PFAS in Deer Harvested in the Fairfield Area, Maine - Fall 2021 Targeted Sampling and Advisory Summary Report

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Maine Center for Disease Control and Prevention

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Summary

On November 23, 2021, the Maine Department of Inland Fisheries and Wildlife (MDIFW), in conjunction with the Maine Center for Disease Control and Prevention (Maine CDC), issued a do not eat advisory for deer harvested in the greater Fairfield area due to the detection of elevated levels of per- and polyfluoroalkyl substances (PFAS) in several deer. In October 2021, MDIFW harvested eight deer in close proximity to several farm fields in Fairfield known to have high PFAS levels in soil. Muscle and liver tissues were collected for PFAS analysis. Five out of the eight deer tested were taken in close proximity to a cluster of fields with average soil levels of the PFAS perfluorooctane sulfonate (PFOS) in the 300 to 1,000 nanograms per gram (ng/g dry weight) range, and surface water levels in the 6,000 to 7,000 nanograms per liter (ng/L) range. These five deer had PFOS levels in meat tissue between 37 and 44 nanograms per gram (ng/g wet weight). PFOS levels in these five deer were similar across life stages, a fawn, a yearling, and three adult females. Two of the eight deer harvested in close proximity of farm fields with soil PFOS levels in the 20 to 200 ng/g range had muscle tissue PFOS levels between 3 and 5 ng/g. One of the eight deer collected in close proximity to fields with average soil PFOS levels of 300 to 450 ng/g had muscle tissue PFOS levels of just over 1 ng/g. PFOS was the predominant PFAS detected in the meat tissue samples. PFOS in liver samples from the eight deer were 4- to 51-fold higher than the muscle tissue levels.

Maine CDC followed general U.S. Environmental Protection Agency (EPA) risk assessment methodology to estimate the number of monthly venison meals adults and young children (aged 1 to 6) could consume without exceeding the U.S. Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Level (MRL) for PFOS, and accounting for background exposure to PFOS estimated from typical serum PFOS levels in the U.S. population. Maine CDC determined that consumption of deer meat with PFOS levels in the 40 ng/g range would warrant a recommendation to not eat more than one or two meals in a year for a child and four or five meals in a year for an adult.

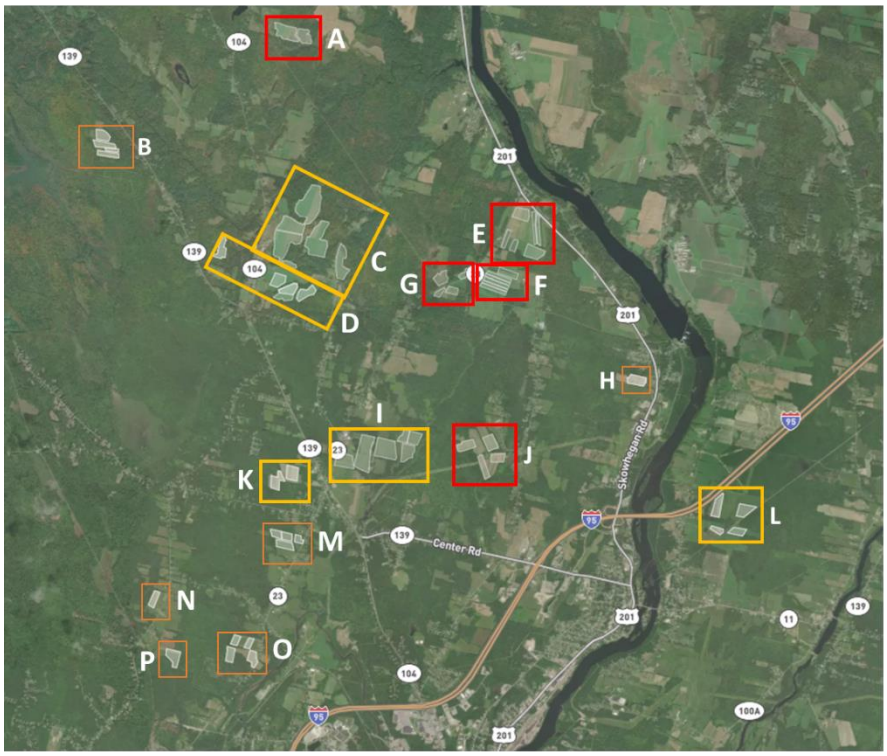
MDIFW in consultation with Maine CDC decided to place a do not eat advisory for all deer in the area of the Fairfield sites. The boundaries of the advisory area were set with an abundance of caution given the limited number of deer tested for PFAS, MDIFW findings from deer collaring studies that seasonal migration can extend up to 5 miles, and the use of easily identifiable landmarks. The Fairfield advisory area begins at the Carter Memorial Bridge in Waterville where Route 137 crosses the Kennebec, heads north up the Kennebec River past Waterville and Skowhegan, to the Eugene Cole Bridge in Norridgewock (Route 8 and 201A), then south from Norridgewock along Route 8 into Smithfield to the intersection of Routes 8 and 137, then south on Route 137 until it crosses the Kennebec River on the Carter Memorial Bridge. The advisory area encompasses multiple farm fields that have been determined to contain elevated levels of PFOS and other PFAS in soil from the spreading of municipal and/or industrial sludge for fertilizer that contained PFAS or manure from animals known to be exposed to PFAS.

Hunters who already harvested a deer in the area were advised not to eat any meat from the harvested deer and to dispose of the meat and any remaining carcass in their trash or landfill. Follow-up testing of deer is planned.

Background on PFAS Contamination in Fairfield, Maine

An investigation into the presence of PFAS in the Fairfield area began after the Maine Department of Agriculture, Conservation and Forestry (DACF) detected PFOS in milk samples collected at local dairy farm before the milk entered the commercial market. The measured PFOS levels in milk at this farm were greater than 20,000 ng/L which were nearly 100 times higher than the DACF's PFOS milk action level of 210 ng/L developed by the Maine CDC in 2017 (MECDC 2017). Subsequent testing of soil and grass by the Maine Department of Environmental Protection (DEP) revealed that the primary PFOS exposure pathway to the cows at this farm was hay and corn grown at the farm in fields with PFOS-contaminated soil. In response to this finding, DEP began testing for PFAS in soil at farms in the Fairfield area which had known histories of application of residual waste materials. As of November 2021, DEP had sampled soil from over 90 individual farm fields in the Fairfield area and surrounding towns of Oakland, Benton, and Unity Township[1]. Figure 1 and Figure 2 summarize average soil PFOS levels in tested farm fields in the Fairfield area and several surface waters. Field averages ranged from less than 10 ng/g to a high of 1,080 ng/g on a dry weight basis.

Figure 1. Range of PFOS soil levels (ng/g, dry weight) for groups of tested farm field parcels.

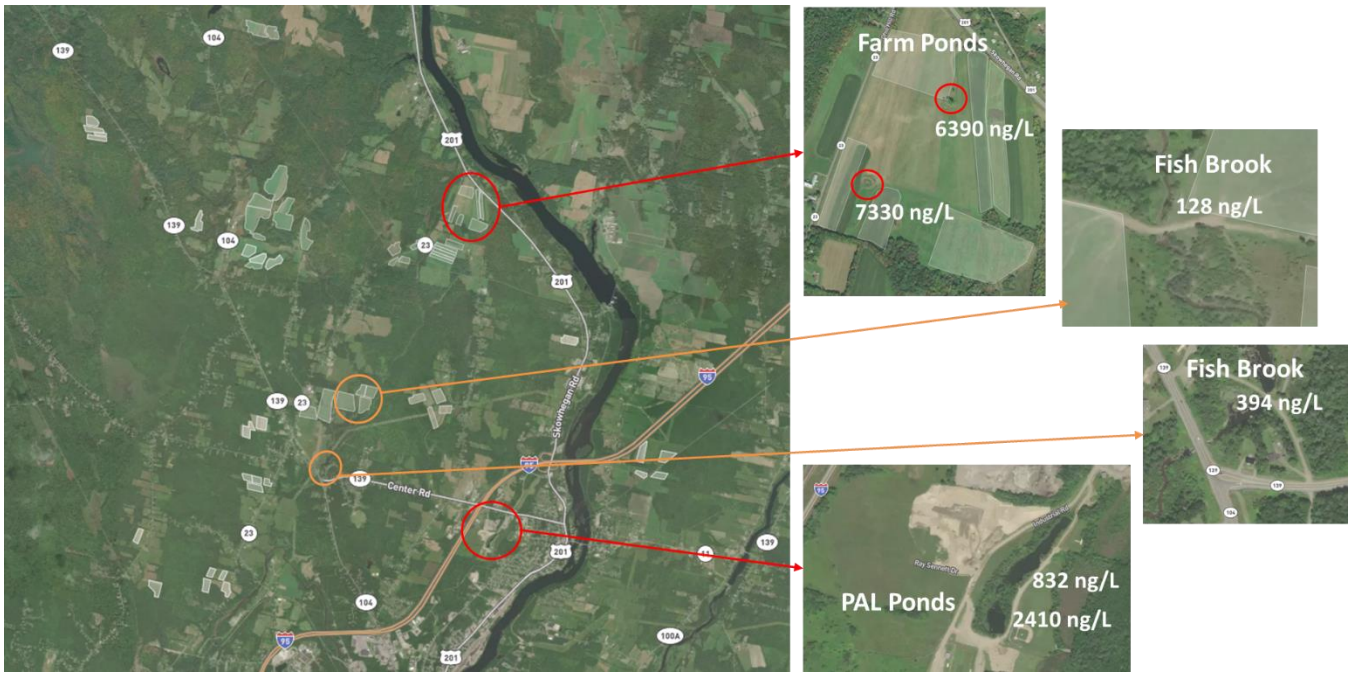


Field	PFOS Soil Level Range (ng/g dry weight)
A	395 - 649
B	5 - 8
C	3 - 232
D	1 - 92
E	285 - 571
F	553 - 1080
G	3 - 311
H	31
I	16 - 150
J	337 - 451
K	16 - 150
L	14 - 181
M	1 - 14
N	25
O	2 - 13
P	7

[1] Maine DEP Fairfield PFAS investigation - https://www1.maine.gov/dep/spills/topics/pfas/fairfield/index.html

After detecting high PFOS levels in soil from farm fields, several surface waters on or near the impacted farm fields were sampled for PFAS. DEP tested two small ponds located directly on PFAS-impacted farm fields, a small stream running through impacted fields and waters from this stream further downstream, and two larger ponds adjacent to PFAS-impacted fields that were historically stocked with brook trout as a "put and take" fishery (Figure 2). Surface water concentrations in the two ponds in the farm fields were measured at 6,390 and 7,330 ng/L. PFOS levels in a brook that borders impacted fields were measured at 128 ng/L near the fields and 394 ng/L further downstream. Two ponds located adjacent to fields with a history of land application of residual waste materials, referred to as the Police Athletic League or PAL Ponds, had PFOS concentrations of 2,410 ng/L in the smaller pond and 832 ng/L in the larger pond.

Figure 2. PFOS levels in sampled surface waters (ng/L).



Sampling conducted by Maine CDC and DEP have shown that the PFAS present in the soil are taken up by plants such as grasses and corn growing in fields with high PFOS soil levels. Dairy cows consuming fodder grown on these soils had elevated levels of PFOS in their milk. The findings of PFAS contamination in soils, plants, surface water, and livestock have prompted concerns surrounding the hunting and consumption of deer in the area that may feed on these fields. In response to concerns from area hunters as well as the recent publications of deer consumption advisories by other states due to elevated PFOS levels in both deer muscle and liver tissue, MDIFW conducted a preliminary, targeted sampling of deer in the Fairfield area in the fall of 2021.

Fairfield Area Deer Sampling and Tissue Collection

In October 2021, eight deer were harvested in the Fairfield, Maine area by the US Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) and MDIFW, and tissue samples were collected for PFAS testing. Fields in the Fairfield area were chosen for targeted sampling of deer

to be reflective of fields with some of the highest soil PFOS levels (Figure 3). Five of the eight deer were collected in the Ohio Hill Road area in close proximity to fields with among the highest soil and surface water PFOS levels. These fields are a mixture of hay fields (some harvested, some fallow) and corn fields. Two deer were collected from the area between the Green and Middle Roads in close proximity to farm fields currently used to grow corn. One deer was collected near the upper Howe Road area in a field behind a home. This location is near to impacted farm fields previously used to grow corn but have laid fallow for the past year.

Figure 3. Locations where deer were collected relative to fields known to have elevated soil PFOS levels as shown in Figure 1.

Landowners of fields with high levels of PFAS soil contamination were contacted by MDIFW biologists, and permissions were obtained to harvest deer for sampling around these fields. APHIS sharpshooters in trucks drove roads after dark near fields where permission had been arranged, and spotlights and night vision were used to locate deer. Deer were harvested by APHIS sharpshooters on or near contaminated fields, and noise suppression was used to limit disturbance. Two nights were spent sampling in the area, and one adult male, four adult females, two yearling females, and one fawn female were collected for testing. Data collected with each animal included date and time of kill, a general description and UTM coordinates at kill location, deer ID, sex, and age-class.

After a deer was harvested, it was transported to a central location where MDIFW staff were available to field dress the deer and collect tissue samples. Participating staff were provided with and adhered to DEP field sample collection guidelines to avoid cross-contamination[2]. At the central processing location, deer were opened to expose the internal organs, and a 200 g sample of liver tissue was taken by a MDIFW biologist wearing nitrile gloves and using a stainless-steel scalpel blade. After field dressing was completed, the MDIFW biologist on-site then collected a 200 g muscle tissue sample from the tenderloin area using the same collection methods as with the liver tissue. Nitrile gloves and stainless-steel scalpel blades were changed between collection of each tissue sample, and other instruments were washed with Liquinox and rinsed with PFAS-free water between samples. Tissue samples were double bagged in Ziploc brand bags and labeled with a sample ID and tissue type. All tissue samples were stored on bagged ice in a Styrofoam cooler until they could be sent to the laboratory for PFAS analysis. Information was added to field data sheets indicating sample type and name of staff collecting samples. Incisor teeth were collected for aging by cementum annuli.

PFAS Deer Tissue Analysis

Tissue samples were shipped to Battelle Laboratory in Massachusetts to be tested for a suite of 18 PFAS chemicals (Appendix 1) by liquid chromatography tandem mass spectrometry (LC-MS/MS) compliant with Department of Defense QSM 5.3 Table B-15[3]. Samples were homogenized by the laboratory prior to extraction and analysis. PFAS were measured by LC-MS/MS in the multiple reaction monitoring (MRM) on a Sciex 5500 (AC) LC-MS/MS. Target PFAS were quantified using the isotope dilution method. From the muscle and liver homogenate of one deer, a matrix spike and a matrix spike duplicate were obtained as QC samples. Method limits of quantitation ranged from 0.4 to 0.5 ng/g.

Fairfield Area Deer Tissue Results

Only two PFAS were detected in muscle samples from deer, PFOS and PFDA. PFOS was detected in all eight deer (Table 1) and was the predominant PFAS present. PFDA was detected in deer muscle from seven of the eight deer, and always at far lower levels than PFOS. PFOS was detected in all liver tissue samples generally at levels 4 to 50-fold higher than muscle levels. Other PFAS detected in deer liver tissue include PFDA (all eight deer), PFUnA (seven of eight deer), PFNA (seven of eight deer), and PFDoA (six of eight deer). PFAS other than PFOS represented a small percentage of total PFAS in these tissues as compared to PFOS (see Appendix 2). There was no evidence of an age dependency on PFOS levels based on results from a fawn, two yearlings, and two adult female deer all collected in fields along Ohio Hill Road (Table 1). PFOS levels were also fairly similar for a fawn and doe family pair (animals 186998 and 186999 in Table 1).

[2] https://www.maine.gov/dep/spills/publications/sops/documents/SOP-RWM-DR-014-Sampling-Analysis-Plan-Development-Addendum-A-PFAS-Requirements-04082020.pdf
[3] https://denix.osd.mil/edqw/documents/manuals/qsm-version-5-3-final/

Table 1. Results of PFOS sampling in deer muscle and liver tissue.

Sample ID	Location	Age, Sex	PFOS Muscle Tissue Result (ng/g wet)	PFOS Liver Tissue Result (ng/g wet)
186996	Middle Rd	Adult, Male	1.4	5.5
186995	Middle Rd	Adult, Female	5.0	22.3
186993	Howe Rd	Yearling, Female	3.4	177
187000	Ohio Hill Rd	Yearling, Female	36.9	786
186997	Ohio Hill Rd	Adult, Female	39.9	700
186999*	Ohio Hill Rd	Fawn, Female	40.6	690
186944	Ohio Hill Rd	Adult, Female	42.5	809
186998*	Ohio Hill Rd	Adult, Female	43.5	624

* Family pair

Assessment of the Need for a PFOS Consumption Advisory

To assess the need for a deer-specific consumption advisory, Maine CDC developed population-specific (i.e., children and adults) risk calculations using the measured PFOS concentrations in muscle tissue following standard EPA risk assessment methods. Maine CDC used a slightly modified version of EPA's equation for the calculation of daily consumption limits in grams per day (USEPA 2000). Maine CDC modified this equation by converting grams to meals using an assumed venison meal size (see below) and months to days. The general equation used to determine the number of venison meals is:

$$CR\ (meals/month) = \frac{RfD\ (ng/kg/day) \times BW\ (kg) \times 30.4\ (days/month)}{Meal\ size\ (g/meal) \times C_D\ (ng/g)} \times RSC \qquad (Equation\ 1)$$

Equation 1 calculates a consumption rate (CR), which is the maximum allowable venison consumption rate, expressed in meals per month. In Equation 1, the reference dose (RfD), measured in nanograms of PFOS per kg of body weight per day, is a toxicity value that provides an estimate of daily PFOS exposure below which there is likely to be minimal risk of any deleterious health effects. Body weight (BW) is a population-specific term that accounts for the body weight of the population of interest (i.e., young children or adults). Multiplying the RfD by BW results in a population specific daily PFOS exposure estimate. In the denominator of Equation 1, meal size is another population-specific term that accounts for the estimated venison meal size for either children or adults. The population-specific venison meal size is multiplied by the measured PFOS concentration in deer muscle tissue (C_D), which gives an estimated PFOS concentration per venison meal. The Relative Source Contribution (RSC) term in Equation 1 is a value used to account for additional background sources of PFOS to help ensure that

the daily dose of PFOS from deer and other sources combined does not exceed the RfD. Specific values for the RfD, BW, meal size, and RSC, and the basis for their selection, are listed below in Table 2 and discussed in further detail in Appendix 3.

Table 2. Inputs for consumption rate calculations in Equation 1.

Equation Parameter	Input Values for Adults	Input Values for Children	Units	Source
Reference Dose (RfD)	2	2	ng/kg/day	ATSDR MRL (2021)
Body Weight (BW)	80	15	kg	USEPA (2011)
Meal Size	8 (227)	3 (85)	oz (g)	Maine CDC (2020)
Relative Source Contribution (RSC)	0.7	0.7	Unitless	NHANES (2017-2018) Serum Levels

Meal Frequency Estimates for Fairfield Deer

Muscle Tissue

Using Equation 1, Maine CDC developed population-specific meal frequency estimates using the PFOS tissue levels detected in the eight deer sampled in the Fairfield area. Those estimates are presented below in Table 3 as the number of venison meals per month a child or adult can consume without exceeding the 2 ng/kg/day PFOS RfD.

Table 3. Meal frequency (meals/month) estimates for deer muscle tissue.

Sample ID	Location	Age Class, Sex	PFOS Muscle Tissue (ng/g wet)	Child (Meals/Month)	Adult (Meals/Month)
186996	Middle Rd	Adult, Male	1.4	5	10
186995	Middle Rd	Adult, Female	5.0	2	3
186993	Howe Rd	Yearling, Female	3.4	2	4
187000	Ohio Hill Rd	Yearling, Female	36.9	< 1 (2 per year)	< 1 (5 per year)
186997	Ohio Hill Rd	Adult, Female	39.9	< 1 (2 per year)	< 1 (4 per year)
186999	Ohio Hill Rd	Fawn, Female	40.6	< 1 (2 per year)	< 1 (4 per year)
186944	Ohio Hill Rd	Adult, Female	42.5	< 1 (2 per year)	< 1 (4 per year)
186998	Ohio Hill Rd	Adult, Female	43.5	< 1 (2 per year)	< 1 (4 per year)

The PFOS concentration in the muscle tissue of all five deer harvested from the Ohio Hill Road area is high enough that venison could only be consumed two to five times a year without exceeding the

ATSDR toxicity value and allowing for typical background exposure. For deer harvested from the Middle Road fields and the Howe Road area, venison could be consumed somewhere between two meals per month and two meals per week.

Liver Tissue

In the Fairfield area, liver tissue PFOS levels in most deer were 4-fold to 51-fold higher than in the muscle tissue. Although there are minimal data available on deer liver consumption among Maine hunters, Maine CDC also calculated meal frequency estimates for deer liver. Using the same meal size assumptions as used in the muscle tissue estimates, Maine CDC developed population-specific meal frequency estimates for deer liver tissue. Those estimates are presented in Table 4 as the number of meals per year an adult or child can consume without exceeding the 2 ng/kg/day PFOS RfD.

Table 4. Meal frequency estimates (meals/month) based on measured deer liver tissue PFOS.

Sample ID	Location	Age Class, Sex	PFOS Liver Tissue (ng/g wet)	Child (Meals/Month)	Adult (Meals/Month)
186996	Middle Rd	Adult, Male	5.5	1	3
186995	Middle Rd	Adult, Female	22.3	< 1 (4 per year)	< 1 (8 per year)
186993	Howe Rd	Yearling, Female	177	< 1 meal per year	< 1 (1 per year)
187000	Ohio Hill Rd	Yearling, Female	786	< 1 meal per year	< 1 meal per year
186997	Ohio Hill Rd	Adult, Female	700	< 1 meal per year	< 1 meal per year
186999	Ohio Hill Rd	Fawn, Female	690	< 1 meal per year	< 1 meal per year
186944	Ohio Hill Rd	Adult, Female	809	< 1 meal per year	< 1 meal per year
186998	Ohio Hill Rd	Adult, Female	624	< 1 meal per year	< 1 meal per year

Liver tissue levels in all five deer harvested from the Ohio Hill Road area were high enough that for both adults and children, consumption of even a single meal per year would exceed the RfD. Only one deer collected from the Middle Road fields area had liver tissue levels that would allow for consumption of one to three meals per month.

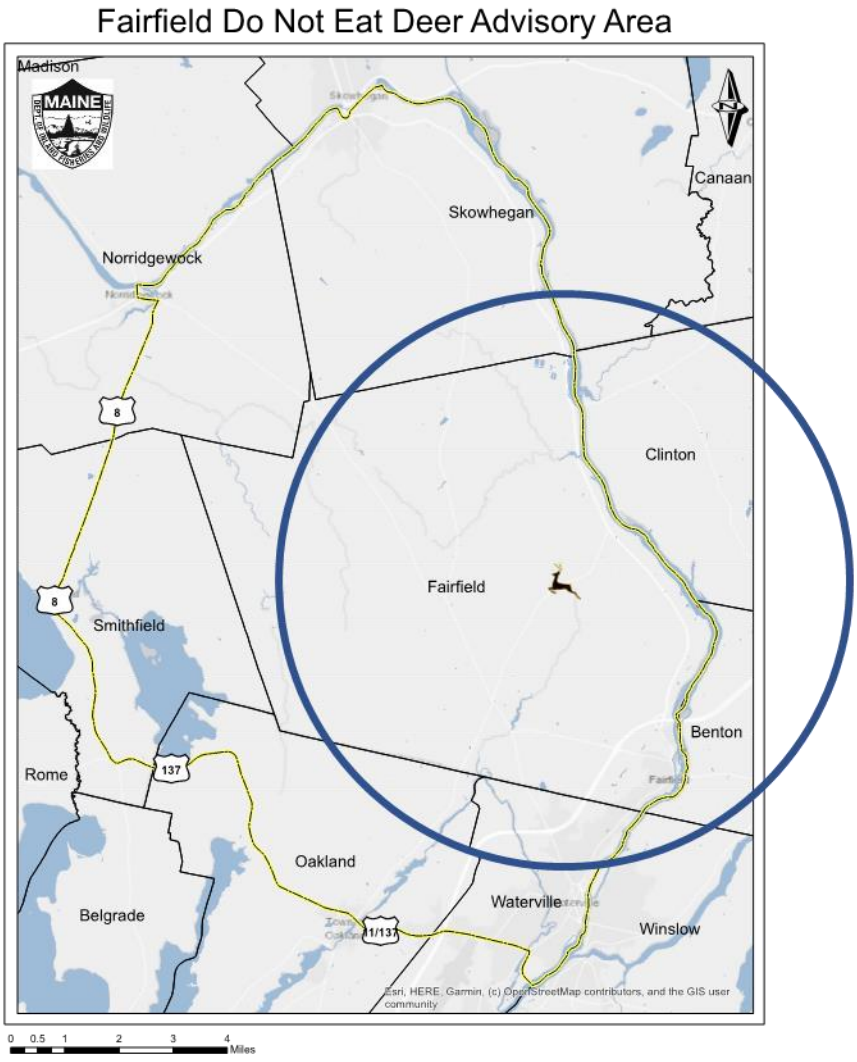
Consumption Advisory

On November 23, 2021, MDIFW, in conjunction with Maine CDC, issued a do not eat advisory for deer harvested in the greater Fairfield area. A do not eat advisory was issued based on the Maine CDC risk assessment analyses that deer in the Ohio Hill Road area cannot be safely consumed with any regularity (as presented in Tables 3 and 4). The boundaries of the do not eat advisory were set with an abundance of caution given the limited data on just eight harvested deer. The advisory area was extended to a five-mile radius around the Ohio Hill Road area where deer with the highest PFAS levels were found. Five miles was selected based on MDIFW information on upper range of seasonal migration distances of collared deer. Advisory area boundaries were defined using readily identifiable land features such as roads or waterways that would encircle the five-mile radius. The Kennebec River

represented a semi-permeable dispersal and movement barrier for deer and thus formed the boundary on the eastern side of the consumption advisory area.

The Fairfield advisory area (Figure 4) begins at the Carter Memorial Bridge in Waterville where Route 137 crosses the Kennebec, heads north up the Kennebec River past Waterville and Skowhegan, to the Eugene Cole Bridge in Norridgewock (Route 8 and 201A), then south from Norridgewock along Route 8 into Smithfield to the intersection of Routes 8 and 137, then south on Route 137 until it crosses the Kennebec River on the Carter Memorial Bridge. The advisory area encompasses multiple farm fields that have been determined to contain high levels of PFOS and other PFAS through the spreading of municipal and/or industrial sludge for fertilizer that contained PFAS or manure from animals known to be exposed to PFAS.

Figure 4. Fairfield Do Not Eat deer advisory area (yellow) with 5-mile radius (blue) around Ohio Hill Road area.



The consumption advisory and supporting information were provided to the public via an MDIFW press release. Targeted emails were sent to all 2021 licensed hunters and to all hunters that had already

harvested a deer in a town impacted by the consumption advisory. An MDIFW website page was created to cover frequently asked questions about PFAS, and a map of the advisory area was included on this page. A dedicated email address for PFAS-related inquiries was created to handle the bulk of PFAS-related questions and information requests, and MDIFW Information Center staff were briefed in preparation for the high call and email volume. An MDIFW staff meeting was held to ensure consistent messaging and knowledge of proper contacts for PFAS-related inquiries. Plans for further sampling are currently in development.

Deer PFAS Advisories in Other States

In recent years other states, including Michigan, Wisconsin, and New Hampshire, have issued deer consumption advisories based on elevated PFOS levels in either muscle or liver tissue, and several other states are in the process of conducting their own investigations. In 2018, Michigan issued a "do not eat" deer advisory for a five-mile area surrounding Clark's Marsh, an area with known environmental PFAS contamination of surface water, due to the detection of elevated PFOS levels in deer muscle and liver tissue, including one deer that had a muscle tissue PFOS level of 548 ng/g (MDHHS DEH 2018). A follow-up study of deer PFAS contamination in the Clark's Marsh area resulted in restricting the "do not eat" advisory area from a five-mile to three-mile radius (MDHHS DEH 2019; MDHHS DEH 2021). In Wisconsin, PFAS were detected in deer liver, but not deer muscle tissue, in the area surrounding the JCI/Tyco Fire Technology Center, which prompted a liver-specific "do not eat" advisory (WI DNR 2020a). In New Hampshire, PFAS have not been detected in any collected muscle tissue samples (NH Fish and Game 2019).

New Hampshire, Wisconsin, and Michigan also have general recommendations to not consume deer liver either statewide, or on an area-specific basis. New Hampshire and Michigan both recommend hunters do not consume deer liver, based in part on detection of PFOS in deer liver and in part because the liver can accumulate chemicals, including PFAS (NH Fish and Game 2019; MDHHS DEH, 2018, 2019, and 2021). Wisconsin has issued a "do not eat" consumption advisory for deer liver for the area surrounding the JCI/Tyco Fire Technology Center but based on statewide PFOS survey results has not extended that advisory (WI DNR 2020a; WI DNR 2020b).

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WI DNE. 2020b. Wisconsin Department of Natural Resources. PFAS Levels in the Liver of White-tailed Deer from Wisconsin.

Appendix 1 – PFAS Analytes

Analyte	Common Abbreviation	CAS No.
Perfluorohexanoic acid	PFHxA	307-24-4
Perfluoroheptanoic acid	PFHpA	375-85-9
Perfluorooctanoic acid	PFOA	335-67-1
Perfluorononanoic acid	PFNA	375-95-1
Perfluorodecanoic acid	PFDA	335-76-2
Perfluoroundecanoic acid	PFUnA	2058-94-8
Perfluorododecanoic acid	PFDoA	307-55-1
Perfluorotridecanoic acid	PFTrDA	72629-94-8
Perfluorotetradecanoic acid	PFTeDA	376-06-7
2-(N-methylperfluorooctanesulfonamido) acetic acid	NMeFOSAA	2355-31-9
2-(N-ethylperfluorooctanesulfonamido) acetic acid	NEtFOSAA	2991-50-6
Perfluorobutanesulfonic acid	PFBS	375-73-5
Perfluorohexanesulfonic acid	PFHxS	355-46-4
Perfluorooctanesulfonic acid	PFOS	1763-23-1
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6
4,8-dioxa-3H-perfluorononanoic acid	Adona	919005-14-4
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid	9Cl-PF3ONS	756426-58-1
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11Cl-PF3OUdS	763051-92-9

Appendix 2 – Deer Muscle and Liver Tissue Results for all PFAS Measured

	Sample ID	**186993**		**186944**		**186995**		**186996**		**186997**		**186998**		**186999**		**187000**	
	Location	Howe Rd.		Ohio Hill Rd.		Middle Rd		Middle Rd.		Ohio Hill Rd.		Ohio Hill Rd.		Ohio Hill Rd.		Ohio Hill Rd.	
	Age, Sex	Yearling Female		Adult Female		Adult Female		Adult Male		Adult Female		Adult Female		Fawn Female		Yearling Female	
Analyte	Limit of Detection (LOD)	Muscle (ng/g)	Liver (ng/g)	Muscle (ng/g)	Liver (ng/g)	Muscle (ng/g)	Liver (ng/g)	Muscle (ng/g)	Liver (ng/g)	Muscle (ng/g)	Liver (ng/g)	Muscle (ng/g)	Liver (ng/g)	Muscle (ng/g)	Liver (ng/g)	Muscle (ng/g)	Liver (ng/g)
PFHxA	0.2	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
PFHpA	0.1	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
PFOA	0.1	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
PFNA	0.2	<LOD	<LOD	<LOD	2.1	<LOD	0.1*	<LOD	0.1*	<LOD	1.1	<LOD	0.6	<LOD	<LOD	<LOD	2.1
PFDA	0.1	<LOD	3.1	1.3	48.1	0.4*	1.4	<LOD	0.2*	0.9	20.6	0.8	13.8	0.6	13.3	1.0	30.3
PFUnA	0.1	<LOD	2.7	<LOD	9.4	<LOD	0.4*	<LOD	<LOD	<LOD	3.9	<LOD	3.4	<LOD	4.7	<LOD	4.5
PFDoA	0.2	<LOD	<LOD	<LOD	3.8	<LOD	<LOD	<LOD	0.1*	<LOD	1.9	<LOD	1.4	<LOD	1.70	<LOD	<LOD
PFTrDA	0.2	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
PFTeDA	0.1	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
NMeFOSAA	0.2	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
NEtFOSAA	0.2	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
PFBS	0.05	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
PFHxS	0.2	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
PFOS	0.1	3.4	177	42.5	809	5.0	22.3	1.4	5.5	39.9	700	43.5	624	40.6	690	36.9	786
HFPO-DA	0.2	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Adona	0.3	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
9Cl-PF3ONS	0.2	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
11Cl- PF3OUdS	0.2	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

* Below the laboratory limit of quantitation (0.4 – 0.5 ng/g)
<LOD: below the laboratory limit of detection
All values rounded to one decimal place

Appendix 3 - Meal Frequency Equation Inputs

Reference Dose

In selecting an RfD, Maine CDC typically relies on toxicity values developed by federal agencies, e.g., the EPA or the Agency for Toxic Substances and Disease Registry (ATSDR). Since 2016, Maine CDC has used the EPA's Office of Water RfD of 20 ng/kg/day for PFOS developed for the EPA drinking water health advisory for PFOS and PFOA (USEPA, 2016). In May 2021, the ATSDR released their final Minimal Risk Levels (MRLs) for four PFAS, including PFOS (ATSDR, 2021). Similar to an RfD, an MRL is an estimate of the daily human exposure to a substance that is likely to be without appreciable risk of adverse health effects over a specified duration of exposure. The ATSDR's PFOS MRL is 2 ng/kg/day and is based on the same study as EPA's 2016 RfD but applies an additional 10-fold uncertainty factor to account for potential immune system effects. On November 17th, 2021, EPA proposed an updated RfD for PFOS that is considerably lower than anything previously proposed. This proposed PFOS RfD is still a draft RfD and is in the process of being reviewed by the agency's Science Advisory Board (SAB). Since 2016, several states and other US and European agencies have derived their own toxicity values for PFOS (and some other PFAS) that range from 0.6 ng/kg/day up to 5 ng/kg/day. Given that EPA will almost certainly be lowering their current toxicity value for PFOS, but does not yet have a finalized RfD, Maine CDC has opted to rely on the 2 ng/kg/day MRL derived by the ATSDR (ATSDR, 2021).

Body Weight

Maine CDC developed separate risk estimates for adults and children to account for differences in bodyweight and meal size. EPA standard bodyweights were used for adults (80 kg) and young children aged 1 to <6 years old (15 kg) (USEPA 2011). These standard adult and child body weights are the weights used in both DEP and Maine CDC risk assessments.

Meal Size

Limited data are available for venison consumption rates or average meal sizes among consumers in the U.S. or in the state of Maine. In lieu of venison-specific meal sizes, Maine CDC used an 8 oz (227 g) meal size for adults, which is consistent with the meal size used in fish consumption advisories. For children Maine CDC assumed a 3 oz (85 g) meal size, which roughly equates to the 90th percentile beef consumption intake for a child aged 1 to 6 years (MECDC, 2020).

Relative Source Contribution

The purpose of the relative source contribution (RSC) factor is to account for additional PFOS exposure sources to ensure that the daily exposure from all sources does not exceed the RfD (USEPA 2000). It is clear from U.S. CDC biomonitoring programs that exposure to PFOS is ubiquitous, as it is present in the blood of most individuals tested in recent samplings of Americans 12 years and older (USCDC 2021). The presence of PFOS, as well as several other PFAS, in the general U.S. population is the result of exposure from multiple sources, including dietary sources, house dust, drinking water, and indoor and outdoor air (ATSDR 2021; Egeghy and Lorber 2011; Gebbnik et al. 2015; Trudel et al. 2008). PFOS levels measured in blood may also reflect some contribution of exposure to PFOS precursors that have undergone biotransformation to PFOS within the body (Gebbnik et al. 2015 and Vestergren et al. 2008). When there is no known exposure source, e.g., contaminated community drinking water, studies estimating daily PFOS exposures from various media suggest that the largest contributor to overall PFOS exposure is likely the diet for adults, and diet and house dust for young children (Egeghy and Lorber 2011; Tittlemier et al. 2007; Trudel et al. 2008). However, the magnitude and relative

contribution of these external daily exposure estimates from various individual sources, such as diet, indoor dust or drinking water, are uncertain and may not be entirely representative of current exposures for the general U.S. population.

A measured PFOS serum level in an individual represents a comprehensive exposure metric as serum integrates all external exposures and absorption from diet, water, hand-to-mouth activities, inhalation etc. Measured PFAS serum levels from U.S. CDC National Health and Nutrition Examinations Surveys (NHANES) biomonitoring studies, which are designed to be nationally representative of the general U.S. population, reflect exposure to PFAS, including PFOS, from all sources for the general population. Thus, measured PFAS serum levels from NHANES biomonitoring can be viewed as representative of background exposure for the general U.S. population and utilized to estimate an RSC factor.

To derive a PFOS-specific RSC factor using recent NHANES PFOS serum levels, Maine CDC utilized a one-compartment pharmacokinetic model (Equation A1). This is the same pharmacokinetic model EPA and ATSDR applied in their PFOS RfD and minimum risk level (MRL) derivations, respectively, to convert a dose on a serum level basis to an oral intake dose (USEPA 2016; ATSDR 2021). The pharmacokinetic model converts a measured serum to an oral equivalent dose, i.e., the ingested dose on a body weight basis that is required to result in the measured serum level.

$$Background\ exposure\ (ng/kg/day) = Cp \times kp \times Vd \qquad (Equation\ A1)$$

where:
Cp = PFOS serum concentration (4.25 ng/mL, NHANES 2017-2018 Total population geometric mean)
kp = first-order elimination rate (0.00056 day^{-1}, 1241-day half-life, Li et al. 2018)
Vd = volume of distribution (230 mL/kg-body weight adults, Thompson et al. 2010)

The calculated background PFOS exposure on a ng/kg/day basis using the geometric mean serum level of 4.25 ng/mL for the total population ages 12 years and older is 0.55 ng/kg/day. The geometric mean was selected to represent the central tendency PFOS serum level, as it is EPA guidance to use central tendencies for RSC intake estimates (USEPA 2000).

Considering this oral equivalent dose to represent average, general background PFOS exposure, the remaining dose which could be allocated to other sources is calculated by subtracting the background exposure from the 2 ng/kg/day PFOS RfD. Here the selected PFOS RfD is the ATSDR PFOS MRL. The RSC is derived by dividing the remaining dose by the PFOS RfD (Equation A2).

$$RSC = \frac{PFOS\ RfD\ (ng/kg/day) - Background\ exposure\ (ng/kg/day)}{PFOS\ RfD\ (ng/kg/day)} \times 100 \qquad (Equation\ A2)$$

Using the 0.55 ng/kg/day background exposure estimate in comparison to the ATSDR PFOS MRL of 2 ng/kg/day produces an RSC of 73%. The rounded value of 70% is used as the RSC for PFOS.

Given that there is also exposure to other PFAS, such as PFOA, PFNA, and PFHxS where there may be a potential for additive toxicities, RSC values were calculated for PFHxS, PFOA, and PFNA based on ATSDR MRLs and NHANES 2017-2018 geometric mean serum levels. Using a toxicity value-weighted approach, the sum of the average daily exposure to PFOS, PFOA, PFNA, and PFHxS results in an RSC of approximately 60%. The 60% RSC is largely dominated by PFOS and PFOA which have higher background serum levels than PFNA and PFHxS. As levels for these four PFAS have continued to decrease based on NHANES biomonitoring from 1999-2018, it's expected that current serum levels are lower than 2017-2018 years. Lower background serum levels would result in a calculated RSC of greater than 60%. The use of a 70% RSC for PFOS is therefore considered generally protective of potential additive effects of background exposure to other PFAS for which toxicity values and serum data are available.

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