PFAS levels in Michigan Deer and Eat Safe Wild Game Guidelines

Michigan Department of Health and Human Services

Division of Environmental Health

Michigan Fish Consumption Advisory Program

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Summary

The State of Michigan collected tissue samples from 128 white-tailed deer across Michigan to test for per- and polyfluoroalkyl substances (PFAS). In October of 2018, the Michigan Department of Health and Human Services (MDHHS) and Michigan Department of Natural Resources (MDNR) issued a 'Do Not Eat' advisory for deer taken within five miles of Clark's Marsh in Oscoda Township. The advisory is due to high levels of PFAS, specifically perfluorooctane sulfonate (PFOS), found in deer taken within five miles of the Marsh. The advisory encircles the five-mile radius around the former Wurtsmith Air Force Base property and covers what the MDNR has estimated to be the expected travel range of deer living in or near the Marsh. The area covered by the deer consumption advisory issued can be described as:

> From Lake Huron west along Aster Street, west on Davison Road, north on Brooks Road, east on Esmond Road, north on Old US 23, north on Wells Road, west on River Road, north on Federal Forest Road 2240, north on Lenard Road, north on Indian Road, and East on E. Kings Corner Road (along the county line) toward Lake to Lake Road, to Lake Huron.

Michigan residents should not eat any deer harvested from within five miles of Clark's Marsh. In addition to the Clark's Marsh deer advisory, MDHHS continues to recommend not eating kidneys or liver from any deer because many chemicals including PFAS can accumulate in these organs.

Included within the 128 samples collected, 20 deer were taken from near each of the PFAS investigation sites in Oscoda area (Iosco County), Alpena (Alpena County), Rockford (Kent County) and Grayling (Crawford and Kalkaska Counties) with known contamination in lakes and rivers. The deer muscle tested from these areas was found to have no PFAS or very low levels of the chemical. An additional 48 samples of deer muscle from the 2017 hunting season were tested from other areas across the state. PFAS was either not detected or detected at very low levels for these deer.

MDNR and MDHHS developed this investigation in response to questions from hunters concerned about harvesting deer in contaminated areas. This is believed to be first study of its kind and very little scientific information exists on white-tailed deer and PFAS chemicals.

It is unknown how PFAS could accumulate in deer to the level observed in the single deer near Oscoda. The State of Michigan is investigating the circumstances of the one deer with elevated levels and doing further analysis on these test results to learn more about PFAS in deer and other wildlife. In addition, the state will be doing additional testing on deer from the Clark's Marsh region and performing modeling studies to learn about PFAS consumption in wildlife.

In April 2025, MDHHS updated the values used to evaluate PFOS in fish. These values are also used in wild game consumption guidelines.

- The "do not eat" advisory for deer around Clark's Marsh remains in place and was updated in 2021 to three miles around the marsh. See the map for the current area.
- For deer collected from the Alpena (Alpena County), Rockford (Kent County) and Grayling (Crawford and Kalkaska Counties) areas, there is no change to the above conclusion that consumption guidelines are not needed, as PFAS were not detected in any of the muscle samples.

Purpose

As part of Michigan's efforts to identify per- and polyfluoroalkyl substances (PFAS) in Michigan, deer were tested from areas known to have PFAS contamination in lakes or rivers. Deer muscle samples were also collected from voluntary deer head submissions at MDNR check stations during the 2017 fall hunting season. The voluntary submissions included deer harvested from multiple counties but were not a statewide representative sampling.

Background

Two sets of deer samples were collected over the past two years in Michigan. One set was muscle tissue samples collected from deer heads voluntarily submitted for disease testing in various counties around the state of Michigan in 2017. The second was a targeted sample collection from deer found in proximity to PFAS contaminated surface water bodies in four locations (Oscoda area [Iosco County], Alpena [Alpena County], Rockford [Kent County] and Grayling [Crawford and Kalkaska Counties]) in Michigan during the spring and summer of 2018. See the sections below describing the PFAS contamination in the four targeted areas.

Iosco County PFAS, including surface water levels

Activities at the former Wurtsmith Air Force Base (WAFB) began in 1923. The base is located in Oscoda, Iosco County, Michigan. In 1993, the based closed and portions have been turned over to the Oscoda Airport Authority for reuse as an industrial park and airfield. The 5,221-acre site is bounded by Van Etten Lake to the north and east, Oscoda and Au Sable Townships to the east and south, the Huron National Forest (including wetlands associated with the Au Sable River) to the south, and the Au Sable State Forest to the north and west. Lake Huron is less than one mile east of the site.

There are two former fire-training (FT) sites at WAFB. FT-01 is located in the northeast end of the runway and was used from 1951 to 1958. FT-02, located at the southwest end of the base near Clark's Marsh (which is north of the Au Sable River) was used from the 1950s to the early 1990s. PFOS-based aqueous film-forming foams (AFFF) was likely used in this area beginning in the 1970s. Data collected by MDEQ and others have shown that PFOS and other perfluorinated chemicals have contaminated this area, leached through the sandy soil into the groundwater, and migrated into the surface water and sediments in the ponds at Clark's Marsh. PFAS have also be found in other nearby water bodies, Van Etten Lake, the Au Sable River, and Allen Lake. (MDHHS 2017)

Surface water PFAS levels were measured in water samples from Clark's Marsh (collected in 2011), the Au Sable River (collected in 2013), and Van Etten Lake (collected in 2013) (MDCH 2015). The geometric mean of the detected PFAS are listed below in Table 1.

Table 1: Geometric mean PFAS surface levels in nanograms per Liter (ng/L or parts per trillion [ppt]) collected in 2011 and 2013 (MDCH 2015).

PFAS	Au Sable River, near river mouth	Clark's Marsh	Van Etten Lake
Perfluoroheptanesulfonic acid (PFHpS)	ND[1]	171	ND
Perfluorobutanesulfonic acid (PFBS)	ND	104	ND
Perfluorobutanoic acid (PFBA)	2.83	116	3.59
Perfluorodecanoic acid (PFDA)	ND	2.5	ND
Perfluoroheptanoic acid (PFHpA)	0.85	173	0.84
Perfluorohexane sulfonate (PFHxS)	4.77	3,756	3.20
Perfluorohexanoic acid (PFHxA)	1.60	922	1.16
Perfluoro-n-hexadecanoic acid (PFHxDA)	0.47	ND	0.49
Perfluorononanoic acid (PFNA)	ND	24.2	ND
Perfluorooctane sulfonamide (PFOSA)	ND	172	ND
Perfluorooctane sulfonate (PFOS)	3.23	5,099	1.37
Perfluorooctanoic acid (PFOA)	1.86	1,309	1.20
Perfluoropentanoic acid (PFPeA)	1.26	418	1.22
Perfluorotetradecanoic acid (PFTeA)	0.21	ND	0.25
1 = This PFAS was not detected (ND) and a geometric mean could not be calculated.			

The highest PFAS levels in surface water were in Clark's Marsh for all detected PFAS. Clark's Marsh geometric mean PFHxS, PFOS, and PFOA levels were the highest at 3,756, 5,099, and 1,309 ng/L, respectively.

Kent County PFAS, including surface water levels

Wolverine Worldwide (WWW) operated a tannery in Rockford, Michigan beginning in the 1930's through 2009 when tannery operations ceased and the tannery buildings were demolished. In the 1950's WWW began using Scotchgard™ (manufactured by 3M Company) as a stain repellant for leather in their manufacturing process. The main chemical constituents in Scotchgard™ are perfluoroalkyl and polyfluoroalkyl substances (PFAS). Between the 1950's and 1960's WWW disposed of tannery wastes/sludges at various old gravel pits and landfills. These historical disposal practices have resulted in PFAS contamination in ground water over an approximate 35 square mile area in northern Kent County.

WWW constructed a wastewater treatment plant (WWTP) at the tannery property sometime between 1950 and 1960. Beginning in the early 1960's through 1978 WWW disposed of PFAS-containing waste sludges from its WWTP at the House Street disposal facility located at 1855 House Street in Plainfield Township, Michigan (House Street site). In 2016 the MDEQ identified PFAS in residential groundwater wells located near the House Street site. As result, the MDEQ notified WWW that the House Street site was a likely source for the PFAS groundwater contamination and required that WWW conduct further investigation to identify the source(s) for and extent of PFAS in groundwater in the area. In 2017 area residents began to notify the MDEQ of additional alleged disposal locations where tannery wastes were known or suspected to have been placed and these locations are currently being investigated by MDEQ staff as part of the Northern Kent County investigation. To date, WWW and MDEQ have sampled over 1,700 private drinking water wells as part of the North Kent County investigation. Additionally, WWW has installed numerous monitoring wells across the site to delineate the horizontal and vertical extent of

PFAS in groundwater. To date, the maximum concentration of combined perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS) detected in private drinking water wells is 71,000 parts per trillion (ppt).

Surface water samples were collected from the Rogue River in August and September of 2018 (MDEQ 2018), between Rockford and Plainfield Charter Township in or near the MDEQ's North Childsdale/10 Mile and Rogue River PFAS Investigation areas. The range of PFAS detected are listed in Table 2.

Table 2: Range (minimum to maximum in nanograms per Liter [ng/L or parts per trillion (ppt)] of PFAS surface water levels and number of detections in water samples collected from the Rogue River (MDEQ 2018).

PFAS	Range (minimum to maximum in ng/L) in the Rogue River	Number of detections
Perfluorobutanoic acid (PFBA)	1 to 7.2	14/14
Perfluorooctanoic acid (PFOA)	ND[1] to 7.3	13/14
Perfluorooctane sulfonate (PFOS)	0.66 to 19	14/14
Perfluoropentanoic acid (PFPeA)	0.94 to 2.6	14/14
Perfluorohexanoic acid (PFHxA)	ND to 2.4	13/14
Perfluoroheptanoic acid (PFHpA)	0.29 to 1.7	14/14
Perfluorononanoic acid (PFNA)	ND to 0.47	7/14
Perfluorodecanoic acid (PFDA)	ND	0/14
Perfluoroundecanoic acid (PFUnA)	ND	0/14
Perfluorododecanoic acid (PFDoA)	ND	0/14
Perfluorotridecanoic acid (PFTriA)	ND	0/14
Perfluorotetradecanoic acid (PFTeA)	ND	0/14
Perfluorobutanesulfonic acid (PFBS)	1.1 to 3.9	14/14
Perfluorohexane sulfonate (PFHxS)	0.55 to 2.3	14/14
Perfluoroheptanesulfonic Acid (PFHpS)	ND to 0.73	7/14
Perfluorodecanesulfonic acid (PFDS)	ND	0/14
Perfluorooctane sulfonamide (PFOSA)	ND	0/14
Perfluoropentanesulfonic acid (PFPeS)	ND to 1.3	9/14
Perfluorononanesulfonic acid (PFNS)	ND	0/14
N-methyl perfluorooctane sulfonamidoacetic acid (NMeFOSAA)	ND	0/14
N-ethyl perfluorooctane sulfonamidoacetic acid (NEtFOSAA)	ND	0/14
4:2 FTS	ND	0/14
6:2 FTS	ND	0/14
8:2 FTS	ND	0/14
1 = This PFAS was not detected (ND).		

Crawford/Kalkaska Counties PFAS, including surface water levels

Between the years of the 1970s and early 1980s, per- and polyfluoroalkyl substances (PFAS), primarily in the form of Aqueous Film Forming Foam (AFFF), were released during firefighting activities or training in several areas of Camp Grayling. Camp Grayling is a military installation located in the city of Grayling. It was established as a training camp in 1913 and currently encompasses over 147,000 acres that spans over three counties – Crawford, Kalkaska and Otsego – making it the largest National Guard training facility in the United States. The facility is known for its four-season Joint Maneuver Training Center providing year-round training for over 10,000 military personnel from National Guard, Army and Reserve units every year. The facility is bisected by the Au Sable River and comprises many ranges and ample maneuver areas.

Grayling Army Air Field (GAAF) and Lake Margrethe are two of the 19 areas of interest identified during the preliminary assessment of Camp Grayling. GAAF serves as an aviation support facility to Camp Grayling and is conveniently located on the installation, between the main branch and the East Branch of the Au Sable River; and Lake Margrethe is a 1,920-acre recreational lake bordered by a cantonment area (military garrison or camp) to the south and a small arms range to the west. PFAS contamination from the installation is suspected to have infiltrated shallow groundwater and migrated towards Lake Margrethe and surrounding private residential wells. (AECOM 2018).

Surface water samples were collected from the Au Sable River near Grayling in June 2017 (MDEQ 2018). The range and number of detections are listed in Table 3.

Table 3: Range (minimum to maximum in nanograms per Liter [ng/L or parts per trillion (ppt)] of PFAS surface water levels and number of detections in water samples collected from the Au Sable River in the Grayling area (MDEQ 2018).

PFAS	Range (minimum to maximum in ng/L) in Au Sable River near Grayling	Number of detections
Perfluorobutanoic acid (PFBA)	1.5 to 6.6	9/9
Perfluoropentanoic acid (PFPeA)	ND[1] to 3.3	4/9
Perfluorohexanoic acid (PFHxA)	ND to 1.2	3/9
Perfluoroheptanoic acid (PFHpA)	ND	0/9
Perfluorooctanoic acid (PFOA)	ND to 0.84	1/9
Perfluorononanoic acid (PFNA)	ND to 19	1/9
Perfluorodecanoic acid (PFDA)	ND to 2.1	1/9
Perfluoroundecanoic acid (PFUnA)	ND to 32	1/9
Perfluorododecanoic acid (PFDoA)	ND	0/9
Perfluorotridecanoic acid (PFTriA)	ND to 0.74	2/9
Perfluorotetradecanoic acid (PFTeA)	0.67 to 1.8	9/9
Perfluoro-n-hexadecanoic acid (PFHxDA)	ND to 0.43	3/9
Perfluoro-n-octadecanoic acid (PFODA)	ND	0/9
Perfluorobutanesulfonic acid (PFBS)	ND	0/9
Perfluorohexane sulfonate (PFHxS)	ND to 2.1	4/9
Perfluoroheptanesulfonic acid (PFHpS)	ND	0/9
Perfluorodecanesulfonic acid (PFDS)	ND	0/9
Perfluorooctane sulfonate (PFOS)	ND to 6	2/9
Perfluorooctane sulfonamide (PFOSA)	ND to 21	4/9
1 = This PFAS was not detected (ND).		

The highest detections of PFAS in surface water samples from the Au Sable River near Grayling were PFNA (maximum of 19 ng/L), PFUnA (maximum of 32 ng/L), and PFOSA (maximum of 21 ng/L). These three PFAS were only detected in a few water samples from the river (PFNA - 1/9 samples, PFUnA – 1/9 samples, and PFOSA – 4/9 samples).

Alpena County PFAS, including surface water levels

Early 1900s marked the beginning of Alpena Combat Readiness Training Center (CRTC) as a military training base. The base is in Alpena, Alpena County, Michigan and extends over 2,500 acres. It is bounded by Lake Winyah to the north, Lower South Branch Thunder Bay River to the west, M-32 to the south and the city of Alpena to the south and east. Thunder Bay and Lake Huron are about 7 miles east of the base. Alpena CRTC provides year-round training to military units and is conveniently located on the county-owned and operated facility, Alpena County Regional Airport.

In the late 1940s, Air National Guard (ANG) took over the site from Army Air Corps. Per- and polyfluoroalkyl substances (PFAS) containing-Aqueous Film Forming Foam (AFFF) was commercially used as a firefighting foam by the ANG between 1970 and 2016 in suppressing fuel fires, in fire training

exercises and in aircraft hangar fire suppression systems. Alpena CRTC replaced legacy AFFF in its fire vehicles with replacement foam in 2016. However, due to the persistent nature of these chemicals, groundwater contamination from PFAS has been identified on-base. Surface water on-base, from samples collected from a sinkhole, had 470 ng/L PFOA and 8,770 ng/L PFOS. The sinkhole is located south of a fire training area and is to the east of the south branch of the Thunder Bay River. (ASL 2018). Table 4 presents the detected PFAS in Thunder Bay River, Lake Besser, which is to the east of the CRTC.

Table 4: Geometric mean surface levels of detected PFAS in nanograms per Liter (ng/L or parts per trillion [ppt]) collected in 2013 from Thunder Bay River, Lake Besser (MDCH 2015).

PFAS	Thunder Bay River, Lake Besser
Perfluorobutanoic acid (PFBA)	3.06
Perfluoroheptanoic acid (PFHpA)	0.93
Perfluorohexanoic acid (PFHxA)	0.85
Perfluoro-n-hexadecanoic acid (PFHxDA)	0.38
Perfluorooctanoic acid (PFOA)	1.01
Perfluorotetradecanoic acid (PFTeA)	0.23

Deer tissue sample collection and testing

Sampling for deer tissue samples occurred using both an opportunistic approach to evaluate tissue from deer collected broadly throughout the state and through a targeted approach from four locations known to have surface water PFAS contamination. Because so little information was available, the opportunistic samples were collected to assess whether PFAS were detected in Michigan deer that are not near known or suspected PFAS contamination sites and at what levels. These samples were limited to only muscle tissue, and thus exposure to PFAS could not be determined. The targeted samples included the additional kidney and liver tissues to determine if exposure could be documented for the individual animals. In other words, muscle tissue alone does not provide sufficient information to create a public health recommendation without the additional knowledge on the animal's exposure that the organ data could provide.

Muscle tissue sample from 2017 disease surveillance deer heads

The objective of this sampling was to use the MDNR bovine tuberculosis (bTB) and chronic wasting disease (CWD) surveillance/voluntary deer head submission at check stations to collect wild deer muscle samples for PFAS analysis.

These deer were harvested from areas not known to be contaminated with PFAS in 39 different counties in Michigan. Samples from these deer provide knowledge of the range of PFAS concentrations in deer at sites not anticipated to have highly elevated levels of PFAS, which will provide limited information on the variability of PFAS levels in the wild deer population. These PFAS levels can be compared to PFAS levels in deer harvested from known PFAS contaminated sites, as there are limited data on PFAS in the food supply, particularly in wild game.

The purpose of sampling deer from throughout the state was done to gain a cursory insight into background levels of deer in general as no information was available on PFAS in deer. The information gained from this sampling approach is limited in that it relied upon deer voluntarily submitted for disease testing as well as selection from a limited pool of samples on a given day. It is not intended to provide a broad statement about geographic representation of PFAS in deer or public health risk, but rather to provide relative information from deer not necessarily associated with a site known to be contaminated.

MDNR Wildlife Disease Lab staff collected approximately 100 to 200 grams of available muscle tissue from the voluntarily submitted deer heads submitted for bTB and CWD testing. While these samples were collected on particular days, limiting the deer heads that were available, an attempt was made to collect a sample from as many counties as possible.

Tissue samples were wrapped in foil and placed in sealable plastic bags. Samples were placed on the dull side of the foil, wrapped, and labeled. All samples were stored in the freezer until processing for analysis at the MDHHS Analytical Chemistry Laboratory. The deer tissue sample packaging and storage conditions were identical to the fish filet sample packaging and storage conditions used in the Michigan Department of Environmental Quality (MDEQ) Fish Contaminant Monitoring Program (MDEQ 2014).

2018 Deer harvest in four areas with surface water PFAS contamination

In spring and summer (after fawns were self-supporting) of 2018, the U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) sharpshooters harvested the deer and collected all tissue samples through an inter-agency agreement with MDNR and funding provided to MDNR through MDHHS. Protocols for tissue sampling were standardized and followed those used in the MDNR Wildlife Disease Laboratory.

Twenty deer (age-1 and older; both sexes) were sampled from the four locations associated with PFAS contamination, for a total of 80 deer sampled, within the following counties: Iosco, Kent, Crawford/Kalkaska, and Alpena Counties. Deer were accounted for non-consecutively; although there were 80 deer harvested, the numbering did not align.

The location details are presented in Table 5.

Table 5: Locations for the 2018 deer harvest areas.

Deer number[1]	Site	Location	Known or potentially contaminated surface waterbodies in the area
Deer #1-20	Former Wurtsmith Air Force Base (Iosco County)	AuSable Twp, 23N R09E sections 3, 4, 5, 6 Oscoda Twp, 24N R09E sections 7, 17-21, 27-34 Oscoda Twp, 24N R08E sections 25, 36 Wilber Twp, 23N R08E section 1	Clark's Marsh Allen Lake Au Sable River Van Etten Lake
Deer #26-45	Rockford (Kent County)	8N 11W sections. 6 & 21, and 9N 11W sections. 21, 22 & 23	Rogue River – Rockford Dam Pond
Deer #51-70	Camp Grayling and Lake Margarethe (Crawford and Kalkaska Counties)	Grayling Twp, 26N R04W sections 1-5, 7-24, 26-29	Lake Margarethe Au Sable River
Deer #76-95	Alpena Combat Readiness Training Center (Alpena County)	Maple Ridge Twp, 31N R07E sections 1, 2, 9-16, 21-28 Alpena Twp, 31N R08E sections 7, 17-19	Thunder Bay River - Lake Winyah
1 = There was non-consecutive numbering of the deer. There were no deer with numbers # 21-25 and #46-50.			

Disease testing after harvest

After deer harvest, sampled deer were tested and found negative for bTB and CWD prior to sample processing for PFAS to prevent exposure of MDHHS Analytical Chemistry Lab personnel. Field and laboratory assessments for bTB (O'Brien et al. 2001, 2002) and CWD were conducted based on existing protocols through the MDNR's Wildlife Disease Laboratory.

Upon collection, individual deer were uniquely identified and all samples were labelled with this unique identification. Additional data collected for targeted deer testing included:

- Location (GPS preferred) of collection;
- Results of TB field assessment (i.e., presence or absence of pleural lesions in the chest cavity suggestive of bTB (O'Brien et al. 2001);
- Date and time of collection;
- Position of the bullet entry hole, exit wound, and bullet/broadhead type;
- Sex of the animal, and
- Health description of the animal.

Hunter-harvested deer heads were collected, processed and transported per MDNR protocols for bTB and CWD surveillance. Any positive results were communicated through normal DNR procedures for disease communication. MDNR communicated the results of the bTB and CWD testing to the MDHHS lab to commence testing for PFAS. No deer were positive for bTB or CWD.

All deer were also aged by MDNR. Tooth eruption and wear is a widely-used, accepted, and reliable method for estimating age in white-tailed deer, particularly in younger animals, which comprise most of the population. Ages of the deer are estimated based on eruption of the teeth through the gums and wear of the cheek teeth (premolars and molars) (Severinghaus 1949).

Sample Collection for PFAS analysis

For the purposes of PFAS testing, the following samples were collected:

- Muscle tissue –100-200 grams, without connective tissue or tendons
- Liver – 100-200 grams
- Kidney – 100-200 grams
- Intraperitoneal and/or back fat - 100-200 grams, if possible[1]

There was no particular muscle targeted nor was there a specific area of the liver or kidney requested from the deer during the field collection of the samples. Sample amounts in excess of 100-200 grams (g) may have been collected, but there needed to be at least 50 g. No more than 250 g was needed for laboratory analysis.

Tissue samples were wrapped in foil and placed in sealable plastic bags. Samples were placed on the dull side of the foil, wrapped, and labeled. The deer tissue sample packaging and storage conditions were identical to the fish filet sample packaging and storage conditions used in the MDEQ Fish Contaminant Monitoring Program (MDEQ 2014).

All samples were stored in the freezer until processing for analysis at the MDHHS Analytical Chemistry Laboratory.

PFAS analysis in deer tissue

The MDHHS Analytical Chemistry Laboratory homogenized, extracted, and analyzed all samples for PFAS. The laboratory's method for PFAS uses Reversed Phase High Performance Liquid Chromatography Multiple Reaction Monitoring Tandem Mass Spectrometry using their standard operating procedures. The list of PFAS analyzed for in deer tissues can be found in Table 6. Only 11 PFAS are quantified.[2]

[1] Due to the time of year and leanness of the deer, there were a limited number of samples collected. The size of the sample also varied and almost all of them had muscle tissue and other components, such as hair, included with the fat sample. While this data is included for completeness, the results should not be considered as only adipose tissue (fat) PFAS levels.

[2] This is the same method that the MDHHS Analytical Chemistry Laboratory developed for fish tissue analysis. Five additional PFAS are included in the method, but not quantified as they are not found in tissue samples.

Table 6: PFAS measured in deer muscle, liver, and kidney, and fat tissue harvested in Michigan and analyzed in the MDHHS Analytical Chemistry Laboratory.

Abbreviation	Name
PFHxA[1]	Perfluorohexanoic acid
PFHpA[1]	Perfluoroheptanoic acid
PFOA	Perfluorooctanoic acid (branched and linear)
PFNA	Perfluorononanoic acid
PFDA	Perfluorodecanoic acid
PFUnA	Perfluoroundecanoic acid
PFDoA	Perfluorododecanoic acid
PFTriA	Perfluorotridecanoic acid
PFTeA	Perfluorotetradecanoic acid
PFHxDA[1]	Perfluoro-n-hexadecanoic acid
PFODA[1]	Perfluoro-n-octadecanoic acid
PFBS[1]	Perfluorobutanesulfonic acid
PFHxS	Perfluorohexane sulfonate (branched and linear)
PFOS	Perfluorooctane sulfonate (branched and linear)
PFDS	Perfluorodecanesulfonic acid
PFOSA	Perfluorooctane sulfonamide
1 = This is not quantified in tissue samples although it is included in the method.	

PFAS levels in muscle, liver, kidney, and fat

Deer head muscle tissue collected from 2017 disease surveillance

Muscle tissue from 48 voluntarily submitted deer head muscle, collected from 39 counties, were tested for PFAS. Eighteen deer were male, ranging from six months to 4.5 year of age. Thirty deer were female, ranging from one to 11.5 years of age. The only detected PFAS was PFOS in two muscle samples (see Table 7). Both samples were from deer harvested in Ingham County (one male approximately 6 months old [0.46 parts per billion (ppb) or nanograms per gram (ng/g) PFOS] and one female approximately 11.5 years old [0.3 ppb PFOS]). The other four deer harvested from Ingham County did not have detectable PFOS. One liver sample was available from a deer harvested in Ingham County. Only PFOS was detected in the liver sample, at a level of 3.45 ppb or ng/g. The muscle sample from this deer did not have detectable PFAS. See Figure 1: PFAS Tested Deer Locations Statewide.

Table 7: Deer head muscle tissue PFAS levels in nanograms per gram (ng/g) or parts per billion (ppb).

PFAS	Number of samples with detections	Range (minimum to maximum in parts per billion [ppb])
PFDA	0/48	<0.25 ppb[1]
PFDoA	0/48	<0.25 ppb
PFDS	0/48	<0.25 ppb
PFHxS	0/48	<0.25 ppb
PFNA	0/48	<0.25 ppb
PFOA	0/48	<0.25 ppb
PFOS	2/48	<0.25 – 0.46 ppb[2]
PFOSA	0/48	<0.25 ppb
PFTeA	0/48	<0.25 ppb
PFTriA	0/48	<0.25 ppb
PFUnA	0/48	<0.25 ppb

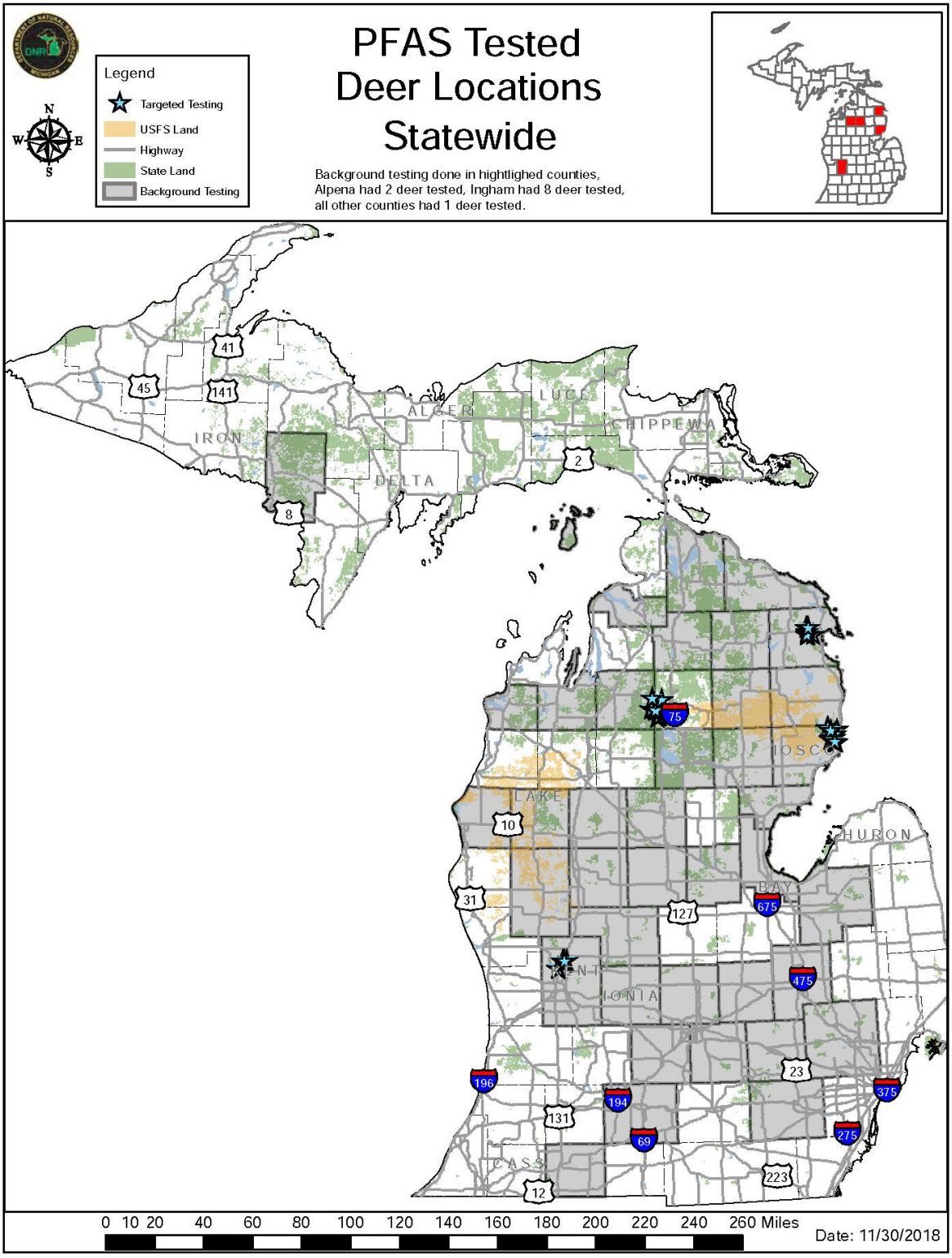
1 = None of the samples had detections of this PFAS.
2 = One liver sample was available from a deer harvested in Ingham County. Only PFOS was detected, at a level of 3.45 ppb. The muscle sample from this deer did not have detectable PFOS.

Only low levels of PFOS were detected in the two of the 48 muscle samples collected from deer harvested in 39 counties. The one liver sample collected from a deer harvested in Ingham County did have detectable PFOS, indicating that the deer was exposed, but the muscle sample from that deer did not have detectable PFOS or other PFAS. Although this was not a representative, statewide sampling, this data did not identify any deer with elevated PFOS necessitating a wild game consumption guideline.[3]

See Appendix A for location information for all deer included in the 2017 disease surveillance.

[3] MDHHS fish consumption screening values (developed for muscle tissue) starts at 9 ppb for PFOS for 16 serving per month and ranges up to 300 ppb at the state of the do not eat category. Description of those screening levels are in the Michigan Fish Consumption Advisory Program Guidance Document, available at https://www.michigan.gov/documents/mdch/MFCAP_Guidance_Document_500546_7.pdf. MDHHS also recommends that people do not eat the organs, regardless of measured amounts as those amounts may vary in animals with different exposures.

Figure 1: PFAS Tested Deer Locations Statewide.



Iosco County deer

Twenty deer were harvested, at the end of April 2018, from the Iosco County in the vicinity of Clarks Marsh, which has elevated PFAS levels in the surface water. Two deer were male and the other 18 were female.[4] The ages range from one to 11 years old, with five and four year old male deer. The PFAS detected were PFDA, PFDoA, PFDS, PFHxS, PFNA, PFOS, PFOSA, PFTriA, and PFUnA (See Table 8). Three PFAS were detected in the muscle sample from one deer: PFDS (1.72 ppb), PFHxS (3.64 ppb), and PFOS (547.77 ppb). Two other deer had detectable PFOS in the muscle samples (one at 1.1 ppb and the other at 0.47 ppb). The other PFAS (PFDA, PFDoA, PFNA, PFOSA, PFTriA, and PFUnA) were only detected in liver and kidney samples. One deer had highly elevated levels of PFOS in muscle, liver, and kidney samples. The muscle PFOS level was about two times higher than the 300 ppb "do not eat" screening level for PFOS.[5] This deer also had a liver PFOS level that was about 20 times higher and a kidney PFOS level that was about 12 times than that do not eat screening level.

Table 8: PFAS levels in muscle, liver, kidney, and fat samples (in nanograms per gram [ng/g] or parts per billion [ppb]) from deer harvested in Iosco County.

PFAS	Deer tissue	Number of samples with detections	Range (minimum to maximum in parts per billion [ppb])
PFDA	Muscle	0/20	<0.25 ppb[1]
	Liver	10/20	<0.25 – 4.92 ppb
	Kidney	2/20	<0.25 – 2.06 ppb
	Fat	1/10	<0.25 – 0.7 ppb
PFDoA	Muscle	0/20	<0.25 ppb
	Liver	1/20	<0.25 – 4.31 ppb
	Kidney	1/20	<0.25 – 0.45 ppb
	Fat	1/10	<0.25 – 0.5 ppb

[4] In general, there were more female than male deer included in this dataset (from all areas). This is expected, as in April, males are solitary or travel in small groups (less than five animals). Males can travel in a two to five mile range most of their life. Females group into matriarchal family units, containing multiple generations, and tend to move very little inside their home range. Females (does) hold the territories and push males out of prime fawn rearing habitat to make sure resources are available for the fawns. In a given territory, there is a doe in charge and other does in the area are likely related. During the winter, deer may travel very little, and they rely on fat reserves to survive the winter. These are generalities for deer in the lower peninsula of Michigan, south of Gaylord.

[5] The MDHHS fish consumption screening value (developed for muscle tissue) for "do not eat" is 300 ppb or higher. As people may eat multiple meals of venison from a single deer throughout the year, the individual deer muscle PFOS levels was compared to the screening value of 300 ppb. Description of those screening levels are in the Michigan Fish Consumption Advisory Program Guidance Document, available at https://www.michigan.gov/documents/mdch/MFCAP_Guidance_Document_500546_7.pdf.

PFAS	Deer tissue	Number of samples with detections	Range (minimum to maximum in parts per billion [ppb])
PFDS	Muscle	1/20	<0.25 – 1.72 ppb
	Liver	2/20	<0.25 - 63.3 ppb
	Kidney	1/20	<0.25 – 11.2 ppb
	Fat	1/10	<0.25 – 11.5 ppb
PFHxS	Muscle	1/20	<0.25 – 3.64 ppb
	Liver	1/20	<0.25 – 4.61 ppb
	Kidney	1/20	<0.25 – 11.6 ppb
	Fat	1/10	<0.25 – 25 ppb
PFNA	Muscle	0/20	<0.25 ppb
	Liver	15/20	<0.25 – 5.78 ppb
	Kidney	6/20	<0.25 – 3.32 ppb
	Fat	2/10	<0.25 – 0.75 ppb
PFOA	Muscle	0/20	<0.25 ppb
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/10	<0.25 ppb
PFOS	Muscle	3/20	<0.25 – 547.77 ppb[2]
	Liver	13/20	<0.25 – 6,080 ppb[3]
	Kidney	13/20	<0.25 – 3,540 ppb[4]
	Fat	1/10	<0.25 – 1,930 ppb
PFOSA	Muscle	0/20	<0.25 ppb
	Liver	1/20	<0.25 – 3.05 ppb
	Kidney	1/20	<0.25 – 0.7 ppb
	Fat	1/10	<0.25 – 0.32 ppb

PFAS	Deer tissue	Number of samples with detections	Range (minimum to maximum in parts per billion [ppb])
PFTeA	Muscle	0/20	<0.25 ppb
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/10	<0.25 ppb
PFTriA	Muscle	0/20	<0.25 ppb
	Liver	1/20	<0.25 - 0.7 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/10	<0.25 ppb
PFUnA	Muscle	0/20	<0.25 ppb
	Liver	14/20	<0.25 – 8.08 ppb
	Kidney	1/20	<0.25 – 0.99 ppb
	Fat	1/10	<0.25 – 0.93 ppb

1 = None of the samples had detections of this PFAS.
2 = For the deer with 547.77 ppp PFOS in the muscle sample, a duplicate sample was run and had 484 ppb PFOS.
3 = For the deer with 6,080 ppb PFOS in the liver sample, a duplicate sample was run and had 6279.12 ppb.
4 = For the deer with 3,540 ppb PFOS in the kidney sample, a duplicate sample was run and had 4659.48 ppb PFOS.

PFAS were detected in muscle, liver, kidney and fat samples from multiple deer harvested from the Oscoda area. Liver samples had the most detections for various PFAS (15 out of 20 deer), followed by kidney (13 out of 20 deer), and muscle (three out of 20 deer) samples. PFDA, PFDoA, PFDS, PFHxS, PFNA, PFOS, PFOSA, PFTriA, and PFUnA were detected in deer. However, PFOS was the PFAS most often detected in muscle, liver, and kidney samples.

For the few deer with detections of PFOS in the muscle, liver, and kidney samples, PFOS levels were about 11 (deer #13) and 50 (deer #11) times higher in the liver than the muscle. The kidney PFOS levels were about three to six times higher than the muscle samples. The liver PFOS levels were about two (deer #13) or eight (deer #11) times higher than the kidney samples.

PFDS and PFHxS were only detected in muscle from deer #13. Liver PFDS was about 36 times higher than the muscle level and liver PFHxS was about the same as the muscle level. Kidney PFDS was about seven times higher and kidney PFHxS was about three times higher than the muscle sample. Liver PFDS was about six times higher than kidney PFDS, however, liver PFHxS was less than half of the kidney PFHxS

level. See Table 9 for PFAS detections in specific deer. Deer that had detectable PFAS in muscle, organs, or fat (19 out 20) ranged in age from one to nine years old. Two were male and 17 were female. All three deer with detectable PFAS in the muscle were female, either one or three years old. See Figure 2: Target Testing Deer Locations Iosco County. Deer #13 was harvested in the Clark's Marsh area.

Table 9: All detections (in nanograms per gram [ng/g] or parts per billion [ppb]) of PFAS in deer harvested in Iosco County.

Deer number	Age and Sex	Muscle	Liver	Kidney	Fat
Deer 2	3 year old female	No PFAS were detected[1]	PFDA 0.42 ppb PFUnA 0.6 ppb	PFOS 0.46 ppb	No PFAS were detected
Deer 3	5 year old male	No PFAS were detected	PFNA 0.55 ppb PFUnA 0.42 ppb	No PFAS were detected	No PFAS were detected
Deer 4	4 year old male	No PFAS were detected	PFNA 0.29 ppb PFOS 2.38 ppb	No PFAS were detected	No PFAS were detected
Deer 5	6 year old female	No PFAS were detected	PFDA 0.77 ppb PFDS 0.6 ppb PFOS 27.5 ppb PFUnA 0.56 ppb	PFOS 3.19 ppb	No PFAS were detected
Deer 6	11 year old female	No PFAS were detected	PFDA 2.15 ppb PFNA 5.78 ppb PFOS 14 ppb PFUnA 1.03 ppb	PFDA 0.3 ppb PFNA 1.38 ppb PFOS 0.93 ppb	PFNA 0.29 ppb
Deer 7	2 year old female	No PFAS were detected	PFDA 0.54 ppb PFNA 1.21 ppb PFOS 4.83 ppb PFUnA 0.57 ppb	No PFAS were detected	No PFAS were detected
Deer 8	4 year old female	No PFAS were detected	PFDA 1.18 ppb PFNA 4.64 ppb PFOS 7.33 ppb PFUnA 0.66 ppb	PFNA 0.35 ppb	No PFAS were detected
Deer 9	4 year old female	No PFAS were detected	PFDA 0.79 ppb PFNA 1.75 ppb PFOS 5.12 ppb PFUnA 0.47 ppb	PFNA 0.33 ppb PFOS 0.45 ppb	No PFAS were detected
Deer 10	2 year old female	No PFAS were detected	PFNA 0.33 ppb PFOS 5.64 ppb PFUnA 0.56 ppb	PFOS 0.58 ppb	No PFAS were detected
Deer 11	3 year old female	PFOS 1.1 ppb	PFDA 0.59 ppb PFNA 0.76 ppb PFOS 54.9 ppb	PFOS 6.53 ppb	No PFAS were detected
Deer 12	3 year old female	No PFAS were detected	PFNA 0.34 ppb PFOS 39.2 ppb PFUnA 0.36 ppb	PFOS 2.16 ppb	No PFAS were detected

Deer number	Age and Sex	Muscle	Liver	Kidney	Fat
Deer 13	1 year old female	PFDS 1.72 ppb (duplicate 1.67 ppb) PFHxS 3.64 ppb (duplicate 3.03 ppb) PFOS 547.77 ppb (duplicate 484 ppb)	PFDA 4.92 ppb PFDoA 4.31 ppb PFDS 63.3 ppb PFHxS 4.61 ppb PFNA 1.88 ppb PFOS 6080 ppb PFOSA 3.05 ppb PFTriA 0.7 ppb PFUnA 8.08 ppb	PFDA 2.06 ppb PFDoA 0.45 ppb PFDS 11.2 ppb PFHxS 11.6 ppb PFNA 3.32 ppb PFOS 3540 ppb PFOSA 0.7 ppb PFUnA 0.99 ppb	PFDA 0.7 ppb PFDoA 0.5 ppb PFDS 11.5 ppb PFHxS 25 ppb PFNA 0.75 ppb PFOS 1930 ppb PFOSA 0.32 ppb PFUnA 0.93 ppb
Deer 14	1 year old female	No PFAS were detected	PFNA 0.26 ppb PFUnA 0.31 ppb	No PFAS were detected	No PFAS were detected
Deer 15	1 year old female	PFOS 0.47 ppb	PFNA 0.48 ppb PFUnA 0.32 ppb	PFOS 1.23 ppb	No PFAS were detected
Deer 16	9 year old female	No PFAS were detected	PFNA 0.72 ppb PFOS 2.89 ppb	No PFAS were detected	No PFAS were detected
Deer 17	7 year old female	No PFAS were detected	PFOS 5.57 ppb	PFOS 0.67 ppb	No PFAS were detected
Deer 18	1 year old female	No PFAS were detected	PFUnA 0.27 ppb	PFOS 0.58 ppb	No PFAS were detected
Deer 19	2 year old female	No PFAS were detected	PFDA 0.5 ppb PFNA 1.01 ppb	PFNA 0.5 ppb PFOS 0.77 ppb	No PFAS were detected
Deer 20	2 year old female	No PFAS were detected	PFDA 0.48 ppb PFNA 0.86 ppb PFOS 3.21 ppb PFUnA 0.68 ppb	PFNA 0.25 ppb PFOS 0.31 ppb	No PFAS were detected
1 = The detection limit all PFAS analyzed for in deer tissue was 0.25 ppb.					

The PFAS that were detected in deer (PFDA, PFDoA, PFDS, PFHxS, PFNA, PFOS, PFOSA, PFTriA, and PFUnA) were similar, but not identical, to the PFAS detected in Oscoda area fish.

The PFAS detected in filets from fish collected from area water bodies are listed below.[6] See Table 10 for the detections listed below.

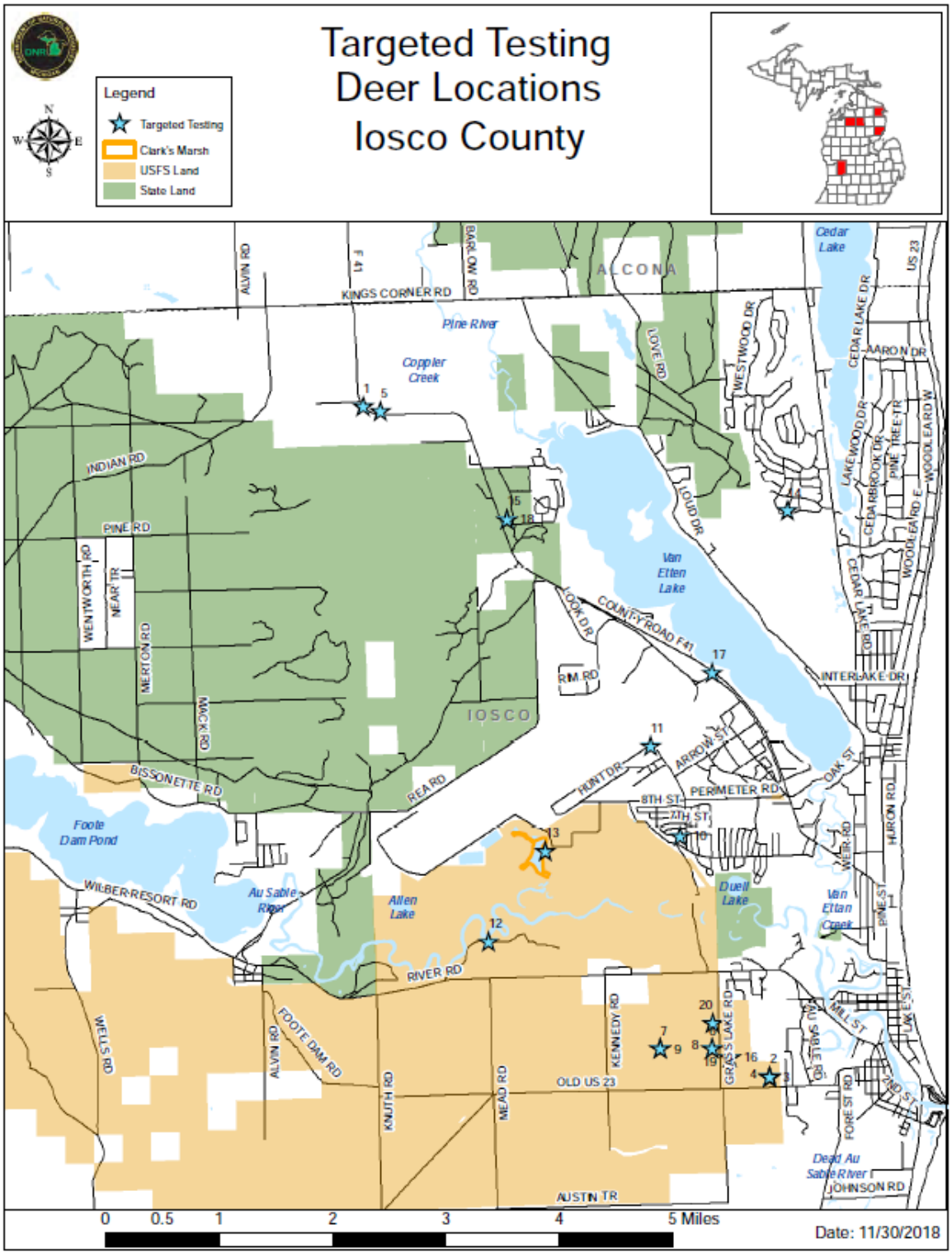
- PFDA, PFDoA, PFOS, PFTriA, and PFUnA were detected in Allen Lake fish
- PFDS, PFDA, PFDoA, PFHxS, PFNA, PFOSA, PFOS, PFOA, PFTeA, PFTriA, and PFUnA were detected in Au Sable River fish
- PFHxS, PFNA, PFOSA, PFOS, PFOA, PFTeA, PFTriA, and PFUnA were detected in Clark's Marsh fish
- PFDA, PFHxS, PFOS, PFOA, PFTeA, PFTriA, and PFUnA were detected in Van Etten Lake fish

Table 10: Detections of PFAS in Iosco County/Oscoda area deer and fish.

PFAS	Iosco County/Oscoda area deer	Allen Lake fish	Au Sable River fish	Clark's Marsh fish	Van Etten Lake fish
PFDA	X[1]	X	X		X
PFDoA	X	X	X		
PFDS	X		X		
PFHxS	X		X	X	X
PFNA	X		X	X	
PFOS	X	X	X	X	X
PFOA			X	X	X
PFOSA	X			X	
PFTeA			X	X	X
PFTriA	X	X	X	X	X
PFUnA	X	X	X	X	X
1 = The "X" indicates that the individual PFAS was detected. Blank spaces indicate that the individual PFAS was not detected.					

[6] The PFAS fish data is from the MDEQ's Fish Contaminant Monitoring Program.

Figure 2: Target Testing Deer Locations Iosco County. Deer #13 was harvested in the Clark's Marsh area.



Kent County deer

Twenty deer were harvested in Kent County, from the Rockford area near the end of August 2018. Two deer were male, both one year old. Eighteen deer were female, ranging from one to seven years old. No PFAS were detected in the muscle samples (See Table 11). Only PFOS was detected in the liver (in 3 samples) and kidney (in 11 samples) samples.

Table 11: PFAS levels in muscle, liver, and kidney samples (in nanograms per gram [ng/g] or parts per billion [ppb]) from deer harvested in Kent County.

PFAS	Deer tissue	Number of samples with detections	Range (minimum to maximum)
PFDA	Muscle	0/20	<0.25 ppb[1]
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb
PFDoA	Muscle	0/20	<0.25 ppb
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb
PFDS	Muscle	0/20	<0.25 ppb
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb
PFHxS	Muscle	0/20	<0.25 ppb
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb
PFNA	Muscle	0/20	<0.25 ppb
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb

PFAS	Deer tissue	Number of samples with detections	Range (minimum to maximum)
PFOA	Muscle	0/20	<0.25 ppb
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb
PFOS	Muscle	0/20	<0.25 ppb
	Liver	3/20	<0.25 – 4.52 ppb
	Kidney	11/20	<0.25 – 0.68 ppb
	Fat	0/20	<0.25 ppb
PFOSA	Muscle	0/20	<0.25 ppb
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb
PFTeA	Muscle	0/20	<0.25 ppb
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb
PFTriA	Muscle	0/20	<0.25 ppb
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb
PFUnA	Muscle	0/20	<0.25 ppb
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb
1 = None of the samples had detections of this PFAS.			

A greater number of kidney samples had detectable PFOS than liver samples. Table 12 presents all of the PFAS detection by deer number. See Figure 3: Target Testing Deer Locations Kent County.

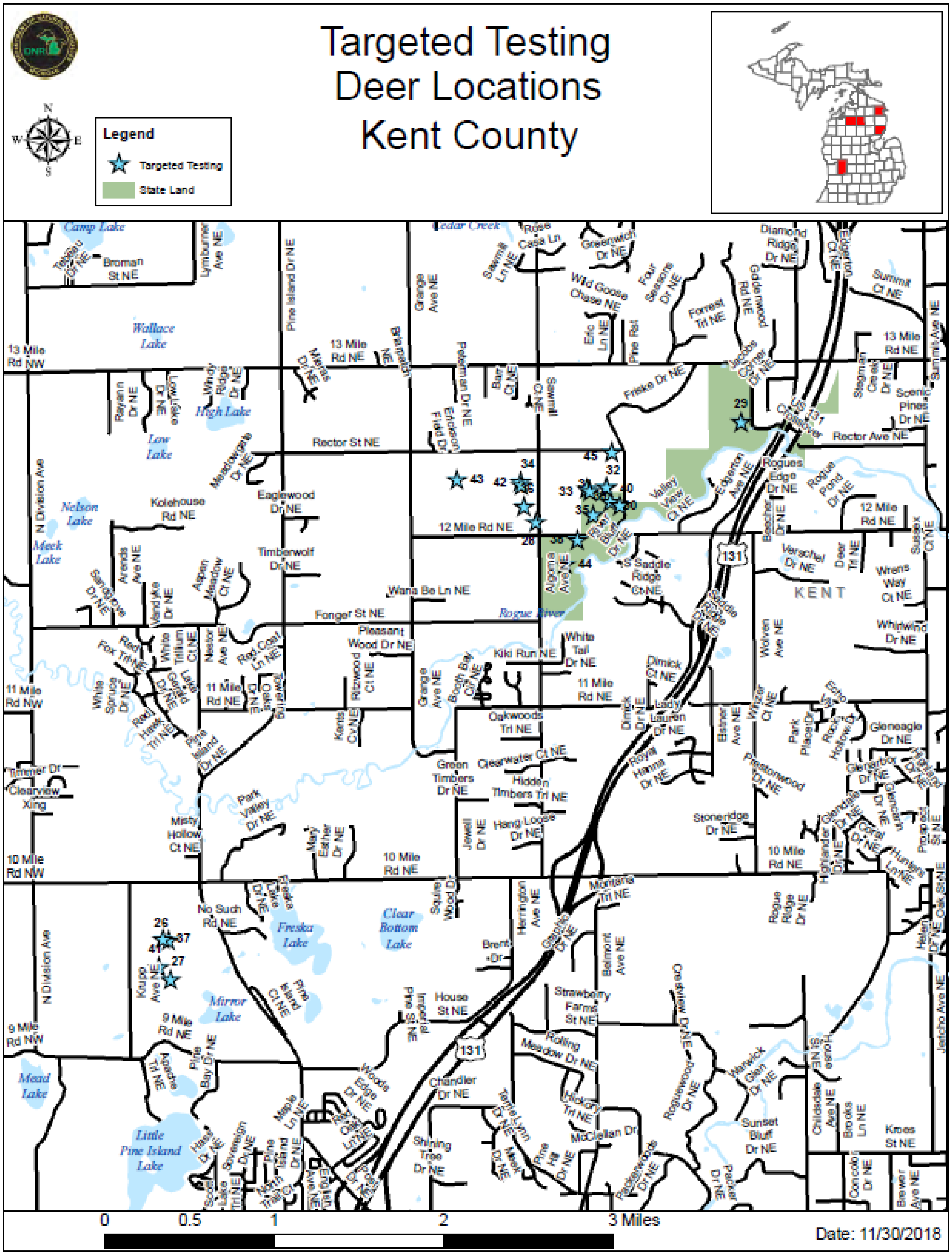
Table 12: All detections of PFAS in deer harvested in Kent County.

Deer number	Age and Sex	Muscle	Liver	Kidney	Fat
Deer 29	2 year old female	No PFAS were detected[1]	No PFAS were detected	PFOS 0.68 ppb	No PFAS were detected
Deer 31	1 year old female	No PFAS were detected	No PFAS were detected	PFOS 0.47 ppb	No PFAS were detected
Deer 32	7 year old female	No PFAS were detected	No PFAS were detected	PFOS 0.5 ppb	No PFAS were detected
Deer 33	3 year old female	No PFAS were detected	No PFAS were detected	PFOS 0.34 ppb	No PFAS were detected
Deer 35	2 year old female	No PFAS were detected	PFOS 4.52 ppb	PFOS 0.53 ppb	No PFAS were detected
Deer 38	3 year old female	No PFAS were detected	PFOS 3.73 ppb	PFOS 0.41 ppb	No PFAS were detected
Deer 39	1 year old male	No PFAS were detected	No PFAS were detected	PFOS 0.47 ppb	No PFAS were detected
Deer 42	2 year old female	No PFAS were detected	No PFAS were detected	PFOS 0.39 ppb	No PFAS were detected
Deer 43	3 year old female	No PFAS were detected	PFOS 4.25 ppb	PFOS 0.36 ppb	No PFAS were detected
Deer 44	1 year old female	No PFAS were detected	No PFAS were detected	PFOS 0.5 ppb	No PFAS were detected
Deer 45	4 year old female	No PFAS were detected	No PFAS were detected	PFOS 0.38 ppb	No PFAS were detected
1 = The detection limit all PFAS analyzed for in deer tissue was 0.25 ppb.					

Only PFOS was detected in the Rockford area deer. A greater number of PFAS were detected in filets from Rogue River/Rockford Dam Pond fish. Fish collected from that water body had detectable levels of PFDS, PFDA, PFDoA, PFNA, PFOSA, PFOS, PFOA, PFTeA, PFTriA, and PFUnA.[7]

[7] The PFAS fish data is from the MDEQ's Fish Contaminant Monitoring Program.

Figure 3: Target Testing Deer Locations Kent County.



Crawford and Kalkaska Counties deer

Twenty deer were harvested in Crawford and Kalkaska Counties from the Grayling area near the end of July 2018. Seven deer were male, ranging from one to two years old. Thirteen deer were female, ranging from one to eight years old. The only PFAS detected was PFOS in liver samples from four deer (See Table 13). The PFOS detections in the liver samples were 1.65 ppb (deer #51, eight year old female), 0.67 ppb (deer #58, four year old female), 0.87 ppb (deer #67, one year old male), and 1.21 ppb (deer #68, two year old male). See Figure 4: Target Testing Deer Locations Crawford/Kalkaska County.

Table 13: PFAS levels in muscle, liver, and kidney samples (in nanograms per gram [ng/g] or parts per billion [ppb]) from deer harvested in Crawford and Kalkaska Counties.

PFAS	Deer tissue	Number of samples with detections	Range (minimum to maximum)
PFDA	Muscle	0/20	<0.25 ppb[1]
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb
PFDoA	Muscle	0/20	<0.25 ppb
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb
PFDS	Muscle	0/20	<0.25 ppb
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb
PFHxS	Muscle	0/20	<0.25 ppb
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb

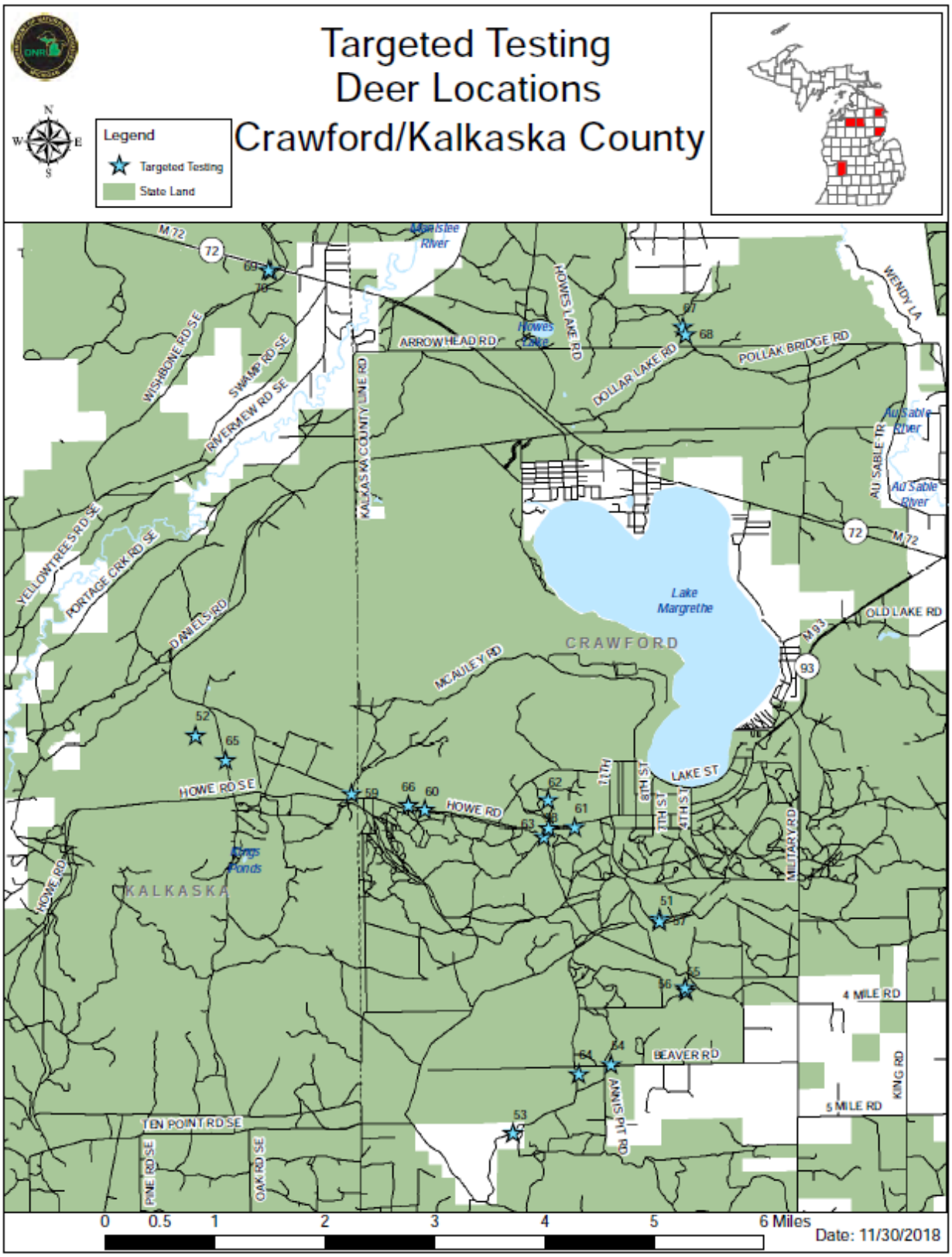
PFAS	Deer tissue	Number of samples with detections	Range (minimum to maximum)
PFNA	Muscle	0/20	<0.25 ppb
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb
PFOA	Muscle	0/20	<0.25 ppb
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb
PFOS	Muscle	0/20	<0.25 ppb
	Liver	4/20	<0.25 – 1.65 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb
PFOSA	Muscle	0/20	<0.25 ppb
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb
PFTeA	Muscle	0/20	<0.25 ppb
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb
PFTriA	Muscle	0/20	<0.25 ppb
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb

PFAS	Deer tissue	Number of samples with detections	Range (minimum to maximum)
PFUnA	Muscle	0/20	<0.25 ppb
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb
1 = None of the samples had detections of this PFAS.			

Only PFOS was detected in deer harvested from the Grayling area. Filets from Lake Margrethe fish had PFOS detections and also detectable PFUnA.[8]

[8] The PFAS fish data is from the MDEQ's Fish Contaminant Monitoring Program.

Figure 4: Target Testing Deer Locations Crawford/Kalkaska County.



Alpena County deer

Twenty deer were harvested from Alpena County, around Lake Winyah, near the end of August 2018. Two deer were male (both one year olds). Eighteen deer were female, ranging from one to eight years old (for one the age was unknown). No PFAS were detected in the muscle samples (See Table 14). Liver and kidney samples had detected levels of PFHxS (in 5 liver and 6 kidney samples), PFNA (1 liver sample), and PFOS (in 3 liver and 6 kidney samples).

Table 14: PFAS levels in muscle, liver, and kidney samples (in nanograms per gram [ng/g] or parts per billion [ppb]) from deer harvested in Alpena County.

PFAS	Deer tissue	Number of samples with detections	Range (minimum to maximum)
PFDA	Muscle	0/20	<0.25 ppb[1]
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb
PFDoA	Muscle	0/20	<0.25 ppb
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb
PFDS	Muscle	0/20	<0.25 ppb
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb
PFHxS	Muscle	0/20	<0.25 ppb
	Liver	5/20	<0.25 – 3.3 ppb
	Kidney	6/20	<0.25 ppb – 3.07 ppb
	Fat	2/20	<0.25 – 1.51 ppb

PFAS	Deer tissue	Number of samples with detections	Range (minimum to maximum)
PFNA	Muscle	0/20	<0.25 ppb
	Liver	1/20	<0.25 – 0.31 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb
PFOA	Muscle	0/20	<0.25 ppb
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb
PFOS	Muscle	0/20	<0.25 ppb
	Liver	3/20	<0.25 – 14.3 ppb
	Kidney	6/20	<0.25 – 1.35 ppb
	Fat	3/20	<0.25 – 0.33 ppb
PFOSA	Muscle	0/20	<0.25 ppb
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb
PFTeA	Muscle	0/20	<0.25 ppb
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb
PFTriA	Muscle	0/20	<0.25 ppb
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb

PFAS	Deer tissue	Number of samples with detections	Range (minimum to maximum)
PFUnA	Muscle	0/20	<0.25 ppb
	Liver	0/20	<0.25 ppb
	Kidney	0/20	<0.25 ppb
	Fat	0/20	<0.25 ppb
1 = None of the samples had detections of this PFAS.			

Of the two organs tested, a greater number of kidney samples had PFAS detections than liver samples from the Alpena area deer. Table 15 presents all of the PFAS detections by deer number. See Figure 5: Target Testing Deer Locations Alpena County.

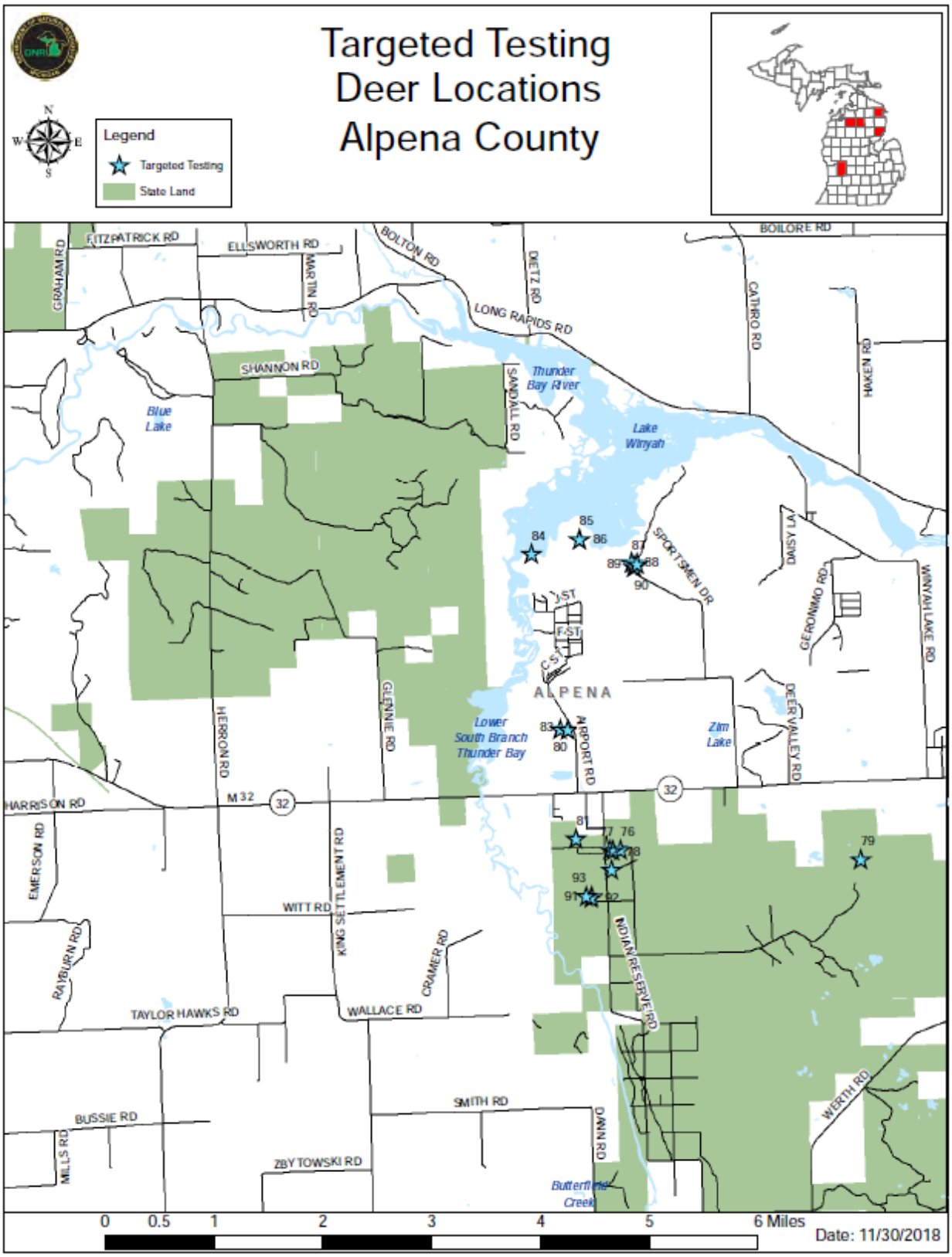
Table 15: All detections of PFAS in deer harvested in Alpena County

Deer number	Age and Sex	Muscle	Liver	Kidney	Fat
Deer 80	6 year old female	No PFAS were detected[1]	PFNA 0.31 ppb	No PFAS were detected	No PFAS were detected
Deer 82	2 year old female	No PFAS were detected	PFOS 4.83 ppb	PFOS 0.67 ppb	PFOS 0.33 ppb
Deer 84	8 year old female	No PFAS were detected	No PFAS were detected	PFOS 0.8 ppb	No PFAS were detected
Deer 87	3 year old female	No PFAS were detected	PFHxS 1.52 ppb	PFHxS 0.7 ppb PFOS 0.36 ppb	No PFAS were detected
Deer 88	3 year old female	No PFAS were detected	PFHXS 0.58 ppb	PFHxS 0.35 ppb	No PFAS were detected
Deer 89	1 year old female	No PFAS were detected	No PFAS were detected	PFHxS 0.41 ppb	No PFAS were detected
Deer 90	unknown age female	No PFAS were detected	PFHxS 0.36 ppb	PFHxS 0.47 ppb PFOS 0.79 ppb	No PFAS were detected
Deer 94	1 year old female	No PFAS were detected	PFHxS 1.02 ppb PFOS 6.85 ppb	PFHxS 0.73 ppb PFOS 0.66 ppb	PFHxS 0.75 ppb PFOS 0.29 ppb
Deer 95	1 year old female	No PFAS were detected	PFHxS 3.3 ppb PFOS 14.3 ppb	PFHxS 3.07 ppb PFOS 1.35 ppb	PFHxS 1.51 ppb PFOS 0.3 ppb
1 = The detection limit all PFAS analyzed for in deer tissue was 0.25 ppb.					

A greater number of PFAS were detected in filets from Alpena area fish than in area deer. PFHxS, PFNA, and PFOS were the only PFAS detected in the deer. Thunder Bay River (Lake Besser) fish had detectable PFDA, PFDoA, PFOSA, PFOS, PFOA, PFTeA. PFTriA, and PFUnA.[9]

[9] The PFAS fish data is from the MDEQ's Fish Contaminant Monitoring Program.

Figure 5: Target Testing Deer Locations Alpena County.



Accumulation of PFAS in organs

From the deer head tissue samples harvested from 39 counties throughout Michigan, only one liver sample was available for analysis. That liver sample had only one PFAS detected, PFOS, at a level higher that the muscle samples. The same pattern was seen with the deer harvested from the four areas with PFAS contamination. In many samples, the only PFAS detections were in the organs. In the few cases where there was also detectable PFAS in the muscle sample, organ samples had higher levels. Liver PFOS levels ranged from about 11 to 50 times higher than the muscle PFOS levels. Kidney PFOS levels ranged from about three to six times higher than the muscle PFOS samples.

While no published studies in white-tailed deer were identified, this trend of higher PFAS levels in organs than muscle is consistent with published information in caribou, cattle, sheep, and wild boar.

Müller et al. (2011) investigated biomagnification of eleven perfluorinated compounds, including perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS), in a terrestrial food chain composed of lichen, caribou, and wolf in remote areas of the Canadian Arctic (no known local sources of PFAS were present). Only the caribou results are described here. Samples were collected from two herds of caribou. One was the Porcupine herd (seven muscle samples, 10 liver samples, and 10 kidney samples) in the Northern Yukon and the other was the Bathurst herd (nine muscle samples and seven liver samples) in the Northwest Territories/Nunavut. Kidney samples were only collected from the Porcupine herd. The average (± the standard error) muscle PFOA level was 0.022 ± 0.008 nanograms per gram wet weight (ng/g ww; parts per billion) from the Porcupine herd samples and 0.024 ± 0.006 ng/g ww from the Bathurst herd samples. The average liver PFOA level was less than 0.5 ng/g ww from the Porcupine herd samples and 0.11 ± 0.01 ng/g ww from the Bathurst samples. The average Bathurst herd liver PFOA level was about five times higher than the average muscle PFOA levels. The average kidney PFOA level was less than 0.01 ng/g ww. The average muscle PFOS level was 0.028 ± 0.023 ng/g ww from the Porcupine herd samples and 0.076 ± 0.019 ng/g ww from the Bathurst herd samples. The average liver PFOS level was 0.67 ± 0.13 ng/g ww from the Porcupine herd samples and 2.2 ± 0.3 ng/g ww from the Bathurst herd samples. The average Porcupine herd liver PFOS level was about 24 times higher than the average muscle PFOS levels. The average Bathurst herd liver PFOS level was about 28 times higher than the average muscle PFOS levels. The average kidney PFOS was 0.020 ± 0.003 ng/g ww. Average PFOA levels were about one percent of the total perfluorinated compounds in the liver (Bathurst herd only) and were five to nine percent in the muscles. Average PFOS levels were about 10 to 18 percent of the total perfluorinated compounds in the liver and were 11 to 14 percent in the muscles. Average PFNA, PFDA, and PFUnA levels accounted for about 72 to 89 percent of the total perfluorinated compounds measured in the liver and were about 66 to 67 percent in the muscles.

Beef muscle (n=176) and liver (n=117) samples were randomly purchased from local supermarkets, retail stores, farmers markets or farms in 22 cities in the Xinjiang territory in northwest China and analyzed for several perfluoroalkyl substances (Wang et al. 2017). A greater number of PFAS were detected in liver (12 PFAS) samples compared to muscle samples (four PFAS) and a greater number of liver samples had detectable PFAS. Ninety-four percent of liver samples had detectable PFAS while only 47% of muscle samples had detectable PFAS. The four PFAS detected in muscle samples were PFHpA, PFOA, PFOS, and PFUdA. Mean levels of these four PFAS ranged from 14 to 92 times higher in the liver

than the mean levels in the muscle samples. Mean PFOS levels were 77 times higher in the liver than the muscle samples.

Lupton et al. (2015) gave beef cattle (three steers and four heifers) a single oral dose of PFOS in a gelatin capsule containing ground corn and PFOS each (steers were given a low-dose, heifers were given a high dose and two were humanely slaughtered at 114 days, and the steers and other two heifers at 343 days). One PFOS dosed steer became part of the control group, as the authors noted it "ejected" its PFOS dose. Control steers had low levels of PFOS contamination, possibly due to ingestion of or dermal contact with urine or fecal materials from dosed animals (they shared the same pasture and pen). The authors noted that liver concentrations were significantly different than all other tissues (kidney, back fat intraperitoneal fat, skin, shoulder, tenderloin, ribeye, rump, and bone) in the steers and heifers (343 day). The liver samples in the steers and heifers were four or more times higher than fat and muscle samples. The kidney samples were two or more times higher than fat and muscle samples.

Kowalczyk et al. (2012) used three dairy sheep to investigate the transfer of PFOA and PFOS to meat and milk. One sheep was fed PFOA and PFOS contaminated feed for 21 days and uncontaminated feed for 21 days, a second sheep was fed contaminated feed for 21 days, and the third sheep (control) was fed uncontaminated feed for 42 days. PFOA was not detectable in the plasma, liver, kidney, and muscle tissue of the two sheep slaughtered on day 42 (the sheep fed contaminated feed for 21 days followed by 21 days uncontaminated feed or the sheep fed uncontaminated feed for 42 days). PFOA was not detected in the control sheep, but low levels of PFOS were detected in the plasma, liver, and kidney (PFOS was not detected in the muscle tissue). For the sheep slaughtered after 21 days of PFOA and PFOS contaminated feed, PFOA levels were highest in the plasma, followed by the kidney, liver, and muscle tissue. PFOS levels were highest in the liver, followed by the kidney, plasma, and muscle tissue. PFOA levels were 11 times higher in the liver compared to the muscle tissue. PFOS levels were 33 times higher in the liver than in the muscle tissue. For the sheep fed contaminated feed for 21 days, then uncontaminated feed for 21 days, no PFOA was detected in the plasma, kidney, liver, and muscle tissue. PFOS levels were the highest in the liver, then plasma and kidney (the two samples were similar to each other, and lowest in the muscle tissue. The liver had 36 times the muscle tissue PFOS level.

Stahl et al. (2011) tested 529 livers and 506 muscle samples from wild boar for PFOS and PFOA in Hesse, Germany. No specific PFAS contamination sites were listed in the paper. Nearly all of the boar were less than two years old. The average PFOA liver level was 4.02 micrograms per kilogram (µg/kg or parts per billion), with a range of less than 5 µg/kg to 45 µg/kg. The average PFOA muscle tissue levels were less than 1 µg/kg (the limit of quantification for muscle tissue), with a range of less than 1 µg/kg to 7.4 µg/kg. The average PFOA liver level was approximately four times higher than the average muscle tissue PFOA level. The average PFOS liver level 117 µg/kg, with a range of less than 5 µg/kg to 1780 µg/kg. The average PFOS muscle tissue level was 1.38 µg/kg, with a range of less than 1 µg/kg to 28.6 µg/kg. The average PFOS liver level was approximately 85 times higher than the average muscle tissue PFOS level.

Considerations of the available data

While the samples collected from deer heads submitted for disease testing were based on voluntary submission during fall of 2017 from areas with bTB or CWD surveillance, there are some additional considerations when considering the information for any conclusions. The muscle tissue from the deer heads were from deer harvested in the fall 2017. The targeted collection was carried out during the spring and summer 2018. The deer harvested during these two times may have had very different consumption of food and water. Deer in the fall are fatter and have had a high intake level of both food and water during the summer. While the implications are unknown, seasonality may effect the amount of PFAS that may be present in samples and should be considered for future sampling.

Additionally, there is a difference in the actual ages of the deer, based on the time during the year that they were aged. For example, a deer is identified as one year old, it may actually be 12 to 23 months old depending on the month that the deer is aged. A one year old deer aged in August is about 14 months old while a deer aged as one year old in April will actually be about 22 months old. This also extends to deer identified as older than one year old, the actual age will depend on the month that the deer is aged. Factoring in actual age of the deer will be important when assessing potential consumption and bioaccumulation of PFAS in deer.

Differences may also be present in female deer harvested in the early spring versus the later spring or summer as deer nursing fawns may lose some of their PFAS due to lactational transfer. PFAS levels in does could potentially be higher prior to lactational PFAS transfer to the fawn.

There are also considerations of the selection of the deer harvest areas. An attempt was made to target sites with known or potential PFAS in the surface water at the time of the sample collection planning for sampling deer that would have likely to have been exposed. Given that there is a lack of information on how deer may be exposed to PFAS, deer may be directly (by drinking) or indirectly (by eating vegetation growing in water with PFAS) exposed to PFAS-contaminated water.

All of these issues will need to be considered as future sampling or determination of PFAS contamination in deer is considered.

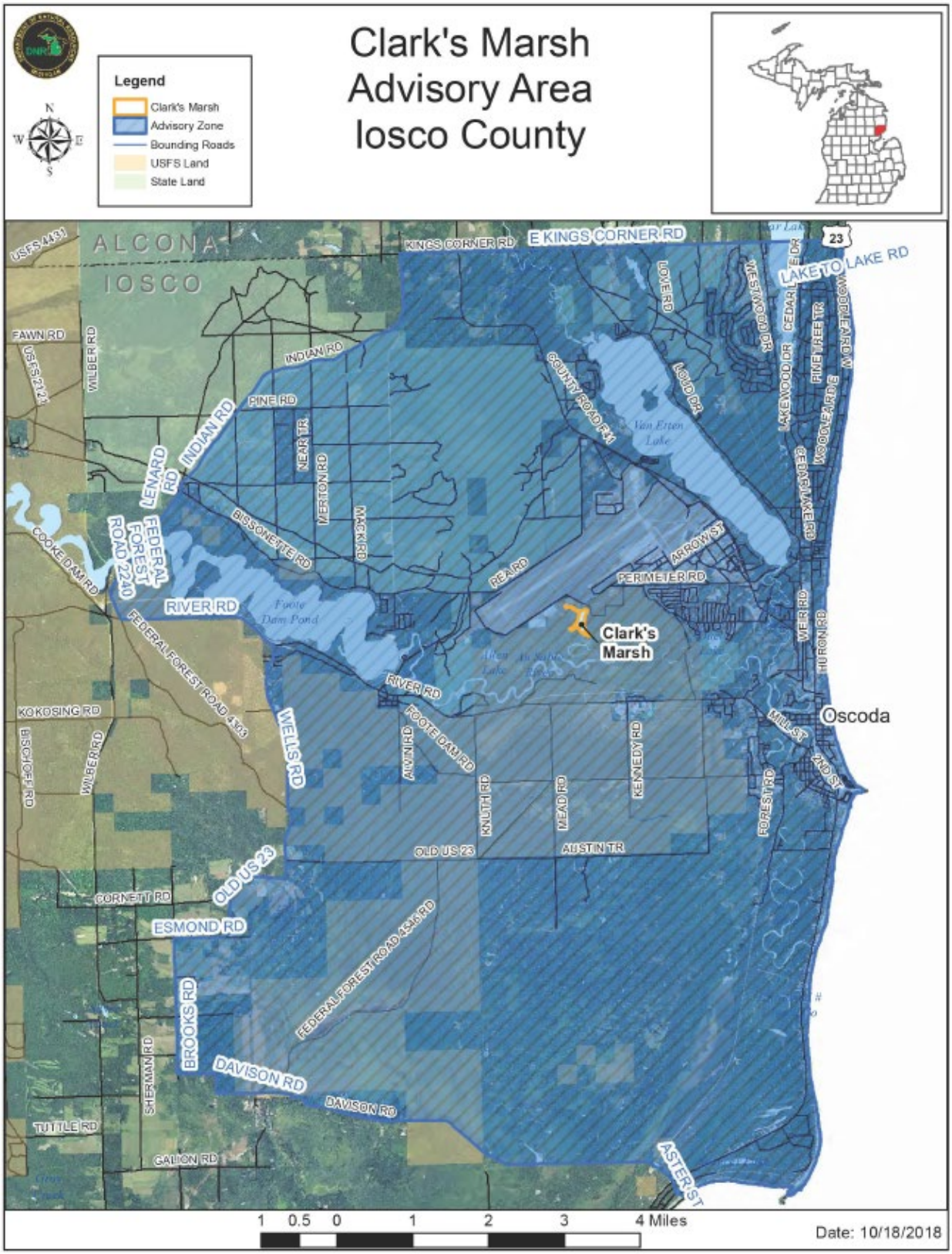
Conclusions

- White-tailed deer in Michigan are exposed to PFAS, however, information on routes of deer exposure to PFAS and duration of exposure is not available at this time.
- Most of the deer included in this dataset do not appear to have PFAS exposures that will lead to elevated, or even detectable levels in muscle tissue.
- MDHHS and MDNR issued a ‘Do Not Eat’ advisory for deer taken within five miles of Clark’s Marsh in Oscoda Township due to one deer having very high PFOS levels in the muscle, liver, and kidney.
    - The area covered by the deer consumption advisory issued can be described as: From Lake Huron west along Aster Street, west on Davison Road, north on Brooks Road, east on Esmond Road, north on Old US 23, north on Wells Road, west on River Road, north on Federal Forest Road 2240, north on Lenard Road, north on Indian Road, and East on

E. Kings Corner Road (along the county line) toward Lake to Lake Road, to Lake Huron. (See Figure 6: Clark's Marsh Advisory Area Iosco County.)

- Deer organs (liver and kidney) have higher levels of PFAS than muscle tissue. These levels may vary based on the amount of PFAS exposure each deer had and how each deer processes PFAS.
- Fish filets tend to have a greater number of PFAS detected than deer samples collected from the same areas. This may be due to fish living in PFAS-containing water, differences in PFAS processing, or a combination of factors.

Figure 6: Clark's Marsh Advisory Area Iosco County.



Recommendations

MDHHS and MDNR has already issued a 'Do Not Eat' advisory for deer taken within five miles of Clark's Marsh in Oscoda Township. The advisory is due to high levels of PFAS found in deer taken within five miles of the Marsh.

MDHHS will continue to work with MDNR on evaluating PFAS in deer and other wild game.

MDHHS continues to recommend not eating organs, including kidneys or liver, from any deer because many chemicals, including PFAS, can accumulate in their organs.[10]

Public Health Action Plan

MDHHS will continue to work with MDNR on outreach and communication materials for hunters and other interested stakeholders.

MDHHS and MDNR will continue to discuss available information on PFAS contamination at locations around Michigan to determine if additional deer samples are needed.

MDHHS will continue to partner with MDNR to evaluate the potential for other wild game sampling, including waterfowl.

MDHHS will continue to assist MDNR in evaluation of PFAS exposure in deer and other wild game.

References

AECOM. 2018. FINAL Preliminary Assessment Report Camp Grayling, Michigan. August 2018. Contract Number: W912DR-12-D-0014. Delivery Order: W912DR17F0192. U.S. Army Corps of Engineers Baltimore District for the Army National Guard Headquarters.

ASL. (Aerostar SES LLC) 2018. Final Site Inspection Report of Aqueous Film Forming Foam Areas at Alpena Combat Readiness Training Center Alpena County, Michigan. March 2018. Contract No. W9128F-15-D-0051, Deliver Order No. 0003. U.S. Army Corps of Engineers Omaha District for the Air Force Civil Engineer Center.

Lupton SJ, Dearfield KL, et al. (2015). "Perfluorooctane Sulfonate Plasma Half-Life Determination and Long-Term Tissue Distribution in Beef Cattle (Bos taurus)." J Agric Food Chem 63(51): 10988-10994.

[10] The MDHHS recommendation to not eat organs can be found in multiple Eat Safe Fish outreach materials, including the Eat Safe Fish in Michigan brochure (https://www.michigan.gov/documents/family_fish_166020_7.pdf), Lead Bullets & Venison fact sheet (https://www.michigan.gov/documents/mdch/Lead_in_Venison_for_Families_310195_7.pdf), Eat Safe Wild Game from the Saginaw Bay Area brochure (https://www.michigan.gov/documents/mdch/Eat_Safe_Wild_Game_277942_7.pdf), and in the Eat Safe Wild Game Do not eat wild game organs flyer (https://www.michigan.gov/documents/mdhhs/2018-11-13_WG_Organs_web_638623_7.pdf).

Kowalczyk J, Ehlers S, Furst, P, et al. 2012. Transfer of perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) from contaminated feed into milk and meat of sheep: pilot study. Arch Environ Contam Toxicol 63(2): 288-298.

Michigan Department of Community Health. (MDCH) 2015. Michigan Department of Community Health Final Report USEPA-Great Lakes Restoration Initiative Project. May 28, 2015. https://www.michigan.gov/documents/mdch/MDCH_GL-00E01122-0_Final_Report_493494_7.pdf.

Michigan Department of Health and Human Services. (MDHHS) 2017. Health Consultation. Perfluorooctane Sulfonate (PFOS) in Fish. Former Wurtsmith Air Force Base Oscoda, Iosco County, Michigan EPA Facility ID: MI5570024278. February 14, 2017. https://www.michigan.gov/documents/mdhhs/WAFB_Fish_HC__Final__2-14-2017_552188_7.pdf.

Michigan Department of Environmental Quality. (MDEQ) 2018. Water Resources Division – surface water data, Personal communication.

Michigan Department of Environmental Quality. (MDEQ) 2014. Water Resources Division Surface Water Assessment Section Policy and Procedure: Subject: Fish Contaminant Monitoring Program – Fish Collection Procedures. May 22, 2014. https://www.michigan.gov/documents/deq/wrd-swas-proc31_445628_7.pdf.

Muller CE, De Silva AO, Small J, et al. 2011. Biomagnification of perfluorinated compounds in a remote terrestrial food chain: Lichen-Caribou-wolf. Environ Sci Technol 45(20):8665-8673.

O'Brien DJ, Fitzgerald SD, Lyon TJ, et al. 2001. Tuberculous lesions in free-ranging white-tailed deer in Michigan. J Wildl Dis. 37(3):608-13.

O'Brien DJ, Schmitt SM, Fierke JS, et al. 2002. Epidemiology of Mycobacterium bovis in free-ranging white-tailed deer, Michigan, USA, 1995–2000. Prev Vet Med. 54(1):47-63.

Severinghous, CW 1949. Tooth development and wear as criteria of age in white-tailed deer. J Wildl Manage 13:195–216.

Stahl T, Falk S, Failing K, et al. 2012. Perfluorooctanoic acid and perfluorooctane sulfonate in liver and muscle tissue from wild boar in Hesse, Germany. Arch Environ Contam Toxicol 62(4):696-703.

Wang G, Lu J, Xing Z, et al. 2017. Occurrence, Distribution, and Risk Assessment of Perfluoroalkyl Acids (PFAAs) in Muscle and Liver of Cattle in Xinjiang, China. Int J Environ Res Public Health 14(9):970-985.

Appendix A: Location information for the 2017 disease surveillance deer heads

Lab No	County	Town	Range	Section	Testor Background	TB Status	CWD Status
387658	Alcona	28N	05E	16	BG	Neg	Negative
350275	Alpena	31N	07E	25	Test	Neg	Not_Tested
543066	Alpena	31N	07E	2	Test	Neg	Not_Tested
343672	Arenac	20N	05E	17	BG	Neg	Not_Tested
391845	Bay	18N	03E	24	BG	Neg	Negative
578531	Benzie	26N	15W	3	BG	Neg	Negative
379537	Calhoun	01S	06W	24	BG	Neg	Negative
573044	Charlevoix	32N	05W	27	BG	Neg	Negative
530140	Cheboygan	33N	02W	35	BG	Neg	Not_Tested
368953	Clare	18N	05W	32	BG	Neg	Negative
577046	Clinton	05N	04W	5	BG	Neg	Negative
520280	Dickinson	43N	28W	20	BG	Neg	Negative
523712	Eaton	03N	03W	2	BG	Neg	Negative
391846	Genesee	08N	08E	14	BG	Neg	Negative
401862	Grand_Traverse	26N	11W	36	BG	Neg	Negative
519636	Ingham	04N	02W	26	Unclear	Neg	Negative
519638	Ingham	04N	02W	26	Unclear	Neg	Negative
519639	Ingham	04N	02W	26	Unclear	Neg	Negative
519640	Ingham	04N	02W	26	Unclear	Neg	Negative
519641	Ingham	04N	02W	26	Unclear	Neg	Negative
519751	Ingham	04N	02W	26	BG	Neg	Negative
582601	Ingham	04N	02W	26	Unclear	Neg	Negative
582602	Ingham	04N	02W	26	Unclear	Neg	Negative
582641[A]	Ingham	04N	02W	26	Unclear	Neg	Negative
519594	Ionia	06N	05W	31	BG	Neg	Negative
386891	Iosco	21N	06E	15	BG	Neg	Negative
387043	Isabella	14N	04W	3	BG	Neg	Negative
192024	Kalkaska	25N	05W	26	BG	Neg	Negative
576839	Kent	10N	09W	17	BG	Neg	Negative
520436	Lake	17N	11W	10	BG	Neg	Negative
522116	Livingston	04N	03E	3	BG	Neg	Negative
520286	Mason	20N	16W	29	BG	Neg	Negative
576315	Mecosta	14N	09W	17	BG	Neg	Negative
386982	Midland	15N	02E	28	BG	Neg	Negative
522654	Montcalm	11N	06W	10	BG	Neg	Negative
365771	Montmorency	30N	03E	7	BG	Neg	Not_Tested
520431	Newaygo	16N	11W	5	BG	Neg	Negative

Lab No	County	Town	Range	Section	Testor Background	TB Status	CWD Status
387657	Oakland	04N	10E	24	BG	Neg	Negative
540506	Ogemaw	22N	03E	26	BG	Neg	Not_Tested
579493	Osceola	19N	07W	12	BG	Neg	Negative
387031	Oscoda	27N	01E	4	BG	Neg	Negative
523743	Otsego	32N	02W	15	BG	Neg	Negative
543459	Presque_Isle	34N	05E	30	BG	Neg	Not_Tested
391844	Roscommon	24N	03W	12	BG	Neg	Negative
563325	Shiawassee	05N	01E	22	BG	Neg	Negative
367923	St._Joseph	07S	09W	1	BG	Neg	Negative
387048	Tuscola	13N	10E	29	BG	Neg	Negative
523708	Washtenaw	04S	05E	21	BG	Neg	Negative
A = A muscle and liver sample were analyzed for PFAS from this deer.							

Report Update – December 8, 2025

Location	Change
Cover page	Year corrected to 2019
Summary, page 2	Added statement to acknowledge the 2025 update to the PFOS fish consumption screening values
Table 9	Deer 5 – Liver PFOS PFOS value corrected to 27.5 ppb
Table 9	Removed semicolons after reported PFAS levels
Table 9	Updated to “No PFAS were detected”
Table 9	Removed comma from value with more than 4 digits (deer 13- fat PFOS of 1930)
Table 15	Removed period after Kidney PFOS level for deer 95