced.

iii. The single measurement must be made on a sample that is an average or composite of a minimum of five individual fish (fillets or muscle) of the same species, ~~game fish when present,~~ collected from the same water body within the same calendar year. Gamefish, of legal catchable size, are the preferred fish species to be collected for analysis if possible. Results from multiple sample events may be averaged or composited provided they represent the same species collected from the same water body within the same calendar year.

vi. When translating the fish tissue element to a water column value, the following procedures will be followed:

(1) Data used to translate the fish tissue element must be based on current conditions and consistent with Subsections 210.03.e.i, ii, and iii.

(2) Fish tissue samples must be ~~representative of the~~ fish species present within the waterbody and include game fish species if such species can be collected. ~~whenever practical.~~ In the

absence of suitable game fish species, other resident species may be used.

5.B. Recreation and Domestic Water Supply Designated Use (fish and water exposure)

The Department has proposed just a water column criterion of 10 μg/L for the recreation and drinking water designated use.

5.B.1 Water Column Element

The proposed 10 μg/L HHWQC is identical to the SDWA MCL for arsenic. For arsenic it is logical and practical for the water supply (ingestion or water column) criterion be the same as the MCL given they are both designed to protect human health. The MCL represents a concentration of arsenic in domestic drinking water that EPA has determined is safe. Its adoption as the water and organism human health water quality criterion is not precedent setting in any way as 16 other states use (and have EPA approval) for the MCL of 10 μg/L $As_{(in)}$ as their water and organism HHWQC. Thirteen other states have a domestic water supply designated beneficial use and use the MCL of 10 μg/L $As_{(in)}$ as the HHWQC for those water bodies.[30]

5.B.2. Fish Tissue Element

The prior version of the proposed rule included a fish tissue element for this designated use in addition to the water column element. Since, this designated use includes fish consumption, the inclusion of a fish tissue element would seem logical. IACI believes that a fish tissue element needs to be included in this standard for the recreation and domestic water supply to be protective of public health for this designated use.

5.B.3 Recommendations: Recreation and Domestic Water Supply Designated Use

IACI has the following specific recommendations for changes to the proposed standard for the “recreation and domestic water supply (fish and water exposure) designated use:

1. IACI supports a water column criterion of 10 μg/L.[31]

[30] See the discussion in Section 2.B of these comments, especially Tables 4 and 5.
[31] As shown in Tables 4 and 5, a number of states have EPA approved HHWQC of 10 μg/L.

2. IACI believes that a fish tissue element is needed for the recreation and domestic water supply designated use. The fish tissue element should be 8 μg/kg (wet weight).

3. A footnote needs to be added to Table 2 that states:

   Criteria for Water and Fish exposure to inorganic arsenic are attained if the fish tissue concentration does not exceed 8.0 μg/kg (wet weight) and water column concentration does not exceed 10 μg/L.

6. GUIDANCE FOR IMPLEMENTATION OF CRITERIA

The proposed rule does not discuss implementation other than fish tissue sampling requirements. Implementation procedures in guidance are important to assure that the recreation and domestic water supply beneficial uses are protected. The *Implementation Guidance for the Idaho Mercury Water Quality Criteria* (IDEQ April 2005) provides a good framework for how the Department could implement a fish tissue criterion for $As_{(in)}$. The mercury Guidance describes how the Department will implement a fish tissue criterion through statewide fish tissue monitoring, total maximum daily load (TMDL) development, reasonable potential to exceed (RPTE) analysis, Idaho Pollutant Discharge Elimination System (IPDES) permitting, Best Management Practices (BMPs) in lieu of numeric limits, site specific criteria development, variances, water quality trading, fish advisories and antidegradation requirements. IACI recommends that the Department, through a public process, develop implementation guidance based on the existing *Implementation Guidance for the Idaho Mercury Water Quality Criteria*.

Another reason for the need for guidance is to address the specifics of arsenic in regards to the lack of relationship between water column and fish tissue concentrations. As an example of where this is important is the use of mixing zones. The restrictions placed by the EPA on mixing zones for bioaccumulative criteria are premised on there being a relationship between higher water column concentrations and higher fish tissue concentrations. That this relationship doesn't exist for inorganic arsenic, suggests that this specific mixing zone restriction should not apply for inorganic arsenic, at least in Idaho. Thus, the development of guidance for the implementation of this criteria can address this matter and related ones.

7. SUMMARY

The State of Idaho has collected an unprecedented amount of data looking at arsenic concentrations (both total and inorganic) in the water column and fish tissue. The State's 2019 dataset is exceptionally robust and represents a one-of-a-kind study given the large number of sampling locations and their geographic coverage. The objective of this study was to use the results to develop a BAF for use in establishing HHWQC for arsenic in Idaho waters.

Historically, BAFs have often been calculated simply as the ratio of the concentration of a substance in fish to the concentration of that substance in water. However, calculating a BAF in this manner, does not necessarily mean it serves as an accurate or appropriate predictor of actual bioaccumulation. Regression analysis represents a method to determine whether a relationship exists between water and fish tissue concentrations.[32] If a statistically significant relationship exists, that relationship can represent the BAF. The absence of a statistically significant relationship indicates that the concentration of a substance in fish tissue is not related to the concentration of the substance in surface water. Thus, deriving a meaningful biologically-based BAF becomes problematic. As has been discussed in the negotiated rulemaking meetings, regression analysis of the State's paired data has shown that the relationship between water and fish tissue concentrations is non-existent or very weak for the data as a whole and for certain data sub-sets.

IACI recognizes that existing EPA guidance and methodology does not contain a methodology for deriving HHWQC when a relationship between water column and fish tissue concentrations is absent. Using a TL weighted BAF based on the geometric mean of ratio BAFs for each sampling location, the Department, has derived a water column concentration from the extensive 2019 study to satisfy the existing EPA methodology.

IACI believes a more scientifically defensible incorporation of the 2019 Idaho data in the TL-weighted BAF process is available: regression-based BAFs are the best representation of the relationship between the concentration of $As_{(in)}$ in the water column and fish tissue. The 2019 data can be combined with the Department's classification of fish into TLs to derive TL-specific BAFs and an overall TL-weighted BAF that uses the results of the TL-specific regression analyses. *The result is a TL-weighted BAF of about 0.6 L/kg and water column criterion of about 13 µg/L.* IACI believes this TL-weighted BAF and resulting HHWQC is more scientifically defensible than the TL-based BAF derived using the geometric mean of individual sample point BAFs proposed by the Department.

Nevertheless, for the recreation designated use (fish only exposure), the Department has proposed a water column element criterion of 4.3 µg/L and a fish tissue element criterion of 8.0 µg/kg (wet weight). As discussed in these comments, the 4.3 µg/L is a conservative

[32] Arcadis. 2018. Idaho Arsenic Human Health Criteria: Comments Prepared in Response to the April 19, 2018 Rulemaking Meeting. April 30, 2018.

value; thus, it is appropriate that the fish tissue element criterion supersedes the water column criterion. IACI is recommending changes in the language as to the use of the fish tissue element criterion because the proposed rule language has the potential to limit the use of the fish tissue element criterion. The conservative methodology used to calculate the water column criterion makes it important to have a fish tissue criterion value that more accurately characterizes potential risk to human health from fish consumption. Due to natural sources of arsenic in Idaho's surface waters (see Table 6, Figures 1 and 3), it is important that the fish tissue element criterion be available to determine whether a water body meets the human health criteria and public health is protected.

For the domestic water supply designated use (both water and fish consumption), IACI agrees with the proposed criterion of 10 μg/L. IACI also believes that a fish tissue element criterion is needed for the domestic water supply designated use and that both the water column and fish tissue criteria need to be met to be protective of human health.

As described in the Background section of these comments, the HHWQC for arsenic have been discussed and litigated for over three decades. The extensive study of arsenic in Idaho's waters and fish that the Department has conducted provides valuable information to help derive updated water quality criteria. IACI appreciates the scientific investigation done by the Department on this matter and the extensive, detailed, open rulemaking process conducted over the past three (3) years.

Attachment A. Statistical comparison of the relative predictive ability of the geometric-based and regression-based BAFs.

The relative performance of the two alternative BAFs were analyzed using the Aikake Information Criterion (AICc) statistic, an estimation of prediction error. This method is based on the model's goodness of fit or how much the model deviates from the existing data (Wagenmakers and Farrell 2004). The BAFs were tested by fitting linear models of the collocated inorganic fish tissue and surface water data while coercing the slopes of the resulting models to be equal to the prescribed BAF. For both models, the y-intercepts were set equal to zero. The AICc values for the resulting models were used to calculate the relative likelihood or probability that each model model best represents the data and allows the models to be ranked based on that relative probability (Burnham et al. 2011).

The models analyzed represented the trophic-level weighted geometric mean-based BAF of 1.87 L/kg and the trophic-level weighted regression-based BAF of 0.61 L/kg. As noted above the slope of each model was set to be equal to the given BAFs. Results provide the relative probability that the models best represent the data. Models with higher relative probabilities better represent the data from which they were developed. The relative probability of the regression-based BAF was approximately 1.0 and the relative probability of the geometric mean-based BAF was approximately 0.0 (Table 1). These results provide clear evidence that the regression-based BAF has a higher relative probability and is therefore better supported by the data than the geometric mean-based BAF.

All analyses were performed using Program R (R Core Team 2021).

Table 1

Model	AICc	Log Likelihood	Probability
Regression-based BAF	231.33	-144.62	0.9999984
Geomean-based BAF	258.06	-127.99	0.0000016

References

Burnham, K.P., Anderson, D.R. and Huyvaert, K.P., 2011. AIC model selection and multimodel inference in behavioral ecology: some background, observations, and comparisons. Behavioral Ecology and Sociobiology, 65(1), pp.23-35.

R Core Team. 2021. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Wagenmakers, E.J. and Farrell, S., 2004. AIC model selection using Akaike weights. Psychonomic Bulletin & Review, 11(1), pp.192-196.