Evaluating Tribal Dietary, Lifestyle, and Ceremonial Exposures for Use in EPA Superfund Risk Assessments

June 2021

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Abstract

This report builds on the 2016 EPA document on biota modeling for Superfund risk assessment. During the 2019-2020 school year, Virtual Student Federal Service Intern Grace Maley researched plant and animal products ingested by North American Indigenous communities that are not included in the EPA online risk calculator tool. Here, this work is extended through the inclusion of additional species found in subsistence diets. Further, this report also describes several kinds of lifestyle and ceremonial exposures that disproportionately affect Indigenous communities. Overall, the goal of this research is to increase the inclusivity of EPA risk assessments and risk calculators, especially with regards to those members of Indigenous communities choosing to eat subsistence diets and participate in culturally traditional activities.

Acknowledgements

This report and project were the result of an internship with the U.S. Environmental Protection Agency (EPA) that was made possible through the Virtual Student Federal Service program. Thank you to the supervisors of this project, which included Stuart Walker and Michele Burgess of the EPA's Office of Superfund Remediation and Technology Innovation, and Jon Richards of EPA's Region 4 Superfund and Emergency Management Division. Thank you as well to all those who provided guidance and advice throughout the project. I'm especially grateful to the 2020 and 2019 EPA interns for their support and dedication to this work. Lastly, thank you to those individuals who provided valuable feedback on the drafts of this project.

Cover Image Credit: Howard Frisk Photography

Introduction

In 2016, the U.S. Environmental Protection Agency (EPA) in collaboration with Oak Ridge National Laboratory (ORNL) published the report, "Biota Modeling in EPA's Preliminary Remediation Goal and Dose Compliance Concentration Calculators for Use in EPA Superfund Risk Assessment: Explanation of Intake Rate Derivation, Transfer Factor Compilation, and Mass Loading Factor Sources." This report, which was authored by Karessa Manning, Fredrick Dolislager, and Michael Bellamy, increased the accuracy and inclusivity of risk assessment modeling for the consumption of contaminated plant and animal products. Specifying 24 produce items with intake rates, transfer factors, and mass loading factors, their work aimed to create a hierarchical selection process of biota modeling for the Preliminary Remediation Goal (PRG) and Dose Compliance Concentration (DCC) calculators.

During the 2019-2020 school year, EPA intern Grace Maley authored two reports that supported the Manning et al. (2016) document. Using a variety of sources, Maley provided data on over thirty additional produce items and over twenty additional animal products that were not included in the Manning et al. (2016) document. In particular, Maley's work focused on produce and animal products consumed by Indigenous populations in North America. By incorporating these products into risk calculators, the EPA can produce more inclusive and comprehensive risk assessments and risk calculator tools. This work is important to furthering environmental justice goals and can greatly benefit marginalized populations who may be disproportionately affected by the contamination at Superfund (CERCLA) sites.

Following a presentation in which Maley presented her work, several tribal and government officials notified the EPA of additional documentation on Indigenous diets and exposures. Here, these sources are considered in the hope of further broadening the scope of risk assessments. Data is provided on over forty plant products and over twenty-five animal products that were not included in the Manning et al. (2016) document, nor the reports authored by Maley. While many of these species constitute entirely new additions, others provide clarity with regards to specific species or cooking preparations. All of these additions pertain specifically to specific Indigenous communities.

Lastly, this report also incorporates lifestyle and ceremonial tribal exposures. Examples include water consumption, soil ingestion, and inhalation rates. For various reasons, each of these exposures tend to be elevated for Indigenous populations compared with the general population that is represented by EPA default exposure rates. Importantly, this data is not meant to represent all members of Indigenous populations. Some Indigenous peoples may eat subsistence diets and participate in tribal activities and ceremonies while others may not. By considering exposure pathways to native populations, however, the EPA can seek to provide more comprehensive and inclusive risk assessments.

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Source: Harper, Barbara, Brian Flett, Stuart Harris, Corn Abeyta, and Fred Kirshner. "The Spokane Tribe's Multipathway Subsistence Exposure Scenario and Screening Level RME." *Risk Analysis* 22, no. 3 (2002): 513–26. <https://pubmed.ncbi.nlm.nih.gov/12088230/>.

Spokane Tribe Subsistence Exposure Scenario

This source analyzes exposures for the Spokane Tribe given its proximity to the Midnite Uranium Mine Superfund site. Scenarios are based on a representative family living on the reservation at or near the site. This family would maintain a garden, participate in subsistence activities, use a sweat lodge daily, practice regular cultural activities, and work in outdoor monitoring. Examples of two subsistence diets are included, one based primarily on fish and the other on game. Both also include native plants and home-grown produce. Lastly, additional potential but unquantified sources of contamination are also included.

Water Consumption

Water consumption is estimated to be higher than default EPA rates. In particular, 1L of additional water is included in the exposure risk scenario to account for daily sweat lodge use during which steam is inhaled.

Table 1. Water consumption estimates for the Spokane Tribe by Category.

Category	**Amount (L/day)**
Water ingestion at home	1
Water taken from home to worksite	1
Water consumed at worksite sources	1
Water consumed during sweat lodge use (from household or spring)	1
Total	4
EPA Default (Adult)	2.5

Soil Ingestion

The Spokane Tribe is estimated to consume soil, dust, and suspended particulates at higher rates than the EPA defaults. Homes likely contain higher amounts of indoor dust than average. Further, soil inhalation may occur during outdoor gatherings, cultural activities, and ceremonies. These values may be underestimates as certain events and practices such as geophagy could dramatically increase soil ingestion.

Table 2. Soil ingestion estimates for the Spokane Tribe compared to EPA defaults.

Category	**Soil Ingestion (mg/day)**
Children: Spokane Tribe	400
Children: EPA Default	200
Adults: Spokane Tribe	400 (100 from indoor sources and 300 from outdoor)
Adults: EPA Default	100

Inhalation Rate

Inhalation rates for the Spokane Tribe are above those of the EPA defaults due to lifestyle factors. The inhalation rate for the Spokane Tribe was calculated using EPA suggested median hourly intakes for various activity levels.

Table 3. Inhalation rate estimates for the Spokane Tribe as compared to EPA defaults.

Spokane Tribe	30 m^3/day
EPA default	20 m^3/day

Diet

Adult daily caloric consumption estimates were set at 2500 kcal/day for the Spokane Tribe. Two scenarios were included in the risk assessment, one high in fish and the other high in game. Diet estimates also include home-grown vegetables. Fish and game are eaten fresh, smoked or dried and no contaminant loss during preparation is assumed.

Table 4. High fish diet consumption estimates for the Spokane Tribe.

Food	**Quantity (g/day)**
Fish (sockeye and mixed trout)	885
Big game	100
Local small game, fowl	50
Aquatic foods	175
Vegetal calories	1600
Dairy (children only)	0.5 L/day milk

Table 5. High game diet consumption estimates for the Spokane Tribe.

Food	**Quantity (g/day)**
Big game	885
Fish	75
Local small game, fowl	50 (25 birds and 25 rabbits)
Aquatic foods	175
Vegetal calories	1600
Dairy (children only)	0.5 L/day milk

Other Sources of Exposure

Several other factors are perhaps unaccounted for in this risk assessment model. For example, certain activities could dramatically increase soil ingestion rates (e.g. gathering plants, basketmaking). Other potential sources of exposure include burning contaminated firewood to heat houses, plants used for teas, plants used in sweat lodges, smudging, medicinal uses of plants, and ceremonial exposures.

Source: Harper, Barbara, Anna Harding, Therese Waterhous, and Stuart Harris. “Traditional Tribal Subsistence Exposure Scenario and Risk Assessment Guidance Manual.” Oregon State University Printing and Mailing, August 2007. <https://health.oregonstate.edu/sites/health.oregonstate.edu/files/research/pdf/tribal-grant/exposure_scenario_and_risk_guidance_manual_v2.pdf>.

This source contains exposure scenarios for several tribes including the Elem Tribe, Washoe Tribe, and the Confederated Tribes of the Umatilla Indian Reservation. For all three tribes, specific information on diet, water intake, soil ingestion, inhalation rates, and other alternative exposure pathways is given.

Elem (Pomo) Scenario

The following tables and information provide information on the Elem Tribe given their lifestyle and environment in the Central California Valley. An estimated 230 plant species are used either for dietary, medicinal, or material purposes. Cultural activities such as basket making and sweat lodge use are also incorporated in risk assessments. Acorns are the primary plant food in the Elem diet, followed by roots and bulbs, seeds and nuts, berries and greens.

Diet

- Seeds: chia, bedstraw, tarweed, wild cucumber, tule, clover, bay, fescue grasses, and the Helianthae tribe of sunflowers
- Berries: manzanita, strawberry, gooseberry, raspberry, thimbleberry, blackberry, elderberry, toyon, salmonberry, salal, currant
- Greens: clover, angelica, anise, poppy, fiddlehead, tule shoots and roots

More information on species, as well as use and preparation is contained in the report.

Acorns

Acorns are the primary plant food in the diet of the Elem Tribe. Although some research has already been done on the nutritional properties of acorns, values may differ significantly based on the form (unshelled nuts, flour, fresh nuts, parched acorns, dried acorn). Dried acorn whole nuts (without the shell) and acorn flour have 500 kcal/100g. Raw acorn nuts (without the shell but fresh) contain 387 kcal/100g. This source also contains further information on acorns on water, protein, fat, fiber, CHO, and Ash content by species.

Table 6. Breakdown of total calories by food category for the Elem Tribe.

Food Category	Percent of Total Calories
Acorns	30
Fish	20
Game (large, small, fowl)	15
Roots, tubers, rhizomes, corms	10
Bulbs	5
Seeds	5
Fruits, berries	5
Greens, shoots	5
Teas, medicines, sweeteners	5

Table 7. Daily intake for various food categories for the Elem Tribe.

Representative 2000 kcal Diet			
Resource	**% of 2000 kcal**	**kcal per 100g (Representative Species)***	**Daily Amount (grams/day)**
Acorns	30% or 600 kcal	Dried acorns & acorn flour—500	120 grams
Fish	20% or 400 kcal	Mixed trout, cooked—190	200
Game (large and small) and waterfowl, other animal species	15% or 300 kcal	Deer, roasted—158 Rabbit, wild, roasted—173 Quail, cooked—234	200
Roots, tubers, rhizomes, corms	10% or 200 kcal	Raw Chicory root—73 Potato (baked tuber)—93	250
Bulbs	5% or 100 kcal	Leek, onions and bulbs (bulb & leaf)—31	360
Seeds, pinole, atole	5% or 100 kcal	Raw dried sunflower seeds—570; Sesame seed flour—526	20
Fruits and berries	5% or 100 kcal	Raw elderberries—73	140
Greens, shoots	5% or 100 kcal	Raw dandelion greens—45 Raw watercress—11	333
Teas, medicines, sweeteners	5% or 100 kcal	Honey—304	36
Totals	**100%**	**-**	**1660g (3.6 lbs)****
* Calorie estimates are from the USDA nutrient database. ** 1 pound = 454g.			

Alternative Exposure Pathways

Adult male sweat lodge use is approximated to be once per day. Other cultural activities also result in heightened exposures including greater dust and particulate inhalation. Basket making is another potential exposure pathway; gathering and washing materials can involve environmental exposures to soil and mud. Materials are also held in the mouth and cuts on hands and fingers are common.

Table 8. Adult exposure pathways for the subsistence forager lifestyle compared to the default suburban lifestyle.

Direct Pathway	**Exposure Factors (Adult)**	
	Default Suburban Lifestyle	**Subsistence Forager Lifestyle**
Inhalation	$20m^3$	$25m^3$/day: This rate is based on a lifestyle that is an outdoor active lifestyle, based on EPA activity databases, foraging theory and ethnographic description of the activities undertaken to obtain subsistence resources as well as allotment-based food (livestock and garden). It is higher than the conventional $20m^3$/day because the respiration rates associated with typical activities are higher than those of suburban activities.
Drinking water ingestion	2L/d	3L/d plus 1L for each use of the sweat lodge during ritual purification, or 4L/day total.
Soil ingestion	100mg/d (conventional suburban); 50mg/d (manicured suburban; less outdoor time).	400 mg/d: This rate is based on indoor and outdoor activities, a greater rate of gathering, processing, and other uses of natural resources, as well as on residual soil on grown and gathered plants. Episodic events (1 gram each) are considered, such as wetland gathering, cultural activities with higher soil contact, and so on. But this might be underestimated. It does not specifically include geophagia or pica.
Dermal exposure	Must be included in the risk assessment. Greater environmental contacts must be factored in; however, suburban defaults may be used until data for traditional lifeways are developed, although a greater fraction of the skin surface and a higher dermal loading rate should be considered.	

Washoe Tribe

The Washoe People still practice a number of aspects of their traditional lifestyle in the Sierra Nevada and Great Basin ecosystems. Staples of their diet include fish and pinyon (pine) nuts, as well as rabbit, acorns, game, fowl, bulbs, roots, seeds, and berries. Basket weaving with willow branches is a common practice, as are fishing, and gathering. Over 200 species are estimated to be used by the tribe, of which 150 are edible and medicinal species.

Diet

The Washoe Tribe Diet includes a wide variety of species. Bulbs and roots used for food include wild onions, watercress, sego lily, camas, bitterroot, wild lilies, wild potatoes, cattail, and tule. Common berries include western chokecherry, elderberry, buckberry, Saskatoon serviceberry, desert and golden currants, wild strawberry, Sierra plum, and Sierra gooseberry. This source also prioritized several other species in various categories for contaminant analysis. These included miner’s lettuce, nettle, various mushrooms, honey, marmot or ground squirrel, crawfish, snail, mussels, and minnow fish.

Table 9. Harper et al. (2007) estimates of the traditional Washoe diet for foothill drainage systems.

Food Category	**Percent of total calories**
Pine nuts	20
Fish and shellfish	15
Game	15
Roots, bulbs, tubers, rhizomes	15
Greens	10
Berries	10
Seeds	10
Honey, rose hips, medicines, teas	5 (combined)

Table 10. Macronutrient content and calories by food category for the traditional Washoe diet.

Representative 2500 kcal Diet					
		Nutrients per 100 grams			
Food Category*	**% of 2500 kcal**	**kcal per 100g (Representative Species)**	**Protein per 100g**	**Lipid per 100g**	**CHO per 100g**
Pine nuts**	20% or 500 kcal	630 kcal	12 grams	61 grams	21 grams
Fish	15% or 375 kcal	Mixed trout, cooked—190	27	8.5	0
Roots, tubers, rhizomes, bulbs	15% or 375 kcal	Raw chicory root—73 Potato (baked tuber) —93 Bitterroot, fresh—90 Camas bulb, fresh—113 Leek, onions and bulbs (bulb & leaf) —31	1 2 0.7 0.7 1	0.2 0.1 0.1 0.2 0.2	17 15 22 27 8
Game & fowl	15% or 375 kcal	Deer, roasted—158 Rabbit, wild, roasted—173 Quail, cooked—234	30 33 25	3 3.6 14	0 0 0
Berries	10% or 250 kcal	Raw elderberries—73	0.7	0.5	19
Greens†	10% or 250 kcal	Raw dandelion greens—45 Raw watercress—11	3 2.3	1 0.1	9 1.3
Seeds	10% or 250 kcal	Raw dried sunflower seeds —570 Sesame seed flour—526	23 31	50 31	19 27
Honey, tea, sweeteners, misc.	5% or 125 kcal	Honey—304	0.3	0	82

* All USDA data except bitterroot and camas (Hunn 1990).
** Pine nuts (*Pinus edulis* and *Pinus pinea*) are in the USDA database; *Pinus monophylla* is not, but there is no indication of major differences between pine species, even though *monophylla* nuts are meatier and less greasy than other pine nuts, so there is less rancidity upon prolonged storage.
† Greens include watercress and the leaves, stems, shoots of other species.

Table 11. Daily calorie assumptions for the traditional Washoe diet.

Food Category	Assumption	Estimate of Daily Quantity
Pine nuts	500 kcal	500 kcal x 100g/630 kcal = 80gpd*
Fish	375 kcal	375 kcal x 100g/190 kcal = 200gpd
Roots, tubers, rhizomes	275 kcal	275 kcal x 100g/90 kcal = 300gpd
Bulbs	100 kcal Allium family	100 kcal x 100g/30 kcal = 300gpd (Allium bulbs)
Game	300 kcal game and	300 kcal x 100g/165 kcal = 180gpd
Fowl	75 kcal fowl	75 kcal x 100g/200 kcal = 40
Berries	250 kcal	250 kcal x 100g/75 kcal = 333gpd
Greens	250 kcal	250 kcal x 100g/30 kcal = 833gpd **
Seeds	250 kcal	250 kcal x 100g/550 kcal = 50gpd
Honey, teas, etc.	125 kcal	125 kcal x 100g/300 kcal = 40gpd

* The original diet had 450gpd of pine nuts available per person per day (Price 1980); a lower estimate considers the lack of clarity in the forms (fresh or parched; whole or ground) analyzed by prior authors.
** Greens include watercress, leaves, stems, and shoots. This estimate includes a consideration that a home garden would include above-ground garden vegetables and may be part of the exposure scenario.

Alternative Exposure Pathways

Washoe tribes are known to use sweat lodges as well as cold and hot springs for therapeutic healing. Sweat lodge frequency estimates are 24 2-hour sessions per year. During each session, about 4 gallons of water is poured on heated rocks to create steam. Inhaled steam may constitute an exposure pathway. Basket weaving is another highly important activity for the Washoe people. Collecting materials may lead to increased rates of soil ingestion, as well as dermal exposure. Firewood collection is also a highly important activity that could result in additional exposures.

Table 12. Alternative exposure pathways for the Washoe tribe traditional lifestyle scenario.

Direct Pathway	Exposure Factors (Adults)		
	Default Suburban Lifestyle	Rural Residential Farmer Lifestyle	Subsistence Forager Lifestyle
Inhalation	$20m^3$	$25m^3$: While EPA does not have official exposure factors for this lifestyle, it is reasonable to assume that a person who farms, gardens, irrigates, and cares for livestock has an intermediate inhalation rate.	$30m^3$/day: This rate is based on a lifestyle that is an outdoor active lifestyle, based on EPA activity databases, foraging theory, and ethnographic description of the activities undertaken to obtain subsistence resources as well as allotment-based food (livestock and garden). It is higher than the conventional $20m^3$/day because the activities with associated respiration rates are higher than suburban activities.
Drinking water ingestion	2L/d	3L/day: This rate is based on water requirements in an outdoor moderately arid environment.	3L/d plus 1L for each use of the sweat lodge during ritual purification: at 24 uses per year, this is 3.065L/d, which we are rounding down to 3L.
Soil ingestion	100mg/d (conventional suburban); 50mg/d (manicured suburban; less outdoor time)	300mg/d	400mg/d: This rate is based on indoor and outdoor activities, a greater rate of gathering, processing, and other uses of natural resources, as well as on residual soil on grown and gathered plants. Episodic events (1 gram each) are considered, such as wetland gathering, cultural activities with higher soil contact, and so on. It does not specifically include geophagia or pica.
Dermal Pathways	Must be included in the risk assessment. Greater environmental contacts must be factored in; however, suburban defaults may be used until data for traditional lifeways are developed, although a greater fraction of the skin surface and a higher dermal loading rate should be considered.		

Confederated Tribes of the Umatilla Indian Reservation
This scenario accounts for the exposure pathways present in the lifestyle and environment of the Confederated Tribes of the Umatilla Indian Reservation. This scenario is not complete, however, and does not take into account ceremonial activities such as basket making, flint knapping, natural medicines, smoke, smudges, paints, or dyes. The most prevalent food source, and therefore the highest likely exposure, is fish. Further, rates of soil ingestion, water ingestion, and air inhalation are estimated to be higher for the Umatilla Tribes than for the general population.

Diet
The diet considered here for the Umatilla Tribes is primarily fish-based. An estimated 135 species of plants are used for food, flavorings, or beverages. High numbers of species are also used as medicinal plants; nearly 120 are used by the southern Columbia Plateau tribes and up to 200 are used by the northern tribes.

Table 13. Breakdown of diet by food category for the fish-based Umatilla Tribal diet.

Food Category	Estimated percent of total calories
Fish	40
Roots	32
Greens	12
Game (including fowl)	6
Berries and fruits	5
Sweeteners, mushrooms, lichens	5

Table 14. Estimates for daily amounts and percent of 2500 kcal per food category for the Umatilla Tribes diet.

Representative 2500 kcal Diet			
Food Category	**% of 2500 kcal**	**Daily Amount (grams/day)**	**Comments**
Fish - 75% anadromous - 25% resident	40% or 1000 kcal	620 grams	Consumption of parts with higher lipid content needs to be added to this total. The lipid content will vary with species; the ratio of species can be provided on request.
Game, fowl	6% or 150 kcal	125	Consumption of organs with higher contaminant concentration (10x) needs to be added to this total. If 10% is organ meat with 10x bioconcentration, the total is *250gpd* equivalents.
Roots (unspeciated, including tubers, corms, bulbs)	32% or 800 kcal	800	Depending on the habitat, this needs to allocated among tubers and bulbs (different plant families) and terrestrial or aquatic species.
Berries, fruits	5% or 125 kcal	125	
Greens, medicinal leaves, tea, stems, pith, cambium	12% or 300 kcal	300	Above-ground plants may have contaminants translocated from the roots as well as dust deposited on the leaves.
Other: sweeteners, mushrooms, lichens	5% combined or 125 kcal	125	General assumption of 1 kcal per gram.
Total	**100%**	**2095g**	This is 4.6 pounds of food per day; this includes a much higher fiber content than domesticated varieties, which were bred for lower fiber and easier commercial processing.

Other Exposure Pathways
Umatilla Tribes have been reported to use Sweat Lodges daily; children begin using them at the age of 2. An approximate 4L of water is used per sweat lodge session to create steam, which is

then inhaled. Umatilla Tribes also participate in basket weaving. Although data is somewhat lacking, this activity is thought to increase soil inhalation rates during the gathering and washing of basket materials.

Table 15. Alternative exposure pathways with estimated rates of inhalation and ingestion for Umatilla Tribes compared to EPA defaults.

Direct Pathway	Exposure Factors (Adults)		
	Default Suburban	Rural Residential Gardener	Subsistence Forager
Inhalation	$20m^3$	$25m^3$: While EPA does not have official exposure factors for this lifestyle, it is reasonable to assume that a person who farms, gardens, irrigates, and cares for livestock has an intermediate inhalation rate.	$30m^3$/day: This rate is based on a lifestyle that is an outdoor active lifestyle, based on EPA activity databases, foraging theory, and ethnographic description of the activities undertaken to obtain subsistence resources as well as allotment-based food (livestock and garden). It is higher than the conventional $20m^3$/day because the activities with associated respiration rates are higher than suburban activities.
Drinking water ingestion	2L/d	3L/day: This rate is based on water requirements in an outdoor moderately arid environment.	3L/d plus 1L for each use of the sweat lodge.
Soil ingestion	100mg/d (conventional suburban); 50mg/d (manicured suburban; less outdoor time).	300mg/d	400mg/d: This rate is based on indoor and outdoor activities, a greater rate of gathering, processing, and other uses of natural resources, as well as on residual soil on grown and gathered plants. Episodic events (1 gram each) are considered, such as very muddy gathering, cultural activities with higher soil contact, and so on. It does not specifically include geophagy or pica.
Other parameters			
Exposure frequency	Up to 365 days per year, but varies. Hours per day varies; typically 24 hrs/d.	Up to 365 days per year, but varies. Hours per day varies; typically 24 hrs/d.	365 days per year. Hours per day varies; typically 24 hrs/d.
Exposure duration	30 years	30 or 70–75 years	70–75 years

Table 16. Summary of exposure pathways for the Confederated Umatilla Tribes.

Medium	Exposure Pathway	Exposure Factor	Value
Soil	Ingestion	Ingestion rate	400mg/d (all ages)
	Dermal	Adherence rate (<150 um particle size)	$1mg/cm^2$ (all ages)
		Skin surface area (head, hands, forearms, lower legs)	$5700cm^2$ (adult) $2800cm^2$ child)
Air	Inhalation	Inhalation rate	$30m^3$/day (adult)
Water	Dermal	Skin surface area	$18{,}000cm^2$ (adult) $14{,}900cm^2$ (child)
	Dermal and Ingestion	Swimming	13 days/yr, 2.6 hrs/event, 50ml/event
	Ingestion	Ingestion rate	4L/d
Biota	Foodchain	Fish ingestion rate	500 lbs per capita per year, or 620gpd
		Game, meat, fowl	125gpd
		Fruit, greens (unprotected)	Berries—125gpd Greens—300gpd Other—125gpd
		Below-ground roots	800gpd
		Milk	Use children's rate (children only)

Notes

- Soil adherence rate is correlated to grain size; soil samples must be sieved, and data for particle size <0.044cm (RAGSe, App. C, Table C-4) should be used for dose estimation. Inhalation is also related to particle size, so the dust resuspension estimate must also include particle size. The adherence rate of $1mg/cm^2$ is higher than most commercial rates but lower than the kid-in-mud rate (RAGSe, Ch.3, Table C-3) to account for longer events and more wet soil (riparian, wetlands) contact.
- Animal meats include organs, which have a bioconcentration potential. Assume that 10% of animal food is organs with 10x higher concentration.
- Sweat lodge parameters are included in the attached appendix.

Other Information Cited in the Report

The appendices in this report contain additional information on fish consumption of specific tribes, as well as further explanations of sweat lodge calculations. Select tables and information are included below.

Table 17. Summary of fish ingestion rates derived from various sources.

Fish Ingestion Rate	Derivation
6.5g/day	Previously used in federal promulgations based on national food consumption surveys of the general non-tribal population; now superceded by 17.5g/d.
17.5g/day	EPA's new recommendation for the general non-tribal population and recreational fishers
48.5g/day	EPA and FDA recommendations for adults to eat two 6-ounce meals per week
54g/d	Model Toxics Control Act (Washington State) and OSWER (Combustor risk assessment guidelines).
63.2g/day (about 1 pound/week)	CRITFC (1994) average for current tribal fish consumers, excluding subsistence fishers; see commentary below
142.4g/day	EPA proposed average rate for tribal subsistence fishers and 99th percentile of the general non-tribal population
389g/day	CRITFC 99th percentile of *non*-subsistence fish consumers plus non-consumers, minus 7 *outliers*. The 90th percentile was between 97 and 130g/day, and the 95th percentile was between 170 and 194g/day.
454g/day (1 pound/day)	Anecdotal subsistence estimate, commonly cited during interviews with traditional and subsistence people
540g/day	Harris & Harper (1997), based on averages for traditional CTUIR fishing families, and the lower end of the Treaty-based range; approved by BOT for use at Hanford and Columbia River. The authors sought out and interviewed traditional and subsistence fishing members.
620g/day	Cited in the Boldt decision ("Salmon, however, both fresh and cured, was a staple in the food supply of these Indians. It was annually consumed by these Indians in the neighborhood of 500 pounds per capita"). U.S. District Judge George Boldt, U.S. v. Washington, February 12, 1974, note 151. *Note: Boldt was referring to Columbia mainstem fishers when he wrote this. This does not include resident fish.*
650g/day	Walker (1999), mid-range of top third of Yakama members using the Columbia River during the 1950s and 1960s (both resident and anadromous fish). This is based on interviews of tribal fishermen, fish market records, nutritional analysis, archaeological and ethnographic evidence, and literature reviews. Walker cites other studies that support this number. Walker estimated that minimal river users ate 80g/d, and the median river user ate 350g/d. The BOT endorsed the numbers in this paper.
1000g/day	Walker (1985) estimate of pre-dam rates for Columbia Plateau tribes, accounting for calorie loss as fish migrate upriver and other documentation.

Table 18. Summary of consumption rates of fish for several Pacific Northwest Tribes. More information on how these values were derived is included in the appendix of this source; these values are based on other studies of fish consumption of individual tribes.

Survey	Mean (converted to g/person/d)			95th	99th
	Finfish	Shellfish	Combined	Fish and Shellfish	
CRITFC	63.2	-	63.2	170–194	389
Suquamish	81.8	132.7	213.9	798	ND
Toy—Tulalip/Squaxin	48.8	22.3	72.9	177	ND
Sechena—Asian/Pac Isl.	-	-	119.3	?	?

CRITFC—outliers were eliminated from the database (implies a presumption of not valid).
Suquamish—no labeling of high end consumers as outliers; says they were assumed to be accurate reports.
Tulalip—recoded outliers (implies a presumption that these were valid but mistaken).

Table 19. Summary of assumptions and parameters used in the calculation of inhalation of volatile and semi-volatile compounds during sweat lodge use.

Parameter	Typical Value	Unit
Volume of water used in a sweat ($V_{w,total}$)	4	L
Radius of a hemispherical sweat lodge (r)	1	m
Inhalation rate (IR)	30	m^3/day
Length of a sweat event (ET)	1	hr/event
Number of sweats per year (EF)	365	events/yr
Number of years a person sweats in a life time (ED)	64	yr
Average body weight (BW)	70	kg
Averaging time (AT)	70 (carcinogen) ED (noncarcinogens)	yr
Conversion factor (CF)	365	day/yr

Table 20. Summary of assumptions and parameters used in the calculation of inhalation of nonvolatile compounds during sweat lodge use.

Parameter	Typical Value	Unit
Temperature of the sweat lodge (T)	339 (150)	K (F)
Ideal gas law constant (R)	0.06237	(mmHg·m^3)/(gmole·K)
Inhalation rate (IR)	30	m^3/day
Length of a sweat event (ET)	1	hr/event
Number of sweats per year (EF)	365	events/yr
Number of years a person sweats in a life time (ED)	64	yr
Average body weight (BW)	70	Kg
Averaging time (AT)	70 (carcinogen) ED (noncarcinogens)	yr
Conversion factor (CF)	365	day/yr
Molecular weight of water (MW_w)	18	g/gmole
Density of liquid water (ρ_w)	1000	g/L

Table 21. Summary of assumptions and parameters used in the calculation of dermal exposure during sweat lodge use for volatile and semi-volatile compounds.

Parameter	Typical Value	Unit
Volume of water used in a sweat ($V_{w,total}$)	4	L
Radius of a hemispherical sweat lodge (r)	1	m
Body surface area available for contact (SA)	1.8	m^2
Fraction of skin area (SA) in contact with vapor ($f_{SA,v}$)	0.0–1.0	unitless
COPC-specific permeability constant for vapor exposure (Kp_v)	1 to 1E-5	cm/hr
Length of a sweat event (ET)	1	hr/event
Number of sweats per year (EF)	365	events/yr
Number of years a person sweats in a life time (ED)	64	yr
Average body weight (BW)	70	kg
Averaging time (AT)	70 (carcinogen) ED (noncarcinogens)	yr
Conversion factor (CF_1)	0.01	m/cm
Conversion factor (CF_2)	365	day/yr

Table 22. Summary of assumptions and parameters used in the calculation of dermal exposure during sweat lodge use for nonvolatile compounds.

Parameter	Typical Value	Unit
Volume of water used in a sweat ($V_{w,total}$)	4	L
Radius of a hemispherical sweat lodge (r)	1	m
Body surface area available for contact (SA)	1.8	m^2
Fraction of skin area (SA) in contact with liquid ($f_{SA,l}$)	0.0–1.0	unitless
Fraction of skin area (SA) in contact with vapor ($f_{SA,v}$)	1.0–$f_{SA,l}$	unitless
COPC-specific permeability constant from vapor contact with skin (Kp_v)	1 to 1E-5	cm/hr
COPC-specific permeability constant from water contact with skin (Kp_l)	1 to 1E-5	cm/hr
Length of a sweat event (ET)	1	hr
Number of sweats per year (EF)	365	events/yr
Number of years a person sweats in a life time (ED)	64	yr
Average body weight (BW)	70	kg
Averaging time (AT)	70 (carcinogen) ED (noncarcinogens)	yr
Molecular weight of water (MW_w)	18	g/gmole
Density of liquid water (ρ_w)	1000	g/L
Temperature of the sweat lodge (T)	389 (150)	K (F)
Ideal gas law constant (R)	0.06237	$(mmHg \cdot m^3)/(gmole \cdot K)$
Conversion factor (CF_1)	0.01	m/cm
Conversion factor (CF_2)	365	day/yr
Conversion factor (CF_3)	10	L/m^2-cm

Source: Donatuto, Jamie. “Project Design and Implementation: Bioaccumulative Toxics in Native American Shellfish.” Georgia Basin/Puget Sound Research Conference, 2003. < https://swinomish-nsn.gov/media/5316/1e_donat.pdf>.

Swinomish Tribe and Risk Assessment

The Swinomish Tribe is located about 65 miles north of Seattle, Washington and relies heavily on clams and crabs for subsistence. The reservation includes about 3000 acres of tidelands, from which tribe members harvest shellfish. For this reason, it is believed that the EPA default rate of shellfish consumption of 6.5 g/day significantly underestimates the shellfish consumption of the Swinomish Tribe. On these tidelands, at least 58 species of fish and many species of shellfish are found, including 14 species of crab. Some examples include Dungeness crab, Japanese oysters, bay mussels, Macoma clams, native littleneck clams, butter clams, manila clams, horse clams, and eastern soft-shell clams. Swinomish tribal dependence on shellfish has increased in recent years with the decline of salmon runs, which once provided a valuable economic and dietary resource.

Table 23. A sample of fish and shellfish consumption rates proposed by various stakeholders, some of which specifically pertain to Native American consumption in Washington State.

Stakeholder	Proposed Rates
EPA default (Ambient Water Quality Criteria 1980)	6.5 g/day fish or shellfish
Washington State Model Toxic Control Act	23 g/day fish or shellfish
Proposed Ecology Rate (based on studies by tribal groups in 1999)	177 g/day fish 68 g/day shellfish
Study by the Suquamish Tribe	More than double Ecology rates

Source: Harper, Barbara. “Shoshone-Bannock Exposure Scenario for Use in Risk Assessment,” May 2017. <https://superfund.oregonstate.edu/sites/superfund.oregonstate.edu/files/shoshone_bannock_scenario_2017.pdf>.

Shoshone-Bannock Exposure Scenario

This document provides a recent exposure scenario for use in risk assessment given the environment and lifestyle of the Shoshone-Bannock Tribe. It includes two exposure scenarios, one for a tribal residential homesteader and the other for a non-residential traditional practitioner. While the former is assumed to consume a completely wild diet, the latter is assumed to consume an unspecified portion of wild foods for his or her diet. Shoshone-Bannock Tribes are also known to use sweat lodges, which constitutes another pathway of exposure in addition to diet. A daily soil ingestion rate is also estimated to be 330mg/day for all ages and both scenarios.

Diet

Table 24. Nutritional data for key species of the Shoshone-Bannock subsistence diet.

Food Category	***Kcal per 100g (Representative species)****	**Food Category**	***Kcal per 100g (Representative species)****
Resident fish and other aquatic resources	Mixed trout, cooked – 190 Crayfish, wild cooked - 82 Turtle, raw - 89	***Bulbs***	Leek, onions and other bulbs (bulb & leaf) – 31
Anadromous and marine fish and shellfish	Salmon, cooked – 180 Shad, cooked - 252 Herring, dry cooked – 200 Pollock, dry cooked - 118 Eel, dry cooked – 236 Oyster, dry cooked – 70 Clam, moist cooked – 148 Lobster, moist heat cooked - 98 Seal, raw – 142 Beluga, raw - 111	***Berries, fruits***	Raw elderberries – 73 Raw strawberries - 70
		Other vegetables (above-ground)	Beans, cooked pinto, kidney or white – 143 Peas, boiled pigeon or split - 120 Squash, cooked winter – 37 Squash, cooked Navajo - 16
Game, large and small	Deer, elk, buffalo, roasted – 158 Moose, roasted – 134 Moose liver, braised - 155 Rabbit, wild, roasted – 173 Beaver, roasted – 212 Muskrat, roasted - 236	***Greens, Tea (includes leaves, stems, medicinal plants, flavorings)***	Raw dandelion greens – 45 Raw watercress – 11 Fiddleheads, raw - 34
		Honey, Maple syrup, other	Honey – 304 Maple syrup - 261
Fowl and Eggs	Quail, cooked – 234 Duck, cooked - 200 Duck eggs – 185 Pheasant (for wild turkey) - 247	***Seeds, Nuts, Grain***	Corn, Navajo strain steamed - 386 Raw dried sunflower seeds – 570 Chia seeds – 490 Hazelnut, dry roast – 646 Butternuts, dried - 612
		Roots, Bulbs, Tubers	Raw chicory root – 73 Boiled burdock root – 88 Potato, baked tuber - 200

Table 25. Tag limits per hunter with conversions to daily intake for game.

Tag Limits per hunter	Average meat per animal (pounds)	Total annual meat per hunter (wet weight; pounds)	Grams/day available to each person (household of 4 people).
2 Mule Deer	175.8	351.6	109g
3 Elk	350	1050	327g
1 Moose	950	950	295g

Table 26. Estimates of caloric intake by food category for the Shoshone-Bannock Tribe.

Food category	Amount	Estimate of Daily Calories
Game	8 oz, 225 g/d	600 kcal
Fish	5 oz, 142.4 g/d	200 kcal
Fowl	1.5 oz, 40 g/d	80 kcal
Roots, tubers, rhizomes	1C, 200 g/d	150 kcal
Greens, Bulbs, other	1C, 150 g/d	100 kcal
Berries, Fruit	1 C, 100 g/d	75 kcal
Seeds, Nuts	½ C, 50 g/d	200 kcal
Grain (modern)	7 oz, 200 g/d	400 kcal
Honey, teas, etc.	30 g/d	100 kcal
Fats, oils	30 g/d	260 kcal
Total	*1168 g (2.6 lbs.)*	*2265 kcal*

Source: Ashley, Joelynn. "Hopi Comprehensive Economic Development Strategy," 2016. http://www.hopi-nsn.gov/wp-content/uploads/2016/09/Hopi-Comprehensive-Economic-Development-Strategy-Final-Draft-2016.pdf

Hopi Tribe

According to this document, the Hopi people hunt and gather a substantial part of their diet. Some gathered plants and animals are also used for ceremonial purposes, although this source does not specify which species. The quantity of food estimated by Hopi women as collected from Hopi land was about 30%. The tribe engages in dry farming practices on arid lands. Pest species such as crows and ravens can decrease the yields of Hopi farmers; the populations of these species increase as individuals improperly dispose of solid waste. Farmers grow several crops, of which corn (blue corn is one variety) is the most common. Alfalfa and cotton are also produced. Other aspects of the traditional, subsistence economy include craft making (dolls, baskets, pottery) and cattle ranching. Farming and ranching not only serve practical purposes for the Hopi, but also social and cultural purposes as well. Livestock production was not a traditional activity of the Hopi Tribe, but has become more important to the Hopi in recent years. Animal species that have been cultivated by the Hopi include sheep, goats, cattle, horses, and swine. Access to water resources in one limiting factor in raising animals on Hopi lands.

Source: Harper, Barbara, Anna Harding, Stuart Harris, and Patricia Berger. "Subsistence Exposure Scenarios for Tribal Applications." Human and Ecological Risk Assessment : HERA 18, no. 4 (July 1, 2012): 810–31. https://doi.org/10.1080/10807039.2012.688706.

This source provides a detailed overview of how tribal risk assessments ought to be conducted. There are several key points that are worth highlighting. First, tribal risk assessment results are almost always higher than suburban, recreational, and occupational scenarios (See table 27). When conducting risk assessment, the authors recommend accounting for a 2000-25000 kcal/day diet with approximate ratios of traditional food groups. They believe that this approach yields more accurate results than those approaches that attempt to measure how many mg/day of about 200 foods and medicines are consumed. Using the method recommended by the authors also allows assessments to avoid errors that occur when native foods are simply substituted into a contemporary food pyramid. Oftentimes, tribal staples in diets are identified, but not quantified, which makes it difficult to conduct risk assessments using the less accurate method. Further, the authors articulate that many factors beyond diet are important. For example, activity level is noted as particularly important. In this report, a basic assumption of 2 hours of high activity, 6 hours of moderate activity, 8 hours of low and sedentary activity, and 8 hours of rest is used. Finally, this source also briefly describes applications of tribal risk assessments, the most important of which is Superfund.

Table 27. Table showing statistical information about how much higher tribal risk assessment results tend to be compared to suburban, recreational, and occupational scenarios.

Category	**How many times higher tribal risk assessment results tend to be compared to other kinds of risk assessment**
Soil Ingestion	2-4 times higher
Fish Ingestion	Up to 100 times greater
Inhalation Rates	Possibly up to 1.5 times higher
Dietary Exposures	0-10 times higher
Exposure Duration	Lifetime compared to 30 years
Cumulative Risk Assessments	10-100 times higher

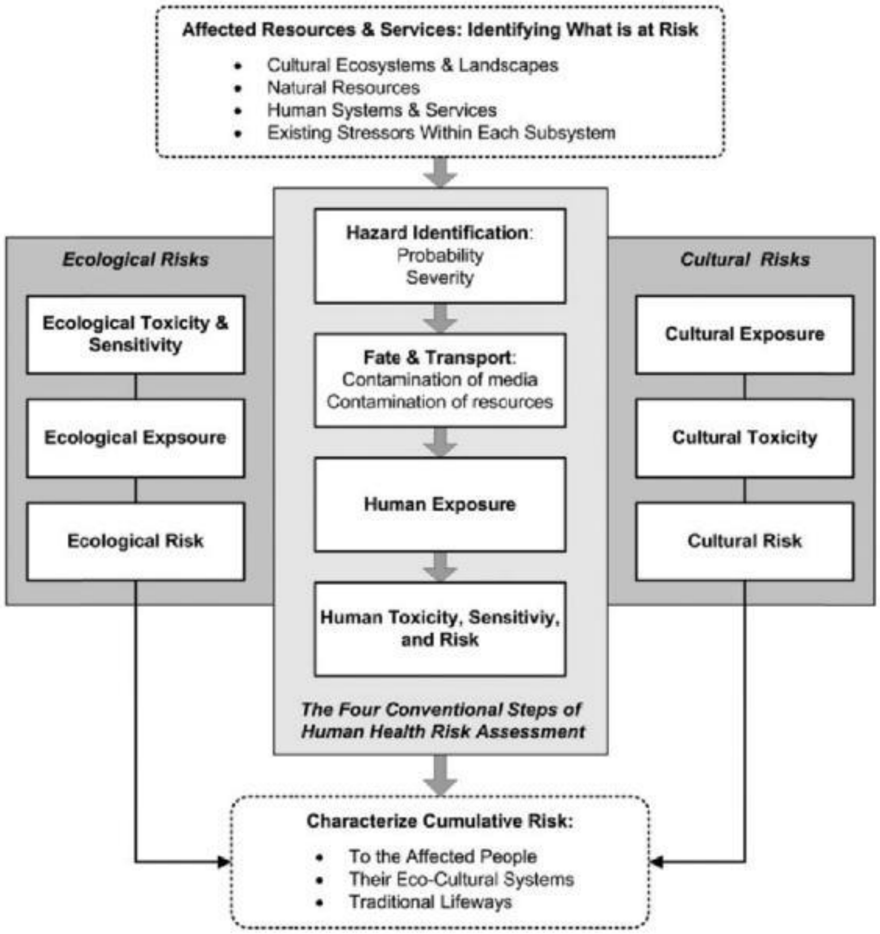
Table 28. Activity level assumptions for Native populations.

Category	**Hours / Day**
High Activity	2
Moderate Activity	6
Low and/or Sedentary Activity	8
Rest	8

Elements of a risk assessment scenario report, according to this source:

- Tribal circumstances and history
- Environmental Setting
- Resource Use Patterns
- Traditional Diet
- Direct Exposure factors

Figure 1. Proposed Broader Risk Assessment Model. This model accounts for ecological risks, cultural risks, and affected resources and services in addition to a traditional risk assessment. Thus, this method is more comprehensive and likely yields more accurate results.



Source: Reeves, Randall R. "The Origins and Character of 'Aboriginal Subsistence' Whaling: A Global Review." *Mammal Review* 32, no. 2 (2002): 71–106. https://doi.org/10.1046/j.1365-2907.2002.00100.x.

The Makah Tribe and Subsistence Whale Hunting

This source examines the history of whaling by the Makah Tribe who live in present-day Washington State. The tradition of whaling goes back hundreds of years and also extends to the present day. Typically, the tribe has hunted for Gray and Humpback whales in the waters off the coast of Washington State. Once killed, nearly all parts of the whale were used for food and ceremonial purposes. Up until the 19^{th} century, whale meat was a staple in the Makah diet. Beginning in 1928, whaling by the Makah tribe began to decline. However, in 1999, the tribe was again allowed to hunt a Gray Whale. This hunt was the first by the tribe in 75 years. In order to complete the hunt, the tribe had to gain permission from federal and local governments. Further, scientific researcher ensured that the population of Gray Whales was stable prior to the hunt. The Makah eventually won the right to this hunt, arguing that it is an integral part of their culture and subsistence diet.

Source: Donatuto, Jamie, and Barbara Harper. "Issues in Evaluating Fish Consumption Rates for Native American Tribes." *Risk Analysis* 28, no. 6 (2008): 1497–1507.

This source describes several problems that may occur when evaluating fish consumption rates for Native Americans. These problems include the following:

- Reports may not specify their intention, or what they plan to do with the data
- Researchers may use data collection methods that are incongruent with aspects of community life
- Data analysis may omit the highest rates in a subset of the population
- Reports may fail to include tribal health co-risk factors
- Reports may not include tribal values and instead focus on state and/or federal action

Data collection typically concludes that tribal members may be content eating lower rates of fish than were historically consumed. Finally, this source also proposes a community-based interview method of data collection based on a report done on the Swinomish Tribe. This method is likely more accurate when capturing rates of fish consumption rates.

Table 29. USEPA recommendations for fish consumption for the general population.

Category	**Recommended grams/day**
Combined fresh water and estuarine finfish and shellfish	6.5
Marine fish	14.1
All fish	20.1

Table 30. Various recommendations for rate of Native American fish consumption rates.

Source of Recommendation	Recommendation
US EPA and Oregon State based on Columbia River Inter-Tribal Fish Commission Survey	63.2 g/day mean ingestion ratel 389 g/day for 99^{th} percentile
2005 US EPA Combustion Guidance	87.4 grams/ day for general population; Native American groups are noted to have unspecified higher fish consumption rates
US EPA Recommendations based on water quality standards	17.5 grams/ day for general population and sport anglers; 142.4 grams/ day for subsistence fishers; 165.5 grams / day for women of childbearing age (designed to protect against fetal developmental effects) *Does not include marine species
Various States, based on water quality standards	6.5 grams/day with higher consumption rates for women, children, tribes, and subsistence fisherman
Proposed recommendation by the Washington State Department of Ecology	57 grams/day with fish diet fraction of 1.0 obtained locally (would replace older guidelines of 54 grams/ day with a fish diet fraction of 0.5 obtained locally)

This source also describes how contaminants in fish may affect not only physical health, but also cultural and spiritual health of Native Peoples; contaminated health may degrade the meaning and importance of tribal values, practices, and ceremonies.

Source: "Leech Lake Band of Ojibwe Tribal Food Guide," 2007.

This two-page pamphlet compiles information about tribal food consumption specifically for the Ojibwe Tribe. Intended as a resource for tribe members, the information is directed towards women of childbearing age and children up to 15 years of age. All servings listed are child-sized, or about 4 oz. The guide includes four categories of guidance: commercial meats, commercial vegetable and produce, wild fish, and wild foods and garden. For each of these four categories, multiple species and/or items are listed, along with a recommended number of meals per month threshold that should not be exceeded. Further, the source also indicates which foods and/or items are associated with different toxins. For all tables, the following code is used to indicate toxins: Mercury (M), DDT (DT), PCBs (P), Dioxins (DF). No author is listed for the source, but the Tribal Contaminant Research Project is referenced as a source.

Table 31. Guidance for commercial meat consumption for women and children of the Ojibwe Tribe.

Commercial Meats Consumption Guidance

FOOD ITEM	MEALS PER MONTH
HAMBURGER, PAN COOKED	3 (DF)
BEEF, CHUCK ROAST, BAKED	EAT NONE (DF)
BEEF LIVER, FRIED	2 (DF)
BOLOGNA, SLICED	3 (DF)
SALMON	1 (DF)
CANNED TUNA	1 (M)
PORK CHOP, PAN COOKED	NO LIMIT
BACON, PAN COOKED	3 (DF)
PORK ROAST, BAKED	4 (DF)
PORK SAUSAGE, PAN COOKED	3 (DF)
HAM, BAKED	8 (DF)
CHICKEN, FRIED	7 (DF)
TURKEY BREAST, ROASTED	8 (DF)
FISH SANDWICH, FISH STICKS	NO LIMIT

Table 32. Guidance for commercial vegetable and produce consumption for women and children of the Ojibwe Tribe.

Commercial Vegetable and Produce Consumption Guidance

FOOD ITEM	MEALS PER MONTH
POTATO, BAKED OR BOILED	NO LIMIT
BEANS, CARROTS, CORN (NO BUTTER)	NO LIMIT
SQUASH, BOILED	NO LIMIT
EGGS, BOILED	NO LIMIT
SWEET POTATO	NO LIMIT
CHEESE, AMERICAN	NO LIMIT
CHEESE, CHEDDAR	2 (DF)
CHEESE, SWISS	3 (DF)
CHEESE, COTTAGE	NO LIMIT

Table 33. Guidance for wild fish consumption for women and children of the Ojibwe Tribe.

Wild Fish Consumption Guidance	
FOOD ITEM	MEALS PER MONTH
WALLEYE & NORTHERN UP TO 3 POUNDS	2 (M)
WALLEYE & NORTHERN OVER 3 POUNDS	EAT NONE (M)
WHITEFISH, ALL	4 (DT)
TULLIBEE, ALL	4 (DT)
LAKE TROUT & SALMON, UP TO 4 POUNDS	4 (DF, DT, M)
LAKE TROUT & SALMON, OVER 4 POUNDS	1 (DF, DT, M)
TROUT, RAINBOW & BROOK UP TO 1 POUND	NO LIMIT
TROUT, RAINBOW & BROOK OVER 1 POUND	4 (DF, DT, M)
PERCH & PANFISH	NO LIMIT
WHITE SUCKER	UNDER REVIEW
FISH , LIVER AND EGGS, ALL	CEREMONIAL ONLY (DF, DT)

Table 34. Guidance for wild foods and garden produce consumption for women and children of the Ojibwe Tribe.

Wild Foods and Garden Produce Consumption Guidance	
FOOD ITEM	MEALS PER MONTH
DEER and MOOSE, MUSCLE	NO LIMIT
DEER and MOOSE, LIVER	2 (DF)
DUCK	NO LIMIT
TURTLE, SNAPPER, MUSCLE	5 (M)
TURTLE, SNAPPER, LIVER	2 (M)
TURKEY	NO LIMIT
SQUIRREL, RABBIT, HARE, GROUSE	UNDER REVIEW
WILD and GARDEN VEGETABLES	NO LIMIT
WILD RICE	NO LIMIT
WILD BERRIES	NO LIMIT

Source: Elise, Krohn. 2007. *Wild Rose and Western Red Cedar: The Gifts of the Northwest Plants*. Chatwin.

- "The therapeutic dosage of seaweeds varies, usually from two to five grams per day. As a dietary supplement, Ryan Drum recommends five to 15 grams of seaweed(s) at least twice a week." (pg. 39)
- Modes of ingestion include diet and capsule forms.
  - Dietary forms include soups, pie, seasoning, or plain (“chips”)
  - Health supplement capsules typically contain 2-5 grams of bladderwrack per day
- A study by Jennifer Hahn used a portion size of 5 grams dry weight per day as this amount is based on the USFDA portion size for dry seaweed

Source: Schmitt, Christopher J., William G. Brumbaugh, Gregory L. Linder, and Jo Ellen Hinck. 2006. "A Screening-Level Assessment of Lead, Cadmium, and Zinc in Fish and Crayfish from Northeastern Oklahoma, USA." *Environmental Geochemistry and Health* 28 (5): 445–71. https://doi.org/10.1007/s10653-006-9050-4.

This study examined consumption of six common species (common carp, channel catfish, flathead catfish, largemouth bass, spotted bass, and white crappie) within Northeastern Oklahoma during 2001-2002. Species were sampled from the Spring River and Neosho River. Additionally, samples were taken from a contaminated site in eastern Missouri and from reference sites. All samples were prepared for human consumption in the same way that local Native Americans prepare them. Specimens were analyzed for lead, cadmium, and zinc. Metal concentrations were generally higher in samples from those sites most affected by mining compared to reference samples. Results indicate that human consumption of carp and crayfish could be restricted to align with current criteria for lead, cadmium, and zinc consumption. Additionally, channel catfish consumption could be restricted based on lead consumption levels. The results of this study also support previous findings. Rather than examining current consumption levels of these species, researchers estimated quantities that would have to be eaten (for adults and for children) that would be necessary to achieve various rate-based toxicity thresholds. The risks of eating contaminated fish to animals are also considered by the authors.

Table 6 Range of lead, cadmium, and zinc concentrations (all μg g^{-1} wet-weight) in common carp from sites in Missouri (MO), Kansas (KS), and Oklahoma (OK) as reported by this and previous investigations. Values shown in *italics* were used to assess potential hazards to humans, wildlife, or both

Sample type and collection location	Lead	Cadmium	Zinc
Individual headless, scaled, eviscerated fish carcasses			
Neosho R., Spring R., and Big R.[a]			
Neosho R., OK	0.06–*1.23*	0.007–*0.356*	22.4–60.2
Spring R., OK	0.08–1.15	< 0.003–0.118	28.6–*71.0*
Big R., MO	1.39–*4.96*	0.047–*0.207*	22.2–*27.5*
Composite samples of whole fish			
Neosho R. system, KS[b]			
Cottonwood R. @ Cottonwood Falls	< 0.50–0.50	0.20–0.35	62.0–64.0
Neosho R. @ Neosho Rapids	0.20–0.30	0.11–0.25	44.0–64.0
Neosho R. @ Humboldt	< 0.50–0.50	0.17–0.17	52.0–59.0
Neosho R. @ Oswego	0.20–0.20	0.37–0.38	45.0–65.0
Neosho R. @ Chetopa	< 0.50–0.60	0.17–0.26	41.0–60.0
Spring R., KS[c]			
Spring R. @ Empire Lake	0.20	0.08	75.0
Spring R. @ Baxter Springs	0.30–*1.00*	0.10–*0.50*	71.0–*120*
Central U.S. rivers[d]			
Verdigris R. @ Oologah Lake, OK	0.18–0.31	0.220–0.270	72.7–101
Arkansas R. @ Keystone Lake, OK	0.14–0.17	0.083–0.092	62.3–73.5
Canadian R. @ Eufaula Lake, OK	0.23–0.28	0.109–0.141	76.2–150
Red R. @ Lake Texoma, OK	0.10–0.11	0.045–0.067	54.1–81.7
Kansas R. @ Bonner Springs, KS	0.08–0.14	0.140–0.239	57.2–75.1
Missouri R. @ Hermann, MO	0.05–0.07	0.084–0.111	37.8–48.7

[a]This study

[b]From Allen et al. (2001)

[c]From Allen and Wilson (1992)

[d]From Schmitt (2004)

Table 2 Criteria[a] used to evaluate the risks of lead, zinc, and cadmium in fish and crayfish to humans and wildlife

Criterion[a]	Units	Lead	Cadmium	Zinc	Source
Human health					
TDI/PTDI	μg/kg body wt/day	3.57[b]	1.0	nv	WHO (1992, 1995)
PTWI	μg/kg body wt/week	25[b]	400–500[c]	nv	WHO (1992, 1995)
PTDI	μg/day	6[d]	nv	nv	USFDA
MRL	μg/kg body wt/day	nv	0.2	nv	ATSDR (2002)
ML (fish)	$\mu g\ g^{-1}$ wet-wt	0.2	0.05–0.10	nv	FAO/WHO (1998)
ML (crustaceans)	$\mu g\ g^{-1}$ wet-wt	0.5	0.05–0.10	nv	FAO/WHO (1998)
RfD	μg/kg body wt/day	nv	1.0	300	USEPA (1994a, 2000a, 2000b)
SV (recreational fishers)	$\mu g\ g^{-1}$ wet-wt	nv	4.0	nv	USEPA (2000a)
SV (subsistence fishers)	$\mu g\ g^{-1}$ wet-wt	nv	0.491	nv	USEPA (2000a)
RDA	μg/kg body wt/day	nv	nv	160	ATSDR (1999)
Ecological risk					
NOAEL-TRV (avian)	mg/kg body wt/day	1.68	1.47	14.5[e]	USEPA (2003a, 2003b; Sample et al., 1996)
NOAEL-TRV (mammal)	mg/kg body wt/day	4.7	0.77	16.0[e]	USEPA (2003a, 2003b; Sample et al., 1996)

[a]TDI, tolerable daily Intake; PTDI, provisionally tolerable daily intake; PTWI, provisionally tolerable weekly intake; MRL, minimum risk level; ML, maximum allowable concentration; RfD, reference dose; SV, screening value; RDA, recommended daily allowance; NOAEL, no observed adverse effect level; TRV, toxicity reference value; WHO, World Health Organization; USFDA, US Food and Drug Administration; FAO, Food and Agricultural Organization of the United Nations; ATSDR, (US) Agency for Toxic Substances and Disease Registry; USEPA, US Environmental Protection Agency; nv, no value

[b]For children and adults

[c]For adults; no value for children

[d]For children; no value for adults

[e]Interim value; consensus value pending

Table 7 Amounts of the most contaminated crayfish and fish of several taxa obtained in 2001–2002 and previous studies from sites in the Tri-States Mining District (TSMD) and from the Big River that would need to be consumed by adults or children of the indicated body weights to reach the Tolerable or Provisionally Tolerable Daily Intake or Provisionally Tolerable Weekly Intake for lead (Pb) and cadmium (Cd)[a], or the chronic effect reference dose (RfD) for zinc (Zn)[b]

Location, collection period, taxon, and metal	Max. conc. ($\mu g\ g^{-1}$ ww)	Site(s)	Daily intake, g/kg/day	Adults (70 kg)				Children (14.5 kg)			
				g/day	lb/day	lb/week	Meals/month[h]	g/day	lb/day	lb/week	Meals/month[h]
TSMD, 2001–2002											
Crayfish, Pb	1.01	3u	3.6	250	0.5	3.8	31	52	0.1	0.8	6
Crayfish, Cd	0.370	2	2.7	189	0.4	2.9	23	40	0.1	0.6	5
Crayfish, Zn	62.6	3u	4.8	336	0.7	5.2	41	70	0.2	1.1	9
Carp, Pb	1.23	3	2.9	205	0.5	3.2	25	43	0.1	0.7	5
Carp, Cd	0.356	3	2.8	197	0.4	3.0	24	41	0.1	0.6	5
Carp, Zn	71.0	2, 4	4.2	296	0.7	4.6	36	62	0.1	0.9	8
Catfish[c], Pb	0.91	1	4.0	277	0.6	4.3	34	58	0.1	0.9	7
Catfish[c], Cd	0.057	6	17.5	1229	2.7	18.9	151	255	0.6	3.9	31
Catfish[c], Zn	52.8	6	5.7	398	0.9	6.1	49	83	0.2	1.3	10
Centrarchid[d], Pb	0.09	2	40.0	2800	6.2	43.1	345	580	1.3	8.9	72
Centrarchid[d], Cd	0.008	1	125.0	8750	19.3	134.8	1078	1813	4.0	27.9	223
Centrarchid[d], Zn	18.0	5	16.7	1166	2.6	18.0	144	242	0.5	3.7	30
TSMD, pre-2000[e]											
Crayfish, Pb	2.80	K[e]	1.3	90	0.2	1.4	11	19	< 0.1	0.3	2
Crayfish, Cd	0.39	K[e]	2.6	180	0.4	2.8	22	37	0.1	0.6	5
Crayfish, Zn	67.4	K[e]	4.5	312	0.7	4.8	38	65	0.1	1.0	8
Crayfish, Pb	5.21	T[e]	0.7	49	0.1	0.7	6	10	< 0.1	0.2	1
Crayfish, Cd	1.64	T[e]	0.6	44	0.1	0.7	5	9	< 0.1	0.1	1
Crayfish, Zn	119.4	T[e]	2.5	176	0.4	2.7	22	36	0.1	0.6	5
Big River, 2001											
Carp, Pb	4.96	9	0.7	51	0.1	0.8	6	11	< 0.1	0.2	1
Carp, Cd	0.207	9	4.8	339	0.7	5.2	42	70	0.2	1.1	9
Carp, Zn	27.5	9	10.9	764	1.7	11.8	94	158	0.3	2.4	20
Centrarchid[d], Pb	1.45	9	2.5	174	0.4	2.7	21	36	0.1	0.6	4
Centrarchid[d], Cd	0.008	9	125.0	8750	19.3	134.8	1078	1813	4.0	27.9	223
Centrarchid[d], Zn	15.7	9	19.1	1338	2.9	20.6	165	277	0.6	4.3	34
Big River, pre-2001											
Crayfish, Pb[f]	38.65	D	0.1	7	< 0.1	0.1	< 1	1	< 0.1	< 0.1	< 1
Crayfish, Cd[f]	0.410	D	2.4	171	0.4	2.6	21	35	0.1	0.5	4
Crayfish, Zn[f]	35.9	D	8.4	585	1.3	9.0	72	121	0.3	1.9	15
Centrarchid, Pb[g]	0.96	F	3.8	263	0.6	4.0	32	54	0.1	0.8	7
Centrachid, Cd[g]	0.118	F	8.5	594	1.3	9.1	73	123	0.3	1.9	15
Centrachid, Zn[g]	29.8	F	10.1	705	1.6	10.9	87	146	0.3	2.2	18

[a] 3.57 μg/kg/day or 25 μg/kg/week for Pb; 400-500 μg/week or 1.0 μg/kg/week for Cd [World Health Organization (WHO) 1995]

[b] 0.3 mg/kg/day [U.S. Environmental Protection Agency (USEPA) 2000b]

[c] Channel catfish (*Ictalurus punctatus*) or flathead catfish (*Pylodictis olivaris*)

[d] Largemouth bass (*Micropterus salmoides*), spotted bass (*M. punctalatus*), or white crappie (*Pomoxis annularis*)

[e] From Wildhaber et al. (1997); T, tributary; K, Kansas (all upstream of 2001–2002 study area)

[f] From Schmitt and Finger (1982); D, near Desloge, MO (upstream of 2001 site)

[g] Longear sunfish (*Lepomis megalotis*) fillets, from Gale et al. (2004); F, Flat River Creek (BR tributary near Desloge, MO, upstream of 2001 site)

[h] 8-oz (227-g) meals

Source: Personal Communications with Kristen Hanson via email, March 18, 2021

- Many of the additions mentioned above are also consumed by the Lac du Flambeau Band of Lake Superior Tribal Members and larger community
- This community consumes a number of panfish including subfish, pumpkinseed, crappies, perch, rockbass, smallmouth and largemouth bass, and smelt
- Smelt is potentially a new addition as it was not listed in the other sources consulted
- The wild mint plant (specifically Monarda fistulosa) is a plant consumed by this community
- A risk evaluation has been completed on wild rice, maple syrup, and wild turkey
- The court case Lac Courte Oreilles Band v. Wisconsin (known as the Voigt Decision) recognized wild rice and wild plants used by Tribal members
- *Plants Used by the Great Lakes Ojibwe* by James Meeker, Joan Elias and John Heim is a book with information on plants used by the Chippewa Tribes in the Great Lakes Nation
- The following link leads to a "Master Food List" Excel spreadsheet with a list of many species consumed by Tribal Members. Daily consumption values are not included. https://share.nmu.edu/moodle/course/view.php?id=33
- Other documents also exist detailing consumption of foods by Tribal Members (such as the one listed below) although they lack detailed information about consumption rates
    - 2018 Traditional Food Contaminant and Food Safety Report by Candance E. Kraft and Owen Holly Maroney

Appendix A: Transfer Factor Source Compilation

Table A—1. Transfer Factor Hierarchy for Plants.

Produce	Primary Transfer Factor Category	Primary Transfer Factor Source	Number of Transfer Factors from Primary Source[1]	Secondary Transfer Factor Category	Secondary Transfer Factor Source	Number of Transfer Factors from Secondary Source[1,2]	Tertiary Transfer Factor Category	Tertiary Transfer Factor Source	Number of Transfer Factors from Tertiary Source[1,2]
Bulbs and Roots									
Sego Lily	Root	IAEA TRS 472	34- Ag, Am, Ba, Ce, Cl, Cm, Co, Cr, Cs, Fe, I, La, Mn, Mo, Na, Nb, Np, P, Pb, Pm, Po, Pr, Pu, Ra, Rb, Ru, Sb, Sr, Tc, Te, Th, U, Y, Zr	Root Vegetable	EA	15- Au, Br, Ca, Er, Eu, Ga, In, Lu, Ni, S, Se, Sm, Tl, V, Zn	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Camass	Root	IAEA TRS 472	34- Ag, Am, Ba, Ce, Cl, Cm, Co, Cr, Cs, Fe, I, La, Mn, Mo, Na, Nb, Np, P, Pb, Pm, Po, Pr, Pu, Ra, Rb, Ru, Sb, Sr, Tc, Te, Th, U, Y, Zr	Root Vegetable	EA	15- Au, Br, Ca, Er, Eu, Ga, In, Lu, Ni, S, Se, Sm, Tl, V, Zn	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Bitterroot	Root	IAEA TRS 472	34- Ag, Am, Ba, Ce, Cl, Cm, Co, Cr, Cs, Fe, I, La, Mn, Mo, Na, Nb, Np, P, Pb, Pm, Po, Pr, Pu, Ra, Rb, Ru, Sb, Sr, Tc, Te, Th, U, Y, Zr	Root Vegetable	EA	15- Au, Br, Ca, Er, Eu, Ga, In, Lu, Ni, S, Se, Sm, Tl, V, Zn	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Wild Lilies	Root	IAEA TRS 472	34- Ag, Am, Ba, Ce, Cl, Cm, Co, Cr, Cs, Fe, I, La, Mn, Mo, Na, Nb, Np, P, Pb, Pm, Po, Pr, Pu, Ra, Rb, Ru, Sb, Sr, Tc, Te, Th, U, Y, Zr	Root Vegetable	EA	15- Au, Br, Ca, Er, Eu, Ga, In, Lu, Ni, S, Se, Sm, Tl, V, Zn	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Tule	Root	IAEA TRS 472	34- Ag, Am, Ba, Ce, Cl, Cm, Co, Cr, Cs, Fe, I, La, Mn, Mo, Na, Nb, Np, P, Pb, Pm, Po, Pr, Pu, Ra, Rb, Ru, Sb, Sr, Tc, Te, Th, U, Y, Zr	Root Vegetable	EA	15- Au, Br, Ca, Er, Eu, Ga, In, Lu, Ni, S, Se, Sm, Tl, V, Zn	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Chicory Root	Root	IAEA TRS 472	34- Ag, Am, Ba, Ce, Cl, Cm, Co, Cr, Cs, Fe, I, La, Mn, Mo, Na, Nb, Np, P, Pb, Pm, Po, Pr, Pu, Ra, Rb, Ru, Sb, Sr, Tc, Te, Th, U, Y, Zr	Root Vegetable	EA	15- Au, Br, Ca, Er, Eu, Ga, In, Lu, Ni, S, Se, Sm, Tl, V, Zn	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.

Produce	Primary Transfer Factor Category	Primary Transfer Factor Source	Number of Transfer Factors from Primary Source[1]	Secondary Transfer Factor Category	Secondary Transfer Factor Source	Number of Transfer Factors from Secondary Source[1,2]	Tertiary Transfer Factor Category	Tertiary Transfer Factor Source	Number of Transfer Factors from Tertiary Source[1,2]
Burdock Root	Root	IAEA TRS 472	34- Ag, Am, Ba, Ce, Cl, Cm, Co, Cr, Cs, Fe, I, La, Mn, Mo, Na, Nb, Np, P, Pb, Pm, Po, Pr, Pu, Ra, Rb, Ru, Sb, Sr, Tc, Te, Th, U, Y, Zr	Root Vegetable	EA	15- Au, Br, Ca, Er, Eu, Ga, In, Lu, Ni, S, Se, Sm, Tl, V, Zn	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Fruits and Berries									
Manzanita	Shrub	IAEA TRS 472	2- Cs, Sr	Fruit	EA	15- Au, Ca, Cm, Er, Ga, I, In, Nb, Np, P, Pm, S, Tc, Tl, Y	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including Am, Co, H, Pu, Ra, Rn, Th, U.
Gooseberry (Sierra)	Shrub	IAEA TRS 472	2- Cs, Sr	Fruit	EA	15- Au, Ca, Cm, Er, Ga, I, In, Nb, Np, P, Pm, S, Tc, Tl, Y	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including Am, Co, H, Pu, Ra, Rn, Th, U.
Thimbleberry	Shrub	IAEA TRS 472	2- Cs, Sr	Fruit	EA	15- Au, Ca, Cm, Er, Ga, I, In, Nb, Np, P, Pm, S, Tc, Tl, Y	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including Am, Co, H, Pu, Ra, Rn, Th, U.
Toyon	Shrub	IAEA TRS 472	2- Cs, Sr	Fruit	EA	15- Au, Ca, Cm, Er, Ga, I, In, Nb, Np, P, Pm, S, Tc, Tl, Y	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including Am, Co, H, Pu, Ra, Rn, Th, U.
Salmonberry	Shrub	IAEA TRS 472	2- Cs, Sr	Fruit	EA	15- Au, Ca, Cm, Er, Ga, I, In, Nb, Np, P, Pm, S, Tc, Tl, Y	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including Am, Co, H, Pu, Ra, Rn, Th, U.
Salal	Shrub	IAEA TRS 472	2- Cs, Sr	Fruit	EA	15- Au, Ca, Cm, Er, Ga, I, In, Nb, Np, P, Pm, S, Tc, Tl, Y	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including Am, Co, H, Pu, Ra, Rn, Th, U.
Currant (Desert and golden)	Shrub	IAEA TRS 472	2- Cs, Sr	Fruit	EA	15- Au, Ca, Cm, Er, Ga, I, In, Nb, Np, P, Pm, S, Tc, Tl, Y	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including Am, Co, H, Pu, Ra, Rn, Th, U.
Western Chokecherry	Shrub	IAEA TRS 472	4- Am, Cs, Pu, Sr	Fruit	EA	15- Au, Ca, Cm, Er, Ga, I, In, Nb, Np, P, Pm, S, Tc, Tl, Y	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Buckberry	Shrub	IAEA TRS 472	2- Cs, Sr	Fruit	EA	15- Au, Ca, Cm, Er, Ga, I, In, Nb, Np, P, Pm, S, Tc, Tl, Y	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including Am, Co, H, Pu, Ra, Rn, Th, U.

Produce	Primary Transfer Factor Category	Primary Transfer Factor Source	Number of Transfer Factors from Primary Source[1]	Secondary Transfer Factor Category	Secondary Transfer Factor Source	Number of Transfer Factors from Secondary Source[1,2]	Tertiary Transfer Factor Category	Tertiary Transfer Factor Source	Number of Transfer Factors from Tertiary Source[1,2]
Fruits and Berries Cont.									
Saskatoon Serviceberry	Shrub	IAEA TRS 472	2- Cs, Sr	Fruit	EA	15- Au, Ca, Cm, Er, Ga, I, In, Nb, Np, P, Pm, S, Tc, Tl, Y	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including Am, Co, H, Pu, Ra, Rn, Th, U.
Sierra Plum	Shrub	IAEA TRS 472	2- Cs, Sr	Fruit	EA	15- Au, Ca, Cm, Er, Ga, I, In, Nb, Np, P, Pm, S, Tc, Tl, Y	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including Am, Co, H, Pu, Ra, Rn, Th, U.
Vegetables									
Leeks	Root	IAEA TRS 472	34- Ag, Am, Ba, Ce, Cl, Cm, Co, Cr, Cs, Fe, I, La, Mn, Mo, Na, Nb, Np, P, Pb, Pm, Po, Pr, Pu, Ra, Rb, Ru, Sb, Sr, Tc, Te, Th, U, Y, Zr	Root Vegetable	EA	15- Au, Br, Ca, Er, Eu, Ga, In, Lu, Ni, S, Se, Sm, Tl, V, Zn	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Tule shoots	Grass Shoot	IAEA TRS 472	17-Am, Ba, Ce, Cs, Co, K, La, Mn, Ni, Np, Pb, Pu, Ra, Sr, Th, U, Zn	Green Vegetable	EA	16- Au, Br, Ca, Cm, Er, Eu, Ga, In, Lu, Ni, Pm, S, Se, Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Greens, Teas									
Clover	Legume Vegetable-Leaf	IAEA 472	3- Cs, Sr, Zn	Green Vegetable	EA	22-Au, Ba, Br, Ca, Ce, Cl, Er, Eu, Ga, In, Lu, Mo, Ni, Pm, Po, Rb, S, Se, Sm, Tc, Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Angelica	Herbs Leaves	IAEA 472	5- Cs, I, Pb, Ra, Sr	Green Vegetable	EA	16- Au, Br, Ca, Cm, Er, Eu, Ga, In, Lu, Ni, Pm, S, Se, Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Anise	Herbs Leaves	IAEA 472	5- Cs, I, Pb, Ra, Sr	Green Vegetable	EA	16- Au, Br, Ca, Cm, Er, Eu, Ga, In, Lu, Ni, Pm, S, Se, Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Poppy	Herbs Leaves	IAEA 472	5- Cs, I, Pb, Ra, Sr	Green Vegetable	EA	16- Au, Br, Ca, Cm, Er, Eu, Ga, In, Lu, Ni, Pm, S, Se, Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Fiddlehead	Herbs Leaves	IAEA 472	5- Cs, I, Pb, Ra, Sr	Green Vegetable	EA	16- Au, Br, Ca, Cm, Er, Eu, Ga, In, Lu, Ni, Pm, S, Se, Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.

Produce	Primary Transfer Factor Category	Primary Transfer Factor Source	Number of Transfer Factors from Primary Source[1]	Secondary Transfer Factor Category	Secondary Transfer Factor Source	Number of Transfer Factors from Secondary Source[1,2]	Tertiary Transfer Factor Category	Tertiary Transfer Factor Source	Number of Transfer Factors from Tertiary Source[1,2]
Greens, Teas Cont.									
Fescue Grasses	Grass Grain	IAEA TRS 472	3- Cs, Sr, Zn	Green Vegetable	EA	16- Au, Br, Ca, Cm, Er, Eu, Ga, In, Lu, Ni, Pm, S, Se, Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Dandelion Greens	Leafy Vegetable	IAEA 472	35- Ag, Am, Ba, Ce, Cl, Cm, Co, Cr, Cs, Fe, I, La, Mn, Mo, Na, Nb, Np, P, Pb, Pm, Po, Pr, Pu, Ra, Rb, Ru, Sb, Sr, Tc, Te, Th, U, Y, Zn, Zr	Green Vegetable	EA	16- Au, Br, Ca, Cm, Er, Eu, Ga, In, Lu, Ni, Pm, S, Se, Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Miner's Lettuce[3]	Leafy Vegetable	IAEA 472	35- Ag, Am, Ba, Ce, Cl, Cm, Co, Cr, Cs, Fe, I, La, Mn, Mo, Na, Nb, Np, P, Pb, Pm, Po, Pr, Pu, Ra, Rb, Ru, Sb, Sr, Tc, Te, Th, U, Y, Zn, Zr	Green Vegetable	EA	16- Au, Br, Ca, Cm, Er, Eu, Ga, In, Lu, Ni, Pm, S, Se, Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Nettle	Herbs Leaves	IAEA 472	5- Cs, I, Pb, Ra, Sr	Green Vegetable	EA	16- Au, Br, Ca, Cm, Er, Eu, Ga, In, Lu, Ni, Pm, S, Se, Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Rose Hips	Herbaceous Shrub	IAEA TRS 472	2- Cs, Sr	Green Vegetable	EA	16- Au, Br, Ca, Cm, Er, Eu, Ga, In, Lu, Ni, Pm, S, Se, Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Seaweed	Leafy Vegetable	IAEA 472	35-Ag, Am, Ba, Ce, Cl, Cm, Co, Cr, Cs, Fe, I, K, La, Mn, Mo, Na, Nb, Np, P, Pb, Po, Pr, Pu, Ra, Pb, Ru, Sb, Sr, Tc, Te, Th, U, Y, Zn, Zr	Green Vegetable	EA	16- Au, Br, Ca, Cm, Er, Eu, Ga, In, Lu, Ni, Pm, S, Se, Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Seeds, Nuts									
Bedstraw	Herbaceous Fruit	IAEA TRS 472	4- Am, Cs, Pu, Sr	None			None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Tarweed	Herbaceous Shrub	IAEA TRS 472	2- Cs, Sr	None			None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Wild Cucumber	Herbaceous Fruit	IAEA TRS 472	4- Am, Cs, Pu, Sr	None			None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.

Produce	Primary Transfer Factor Category	Primary Transfer Factor Source	Number of Transfer Factors from Primary Source[1]	Secondary Transfer Factor Category	Secondary Transfer Factor Source	Number of Transfer Factors from Secondary Source[1,2]	Tertiary Transfer Factor Category	Tertiary Transfer Factor Source	Number of Transfer Factors from Tertiary Source[1,2]
Seeds, Nuts Cont.									
Bay Nuts	Woody Tree	IAEA TRS 472	4- Am, Cs, Pu, Sr	None			None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Hazelnut	Woody Tree	IAEA TRS 472	4- Am, Cs, Pu, Sr	None			None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Butternuts	Woody Tree	IAEA TRS 472	4- Am, Cs, Pu, Sr	None			None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Other									
Maple Syrup	Other	IAEA TRS 472	8-Cs, Co, Sr, K, Pu, Pb, U, Zn	None			None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.

1. Red elements are on the 'Common Isotopes' list of EPA calculator webpages. (Am, Co, Cs, H, I, Pu, Ra, Rn, Sr, Tc, Th, U)
2. Transfer Factors from NCRP-123, RADSSL, and RESRAD are universal soil to plant Transfer Factors that are not specific to a particular plant category or type, but rather the element itself.
3. https://www.ediblewildfood.com/miners-lettuce.aspx

Table A—2. Transfer Factor Hierarchy for Animal Products.

Animal Product	Primary Transfer Factor Category	Primary Transfer Factor Source	Number of Transfer Factors from Primary Source[1]	Secondary Transfer Factor Category	Secondary Transfer Factor Source	Number of Transfer Factors from Secondary Source[1]	Tertiary Transfer Factor Category	Tertiary Transfer Factor Source	Number of Transfer Factors from Tertiary Source[1]
Fish									
Sockeye Salmon	Marine fish	IAEA TRS 479	19- Ag, Cd, Cl, Co, Cs, Cu, Mn, Ni, P, Pb, Po, Pu, Ra, Ru, Sr, Th, U, Zn, Zr	Marine	EA	34- Am, Au, Ba, Br, C, Ca, Ce, Cm, Cr, Er, Eu, Fe, Ga, H, I, In, La, Lu, Mo, Na, Nb, Np, Pb, Pm, Po, Rb, S, Sb, Se, Sm, Tc, Tl, V, Y	None	NCRP- 123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Trout (Lake, Rainbow, Brook)	Freshwater fish	IAEA TRS 472	49- Ag, Al, Am, As, Au, Ba, Br, C, Ca, Ce, Cl, Co, Cr, Cs, Cu, Dy, Eu, Fe, Hf, Hg, I, K, La, Mg, Mn, Mo, Na, Ni, P, Pb, Po, Pu, Ra, Rb, Ru, Sb, Sc, Se, Sr, Tb, Te, Th, Ti, Tl, U, V, Y, Zn, Zr	Fresh Water Fish Whole Body	IAEA TRS 479	2- Cd, Sn	Fresh	EA	8- Cm, Er, Ga, H, In, Lu, Nb, Np, Pm, S, Sm, Tc
Minnow	Freshwater fish	IAEA TRS 472	49- Ag, Al, Am, As, Au, Ba, Br, C, Ca, Ce, Cl, Co, Cr, Cs, Cu, Dy, Eu, Fe, Hf, Hg, I, K, La, Mg, Mn, Mo, Na, Ni, P, Pb, Po, Pu, Ra, Rb, Ru, Sb, Sc, Se, Sr, Tb, Te, Th, Ti, Tl, U, V, Y, Zn, Zr	Fresh Water Fish Whole Body	IAEA TRS 479	2- Cd, Sn	Fresh	EA	8- Cm, Er, Ga, H, In, Lu, Nb, Np, Pm, S, Sm, Tc
Shad	Marine fish	IAEA TRS 479	19- Ag, Cd, Cl, Co, Cs, Cu, Mn, Ni, P, Pb, Po, Pu, Ra, Ru, Sr, Th, U, Zn, Zr	Marine	EA	34- Am, Au, Ba, Br, C, Ca, Ce, Cm, Cr, Er, Eu, Fe, Ga, H, I, In, La, Lu, Mo, Na, Nb, Np, Pb, Pm, Po, Rb, S, Sb, Se, Sm, Tc, Tl, V, Y	None	NCRP- 123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Herring	Marine fish	IAEA TRS 479	19- Ag, Cd, Cl, Co, Cs, Cu, Mn, Ni, P, Pb, Po, Pu, Ra, Ru, Sr, Th, U, Zn, Zr	Marine	EA	34- Am, Au, Ba, Br, C, Ca, Ce, Cm, Cr, Er, Eu, Fe, Ga, H, I, In, La, Lu, Mo, Na, Nb, Np, Pb, Pm, Po, Rb, S, Sb, Se, Sm, Tc, Tl, V, Y	None	NCRP- 123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Pollock	Marine fish	IAEA TRS 479	19- Ag, Cd, Cl, Co, Cs, Cu, Mn, Ni, P, Pb, Po, Pu, Ra, Ru, Sr, Th, U, Zn, Zr	Marine	EA	34- Am, Au, Ba, Br, C, Ca, Ce, Cm, Cr, Er, Eu, Fe, Ga, H, I, In, La, Lu, Mo, Na, Nb, Np, Pb, Pm, Po, Rb, S, Sb, Se, Sm, Tc, Tl, V, Y	None	NCRP- 123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Eel	Freshwater fish	IAEA TRS 472	49- Ag, Al, Am, As, Au, Ba, Br, C, Ca, Ce, Cl, Co, Cr, Cs, Cu, Dy, Eu, Fe, Hf, Hg, I, K, La, Mg, Mn, Mo, Na, Ni, P, Pb, Po, Pu, Ra, Rb, Ru, Sb, Sc, Se, Sr, Tb, Te, Th, Ti, Tl, U, V, Y, Zn, Zr	Fresh Water Fish Whole Body	IAEA TRS 479	2- Cd, Sn	Fresh	EA	8- Cm, Er, Ga, H, In, Lu, Nb, Np, Pm, S, Sm, Tc

Animal Product	Primary Transfer Factor Category	Primary Transfer Factor Source	Number of Transfer Factors from Primary Source[1]	Secondary Transfer Factor Category	Secondary Transfer Factor Source	Number of Transfer Factors from Secondary Source[1]	Tertiary Transfer Factor Category	Tertiary Transfer Factor Source	Number of Transfer Factors from Tertiary Source[1]
Fish Cont.									
Walleye	Freshwater fish	IAEA TRS 472	49- Ag, Al, Am, As, Au, Ba, Br, C, Ca, Ce, Cl, Co, Cr, Cs, Cu, Dy, Eu, Fe, Hf, Hg, I, K, La, Mg, Mn, Mo, Na, Ni, P, Pb, Po, Pu, Ra, Rb, Ru, Sb, Sc, Se, Sr, Tb, Te, Th, Ti, Tl, U, V, Y, Zn, Zr	Fresh Water Fish Whole Body	IAEA TRS 479	2- Cd, Sn	Fresh	EA	8- Cm, Er, Ga, H, In, Lu, Nb, Np, Pm, S, Sm, Tc
Northern Pike	Freshwater fish	IAEA TRS 472	49- Ag, Al, Am, As, Au, Ba, Br, C, Ca, Ce, Cl, Co, Cr, Cs, Cu, Dy, Eu, Fe, Hf, Hg, I, K, La, Mg, Mn, Mo, Na, Ni, P, Pb, Po, Pu, Ra, Rb, Ru, Sb, Sc, Se, Sr, Tb, Te, Th, Ti, Tl, U, V, Y, Zn, Zr	Fresh Water Fish Whole Body	IAEA TRS 479	2- Cd, Sn	Fresh	EA	8- Cm, Er, Ga, H, In, Lu, Nb, Np, Pm, S, Sm, Tc
Whitefish	Freshwater fish	IAEA TRS 472	49- Ag, Al, Am, As, Au, Ba, Br, C, Ca, Ce, Cl, Co, Cr, Cs, Cu, Dy, Eu, Fe, Hf, Hg, I, K, La, Mg, Mn, Mo, Na, Ni, P, Pb, Po, Pu, Ra, Rb, Ru, Sb, Sc, Se, Sr, Tb, Te, Th, Ti, Tl, U, V, Y, Zn, Zr	Fresh Water Fish Whole Body	IAEA TRS 479	2- Cd, Sn	Fresh	EA	8- Cm, Er, Ga, H, In, Lu, Nb, Np, Pm, S, Sm, Tc
Tullibee	Freshwater fish	IAEA TRS 472	49- Ag, Al, Am, As, Au, Ba, Br, C, Ca, Ce, Cl, Co, Cr, Cs, Cu, Dy, Eu, Fe, Hf, Hg, I, K, La, Mg, Mn, Mo, Na, Ni, P, Pb, Po, Pu, Ra, Rb, Ru, Sb, Sc, Se, Sr, Tb, Te, Th, Ti, Tl, U, V, Y, Zn, Zr	Fresh Water Fish Whole Body	IAEA TRS 479	2- Cd, Sn	Fresh	EA	8- Cm, Er, Ga, H, In, Lu, Nb, Np, Pm, S, Sm, Tc
Perch (freshwater variety)	Freshwater fish	IAEA TRS 472	49- Ag, Al, Am, As, Au, Ba, Br, C, Ca, Ce, Cl, Co, Cr, Cs, Cu, Dy, Eu, Fe, Hf, Hg, I, K, La, Mg, Mn, Mo, Na, Ni, P, Pb, Po, Pu, Ra, Rb, Ru, Sb, Sc, Se, Sr, Tb, Te, Th, Ti, Tl, U, V, Y, Zn, Zr	Fresh Water Fish Whole Body	IAEA TRS 479	2- Cd, Sn	Fresh	EA	8- Cm, Er, Ga, H, In, Lu, Nb, Np, Pm, S, Sm, Tc
Perch (marine variety)	Marine fish	IAEA TRS 479	19- Ag, Cd, Cl, Co, Cs, Cu, Mn, Ni, P, Pb, Po, Pu, Ra, Ru, Sr, Th, U, Zn, Zr	Marine	EA	34- Am, Au, Ba, Br, C, Ca, Ce, Cm, Cr, Er, Eu, Fe, Ga, H, I, In, La, Lu, Mo, Na, Nb, Np, Pb, Pm, Po, Rb, S, Sb, Se, Sm, Tc, Tl, V, Y	None	NCRP- 123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Panfish	Freshwater fish	IAEA TRS 472	49- Ag, Al, Am, As, Au, Ba, Br, C, Ca, Ce, Cl, Co, Cr, Cs, Cu, Dy, Eu, Fe, Hf, Hg, I, K, La, Mg, Mn, Mo, Na, Ni, P, Pb, Po, Pu, Ra, Rb, Ru, Sb, Sc, Se, Sr, Tb, Te, Th, Ti, Tl, U, V, Y, Zn, Zr	Fresh Water Fish Whole Body	IAEA TRS 479	2- Cd, Sn	Fresh	EA	8- Cm, Er, Ga, H, In, Lu, Nb, Np, Pm, S, Sm, Tc

Animal Product	Primary Transfer Factor Category	Primary Transfer Factor Source	Number of Transfer Factors from Primary Source[1]	Secondary Transfer Factor Category	Secondary Transfer Factor Source	Number of Transfer Factors from Secondary Source[1]	Tertiary Transfer Factor Category	Tertiary Transfer Factor Source	Number of Transfer Factors from Tertiary Source[1]
Fish Cont.									
Whitesucker	Freshwater fish	IAEA TRS 472	49- Ag, Al, Am, As, Au, Ba, Br, C, Ca, Ce, Cl, Co, Cr, Cs, Cu, Dy, Eu, Fe, Hf, Hg, I, K, La, Mg, Mn, Mo, Na, Ni, P, Pb, Po, Pu, Ra, Rb, Ru, Sb, Sc, Se, Sr, Tb, Te, Th, Ti, Tl, U, V, Y, Zn, Zr	Fresh Water Fish Whole Body	IAEA TRS 479	2- Cd, Sn	Fresh	EA	8- Cm, Er, Ga, H, In, Lu, Nb, Np, Pm, S, Sm, Tc
Shellfish									
Crawfish	Crustaceans	IAEA TRS 479	18- Am, Cd. Ce, Cl, Co, Cs, Hg, Mn, Nb, Np, Pb, Po, Pu, Ra, S, Sr, Tc, Zr	Fresh	EA	8- Cm, Er, Ga, H, In, Lu, Nb, Np, Pm, S, Sm, Tc	None	NCRP- 123, RADSSL, ResRad, Baes paper	Any elements not previously listed, including H and Rn.
Lobster	Crustaceans	IAEA TRS 479	18- Am, Cd. Ce, Cl, Co, Cs, Hg, Mn, Nb, Np, Pb, Po, Pu, Ra, S, Sr, Tc, Zr	Marine	EA	34- Am, Au, Ba, Br, C, Ca, Ce, Cm, Cr, Er, Eu, Fe, Ga, H, I, In, La, Lu, Mo, Na, Nb, Np, Pb, Pm, Po, Rb, S, Sb, Se, Sm, Tc, Tl, V, Y	None	NCRP- 123, RADSSL, ResRad, Baes paper	Any elements not previously listed, including H and Rn.
Bay mussels	Mollusk	IAEA TRS 479	27- Am, Cd, Ce, Cl, Cm, Co, Cs, Eu, I, Mn, Nb, No, Np, P, Pb, Po, Pu, Ra, Ru, S, Sb, Se, Sr, Tc, Th, U, Zr	Marine	EA	34- Am, Au, Ba, Br, C, Ca, Ce, Cm, Cr, Er, Eu, Fe, Ga, H, I, In, La, Lu, Mo, Na, Nb, Np, Pb, Pm, Po, Rb, S, Sb, Se, Sm, Tc, Tl, V, Y	None	NCRP- 123, RADSSL, ResRad, Baes paper	Any elements not previously listed, including H and Rn.
Dungeness Crab	Crustaceans	IAEA TRS 479	18- Am, Cd. Ce, Cl, Co, Cs, Hg, Mn, Nb, Np, Pb, Po, Pu, Ra, S, Sr, Tc, Zr	Marine	EA	34- Am, Au, Ba, Br, C, Ca, Ce, Cm, Cr, Er, Eu, Fe, Ga, H, I, In, La, Lu, Mo, Na, Nb, Np, Pb, Pm, Po, Rb, S, Sb, Se, Sm, Tc, Tl, V, Y	None	NCRP- 123, RADSSL, ResRad, Baes paper	Any elements not previously listed, including H and Rn.
Japanese Oysters	Mollusk	IAEA TRS 479	27- Am, Cd, Ce, Cl, Cm, Co, Cs, Eu, I, Mn, Nb, No, Np, P, Pb, Po, Pu, Ra, Ru, S, Sb, Se, Sr, Tc, Th, U, Zr	Marine	EA	34- Am, Au, Ba, Br, C, Ca, Ce, Cm, Cr, Er, Eu, Fe, Ga, H, I, In, La, Lu, Mo, Na, Nb, Np, Pb, Pm, Po, Rb, S, Sb, Se, Sm, Tc, Tl, V, Y	None	NCRP- 123, RADSSL, ResRad, Baes paper	Any elements not previously listed, including H and Rn.
Clams (Macoma, Native Littleneck, Butter, Manilla, Horse, Eastern Softshell)	Mollusk	IAEA TRS 479	27- Am, Cd, Ce, Cl, Cm, Co, Cs, Eu, I, Mn, Nb, No, Np, P, Pb, Po, Pu, Ra, Ru, S, Sb, Se, Sr, Tc, Th, U, Zr	Marine	EA	34- Am, Au, Ba, Br, C, Ca, Ce, Cm, Cr, Er, Eu, Fe, Ga, H, I, In, La, Lu, Mo, Na, Nb, Np, Pb, Pm, Po, Rb, S, Sb, Se, Sm, Tc, Tl, V, Y	None	NCRP- 123, RADSSL, ResRad, Baes paper	Any elements not previously listed, including H and Rn.

Animal Product	Primary Transfer Factor Category	Primary Transfer Factor Source	Number of Transfer Factors from Primary Source[1]	Secondary Transfer Factor Category	Secondary Transfer Factor Source	Number of Transfer Factors from Secondary Source[1]	Tertiary Transfer Factor Category	Tertiary Transfer Factor Source	Number of Transfer Factors from Tertiary Source[1]
Big Game									
Buffalo									
Moose (muscle and liver)	Moose	NORMAL YSA	9-Ac, Cs, Pa, Pb, Po, Ra, Sr, Th, U	Mammals: herbivorous	IAEA TRS 479	3-Am, Cd, Pu	None	NCRP- 123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Deer liver	Mammals: herbivorous	IAEA TRS 479	8-Am, Cd, Cs, Pb, Po, Pu, Ra, Sr	Whitetailed Deer	NRPA SPACE 2016:2	9-Am, C, Cl, I, Np, Se, Tc, Th, U	None	NCRP- 123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Small Game									
Squirrel (Marmot and Ground)	Rat (Apodemus agrarius)	Beresford et al.	2-Cs, Sr	Brown Rat	NRPA SPACE 2016:2	11- C, Cl, I, Np, Pb, Po, Ra, Se, Tc, Th, U	None	NCRP- 123, RADSSL, RESRAD, Baes Paper	Any elements not previously listed, including H and Rn.
Birds									
Grouse	Pheasant	NRPA SPACE 2016:2	12-C, Cl, Cs, I, Np, Pb, Po, Ra, Se, Tc, Th, U	Poultry	IAEA TRS 472	30- Ag, Am, Ba, Ca, Cd, Co, Cs, Cu, Fe, Hg, I, La, Mn, Mo, Na, Nb, Nd, Pm, Po, Pr, Pu, Ru, Se, Sr, Tc, Te, U, Y, Zn, Zr	None	NCRP-123, RADSSL, RESRAD, Baes Paper	Any elements not previously listed, including H and Rn.
Other									
Honey									
Snail	Mollusks	IAEA TRS 479	6-Am, Cs, I, Po, Pu, Sr	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.			
Whale (Gray, Humpback, Beluga)	Marine Mammals	IAEA TRS 479	13- Ag, Cd, Co, Cs, I, Mn, P, Pb, Po, Pu, S, Se, Sr						
Turtle (Snapper, muscle and liver)	Reptile carcass	IAEA TRS 472	6- Ca, Co, Cs, K, Mg, Na	Freshwater reptile	IAEA TRS 479	17- Am, As, Cd, Cr, Cu, Fe, Hg, Mn, Pb, Po, Ra, Se, Sn, Sr, Th, U, Zn	None		

1. Red elements are on the 'Common Isotopes' list of EPA calculator webpages. (Am, Co, Cs, H, I, Pu, Ra, Rn, Sr, Tc, Th, U)