Friends of Merrymeeting Bay

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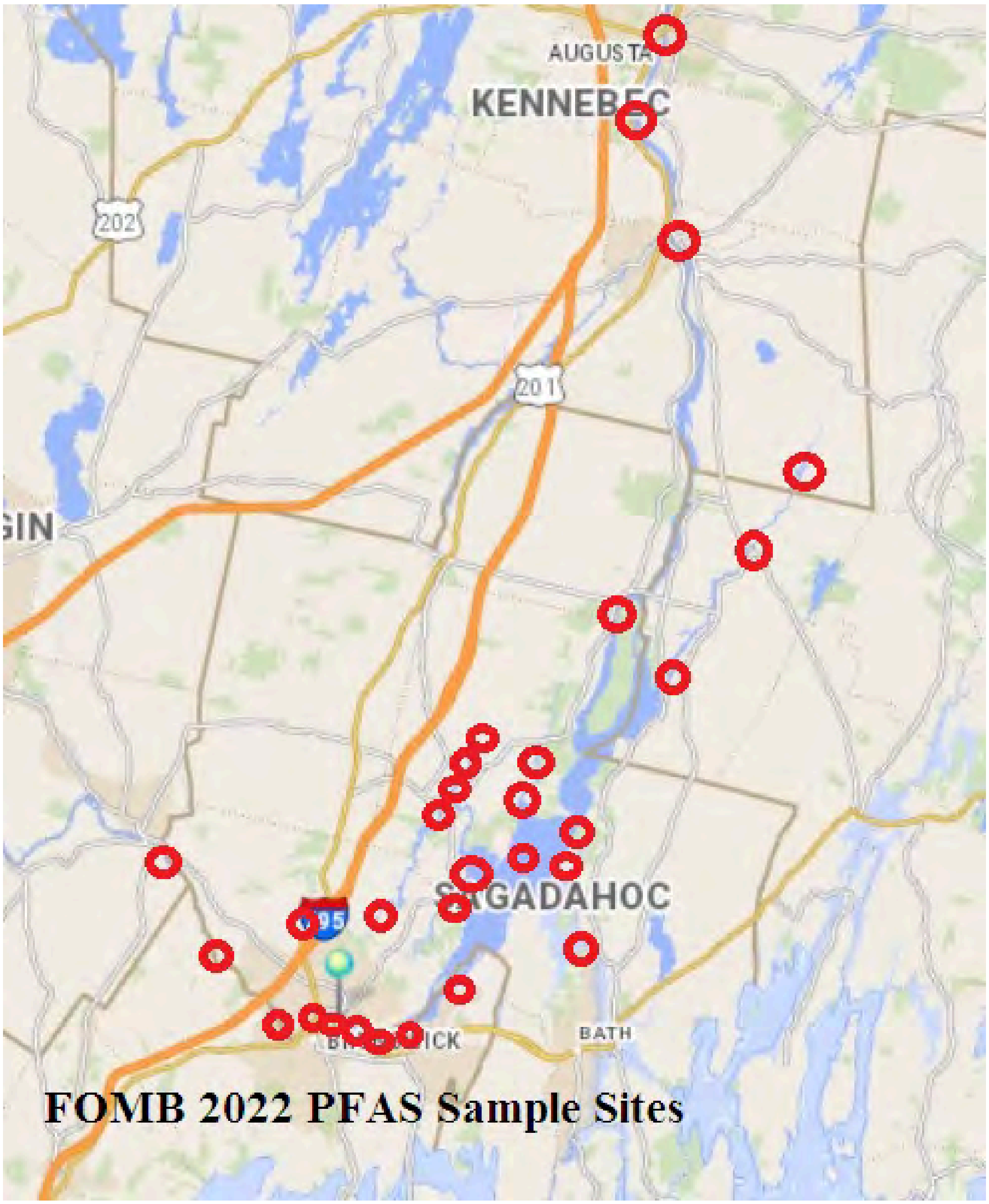
A Spatial Probe for PFAS Chemicals in the Surface Waters of Merrymeeting Bay and its Tributaries



10/24/22

A Spatial Probe for PFAS Chemicals in the Surface Waters of Merrymeeting Bay and its Tributaries

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Abstract

Merrymeeting Bay and its six main tributaries drain just under 40% of Maine and part of NH. The Bay is freshwater tidal riverine and geologically, an inland delta. Many species of wildlife use the Bay. It is the only waterbody in Maine to provide spawning and nursery habitat to all diadromous fish found in the Gulf of Maine including the endangered Atlantic salmon, is the largest staging ground north of Chesapeake Bay for migratory waterfowl and the second hottest spot in the state after Cobscook Bay on the Canadian border for bald eagle recovery. All of these species and more are susceptible to environmental contaminants as are hunters and fisherman in particular.

In the summer of 2022, Friends of Merrymeeting Bay (FOMB) conducted the first widespread surface water sampling for PFAS in the lower Merrymeeting Bay watershed. PFAS were found in 27 of 30 samples sites and 19 PFAS compounds were represented of a possible 55 analyzed for. The study area ranged from Lisbon Falls on the Androscoggin River to the Bay and from Augusta on the Kennebcc River down to Thorne Head between Woolwich and North Bath. The other 4 main tributaries were also covered as was the West Branch of the Cathance River.

Highest levels of PFAS contamination found were from 3 creeks draining the north end of the former Brunswick Naval Air Station (BNAS). Detected PFAS compounds are consistent with inputs from past and current firefighting foam use and storage. BNAS is a known CERCLA or "Superfund" site, now being managed by the Midcoast Regional Redevelopment Authority (MRRA), a State of Maine entity. Cyclopure PFAS water test kits were used measure the levels of PFAS compounds in surface water samples throughout the area. These relatively inexpensive and reliable water test kits from Cyclopure have proven very suitable for PFAS screening purposes. Limitations to surface water sampling are discussed.

Introduction

In the summer/fall of 2021, Friends of Merrymeeting Bay (FOMB) in cooperation with the Military Poisons and the Women's International League for Peace and Freedom (WILPF) conducted some initial and very limited area sampling for PFAS chemicals (Elder, 2022). PFAS are widely used, long lasting per-and polyfluoroalkyl synthetic organofluorine chemical compounds that have multiple fluorine atoms attached to an alkyl chain. These are often referred to as "forever chemicals" because of their persistence in the environment. They break down very slowly over time and many of them have been linked to harmful health effects in humans and animals (ATSDR, 2021). There are thousands of PFAS chemicals, and they are found in many different consumer, commercial, and industrial products. Because of their widespread use and their persistence in the environment, many PFAS compounds are found in the blood of people (Environmental Working Group & Commonweal, 2011) and animals all over the world and are present at low levels in a variety of food products and in the environment. The Maine Monitor has featured an excellent series on PFAS in Maine, Invisible and Indestructible by Marina Schauffler including articles on agricultural/municipal PFAS vectors into soil, PFAS in waterways and wildlife, assessing impacts from firefighting foam, and Brunswick Naval Air

Station as a plume source, Due to their prevalence (Waterkeeper Alliance, 2022), PFAS chemicals might also be termed “everywhere” chemicals. In October, 2022, Cyclopure also provided a thorough report on the nationwide Waterkeeper Alliance “upwatershed/down-watershed” sampling project using Cyclopure test kits. FOMB 2021 sampling also used relatively inexpensive water test kits from Cyclopure and results compared favorably with past results at the same locations from the Maine Department of Environmental Protection (DEP) and the Navy.

Following our findings of elevated PFAS levels on the northern part of the former Brunswick Naval Air Station (BNAS) and the Brunswick Sewage District (BSD) discharge into the Androscoggin River, our Research & Advocacy Committee recommended a Bay-wide screening for PFAS using the affordable Cyclopure water test kits if we could formally validate them in a side-by-side comparison with certified labs using split samples all coming from the same source.

On April 22, 2022, the Brunswick Sewage District hosted and assisted FOMB in gathering split samples of sewage effluent to be sent to each lab. A stainless steel bucket was lowered into the large BSD tank of agitating combined effluent from all Brunswick pumping stations. Split samples from this bucket went to Cyclopure and certified labs Alpha Analytical, Eurofins (the leader in PFAS testing), and Battelle (a lab often used by the military, industry and universities). Replicate samples were included for Cyclopure and Alpha Analytical. Field blanks were captured for all lab samples. Results were telling-with Cyclopure, Alpha Analytical and Eurofins all being similar in number of compounds (9-14) and concentrations found. Battelle on the other hand only detected one compound. Since this study (Friedman, 2022) validated Cyclopure testing, FOMB purchased 30 test kits with which the current study was conducted.

Figure 1: Split sampling for FOMB lab validation project at Brunswick Sewage District

Photos: Martha Spiess and Jason Prout

Materials & Methods-

We sampled from Augusta to Thorne Head on the Kennebec, Pejepscot Boat Launch in Lisbon Falls to the Bay on the Androscoggin, from Rte. 201 to the Bay on the Cathance, head of tide to the mouths of the Abbagadassett and Eastern Rivers and at the Foreside Rd. bridge and mouth on the Muddy River. Most of our sampling sites were in tidewater. To better define where possible

PFAS contamination might be coming from, samples were gathered at the tail end of the ebb tide. In this way we knew any contamination was likely coming from upstream of the sample site. Sites were chosen both for geographic representation and because of possible contamination factors (wastewater treatment plants, agriculture, industry, known toxic sites, sludge spreading, etc.). Where possible, most sites were accessed from shore or a dock or float.

In order to get further from shore, a heavily weighted (3.25 lbs.) 48 oz. throw bottle on a 23' line was used to gather a sample which was then poured into the Cyclopure test cup to drain. The throw bottle was made of PETE plastic and had been used in the FOMB water monitoring program for approximately twelve years in gathering bacteria samples. Before using this we checked with Cyclopure scientists to be sure the bottle would not contaminate the samples. At each site the bottle was rinsed three times in ambient water before making the toss and very rapid retrieve.

Cyclopure water test kits contain a filter made from corn-based material they have developed called DEXSORB® that filters out PFAS chemicals from water. Water in the test cup is allowed to filter through and then empty cup with filter are returned to Cyclopure for PFAS analysis. Most relatively clear water samples take about 10-15 minutes to drain through the filter. In order to immediately drive to the next site or more often continue by boat to the next site for those sites accessed that way, the Cyclopure test kit was put in a wooden holder over a basin allowing the water to drain while we proceeded onward.

Figure 2: Cyclopure water test kit, drain board and throw bottle.

Photos: Ed Friedman

To access deep-water sites inaccessible by land, an aluminum skiff with 4-stroke outboard was used. These sites were the Eastern River Mouth (ERM), Abbagadasset Point (ABK), Abbagadassett River Mouth (ARM), Cathance-Muddy River Mouth (CMRM), The Chops (CHP) and Thorne Head (KTH). For West Branch of the Cathance (WB) sites, a 20' Grand Laker Canoe with small kicker outboard was used. In all boat collections, the boat was headed into the current, and the Cyclopure test kit dipped directly over the side into the water from a position towards the bow. GPS coordinates; time and a photo or two were taken at each site. As soon as a sample was drained through the kit cup the cup was re-packed in the Cyclopure kit box.

Throughout this report, PFAS water concentrations are reported in parts-per-trillion (ppt, ng/L). Different studies, present data in different concentrations units. MEDEP and the Navy customarily report as parts per billion (ppb, ug/L), where 1000 ppt – 1 ppb. In comparing data from different sources, it is important to ensure that the units are the same.

Figure 3: Deepwater sampling from skiff.

Photos: Dave Mention

Results

See Appendix 1 for results in PDF form or [FOMB Bay PFAS Survey Results Excel-9-16-22.xlsx] in Excel.

Two of the several PFAS compounds EPA has set drinking water health advisories on are PFOA (.004 ppt) and PFOS (.02 ppt). The creeks draining the former BNAS are discussed further below but PFAS chemicals were found at some levels throughout the study area. Average levels of these two prominent chemicals by river segment are shown in the following table:

Table 1. Average PFOA and PFOS concentrations (parts per trillion, ppt, ng/L) per river in relation to EPA health advisories for drinking water

Compound	**River**	**Avg. in ppt**	**Excess of EPA advisory**
PFOA	Abbagadassett	1.73	433X
EPA limit:	Eastern	1.33	333X
.004 ppt	Muddy	2.2	379X
	W. Branch Cat.	1.8	450X
	Cathance	2.5	613X
	Kennebec	.6	150X
	Androscoggin	5.3	1,325X
	Andro w/o BNAS	1.78	445X
PFOS	Abbagadasset	1.4	70X
EPA limit:	Eastern	1.2	60X
.02 ppt	Muddy	1.2	60X
	W. Branch Cathance	2.36	118X
	Cathance	2.05	103X
	Kennebec	6.7	335X
	Androscoggin	26	1,300X
	Andro w/o BNAS	3	150X

Nineteen PFAS compounds were detected in the study area. The breakdown by river was:

Androscoggin-19
Cathance-9
Abbagadasset-6
Kennebec-5
West Branch of the Cathance-4
Muddy-4
Eastern-4

Certain compounds (part of a larger set detected at these sites) are unique to BNAS and the Brunswick Sewage District:

PFBA
PFPeA
PFHpA
PFBS
PFOS
5:3 FTCA
6:2 FTS
FHxSA

And others unique only to BNAS:

4:2 FTS
PFPeS
PFHpS
FBSA

Figure 4: BSD and BNAS W discharge points to the Androscoggin River

Photo: Point of View Helicopter Services

Discussion

The study and certainly regulation and testing of PFAS chemicals is a relatively new effort. Currently the EPA has established some, but not many standard analytical methods for testing - potable water testing (Methods 537 & 533) for only 24 of the chemicals, methods for non-potable water (Method 8327-24 analytes) and has draft methods for a number of others (1633-for analytes in wastewater, soil, leachate, etc.).

EPA's lifetime health advisories identify levels to protect all people, including sensitive populations and life stages, from adverse health effects resulting from exposure throughout their lives to these PFAS in drinking water. The health advisory levels were calculated to offer a margin of protection against adverse health effects. EPA's lifetime health advisories also take into account other potential sources of exposure to these PFAS beyond drinking water (for example, food, air, consumer products, etc.), which provides an additional layer of protection.

EPA's lifetime health advisory levels, measured in parts per trillion (ppt), are meant to offer protection for people from adverse health effects resulting from exposure throughout their lives to these individual PFAS in drinking water:

- Interim updated health advisory for PFOA = 0.004 ppt
- Interim updated health advisory for PFOS = 0.02 ppt
- Final health advisory for GenX chemicals = 10 ppt
- Final health advisory for PFBS = 2,000 ppt

The Environmental Working Group/ Commonweal Human Toxome Project looked at contaminant concentrations in humans. They list some details on a number of more common PFAS chemicals:

PFBA (Perfluorobutyric acid),
PFBS (Perfluorobutane sulfonate),
PFDA (Perfluorodecanoic acid),
PFDoA (Perfluorododecanoic acid),
PFHpA (Perfluoroheptanoic acid),
PFHxA (Perfluorohexanoic acid),
PFHxS (Perfluorohexanesulfonate),
PFNA (Perfluorononanoic acid),
PFOA (Perfluorooctanoic acid),
PFOS (Perfluorooctanesulfonate),
PFOSA (Perfluorooctanesulfonic acid),
PFPeA (Perfluoro-n-pentanoic acid),
PFTA (Perfluorotetradecanoic acid),
PFUnA (Perfluoroundecanoic acid)

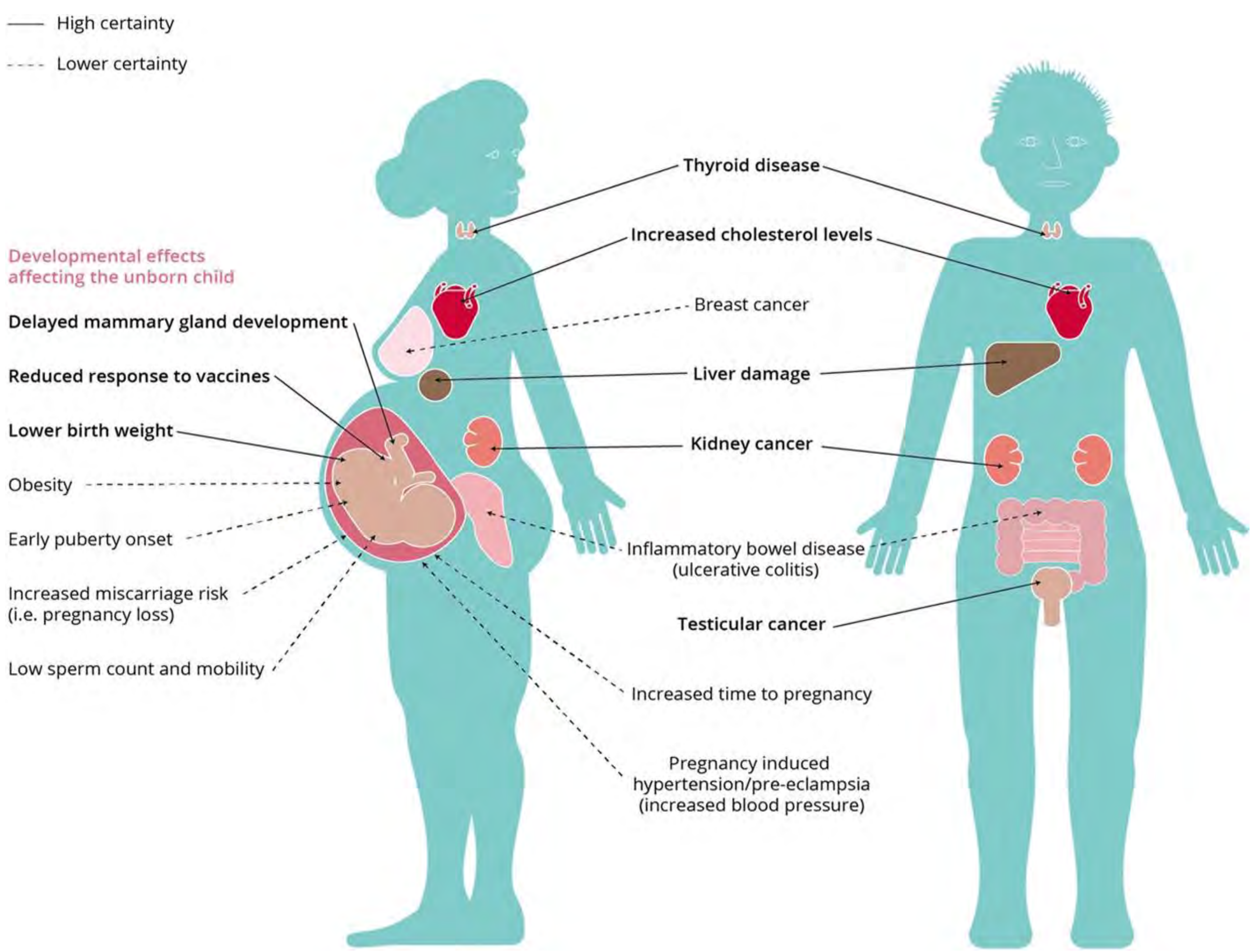
In Maine, with the passage of S.P. 64 (Resolve, To Protect Consumers of Public Drinking Water by Establishing Maximum Contaminant Levels for Certain Substances and Contaminants), the legislature has mandated that Public Water Systems that are either community water systems (C) or non-transient, non-community (NTNC) schools and child care facilities sample their finished drinking water for PFAS. An interim standard of 20 parts per trillion (ppt) for six PFAS (alone or in combination) is immediately in effect. The six regulated PFAS are: perfluorooctanoic acid

(**PFOA**), perfluorooctane sulfonic acid (**PFOS**), perfluorohexane sulfonic acid (**PFHxS**), perfluorononanoic acid (**PFNA**), perfluoroheptanoic acid (**PFHpA**) and perfluorodecanoic acid (**PFDA**).

According to the U.S. Agency for Toxic Substances and Disease Registry, some, but not all, studies in people who have higher PFOS or PFOA levels in the blood have shown that these chemicals may:
• increase the risk of kidney and testicular cancer;
• increase cholesterol levels;
• increase the risk of high blood pressure or pre-eclampsia in pregnant women;
• lower infant birth weights; however, the decrease in birth weight is small and may not affect the infant's health;
• decrease how well the body responds to vaccinations;
• cause changes in liver enzyme levels.

Following a longstanding pattern, European countries generally take a more precautionary approach when it comes to protecting human health from chemicals:

Figure 5: European Environmental Agency, Effects of PFAs on Human Health

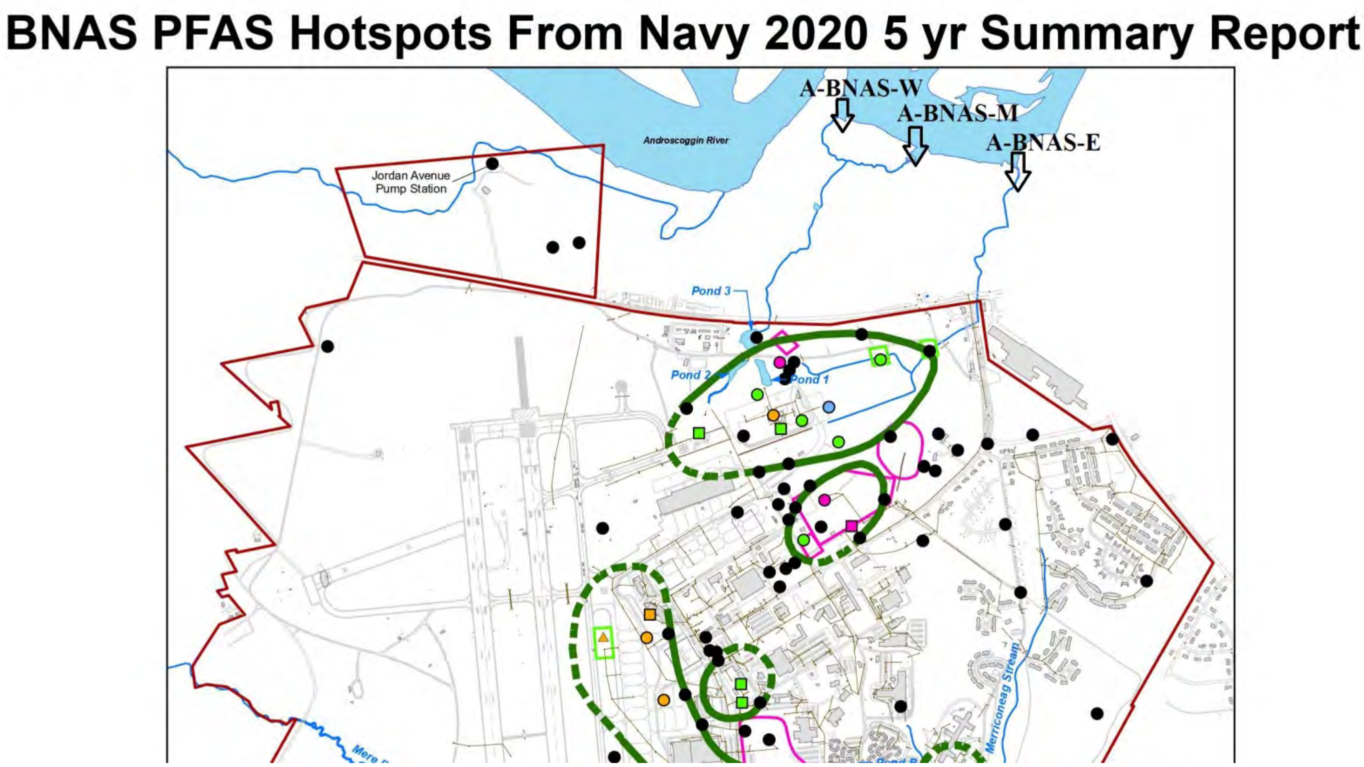


Of the 30 sites sampled by FOMB, only three did not show evidence of at least one PFAS compound. These were Hallowell (HLK), Abbagadasset Point (ABK) and Kennebec Thorne Head (KTH). All of these were deep water sites so as discussed under "Limitations" this is not surprising. The highest levels of contamination found in our survey were, in descending order to

20 ppt: the three sites downstream of former BNAS: BNAS-W (922 ppt), BNAS-M (147 ppt), BNAS-E (125 ppt); the BSD outfall pipe (56 ppt); Gardiner (GRK) 52 ppt and just above head tide of the Cathance River (CHT) 20.3 ppt. Table 1 shows that even small PFAS concentrations should be of concern.

In 2021, finding high PFAS levels in BNAS Pond 3 indicative of aqueous fire-fighting foam (AFFF) contamination, we wondered what levels of PFAS if any were actually making it to the Androscoggin River via three creeks draining the north end of the former Naval Air Station, a known CERCLA (Superfund) site? One creek drained directly from Pond 3 and then split into two (BNAS-W and BNAS-M) and one drained a more amorphous area coming into the Androscoggin east of the others (BNAS-E). In our Bay-wide survey we included these creek mouths as well as resampling the BSD outfall. Elevated PFAS levels indicate these contaminants are indeed running off from BNAS directly to the river as well as probably indirectly through the Sewage District.

Figure 6: North BNAS PFAS hotspots showing Pond 3 and BNAS W, M & E sample sites



Extraordinarily high PFAS levels point to the westerly creek (BNAS-W) as the primary contaminant conduit from the former base to the river. One might theorize that PFAS levels would decrease with distance from the source but this was not necessarily the case. Note in the following table only the top four compounds with highest concentrations of parts per trillion (ppt) at the creek mouth are listed specifically. This is not to say other compounds found at lower concentrations are not problematic. For instance levels of PFOA at BNAS-W were 22 ppt, 5,500 times higher than the EPA health advisory level of .004 ppt. In the table below it can be seen that PFOS levels at the outlet stream of Pond 3 are 18,150 times the EPA health advisory level of .02

ppt and downstream at the creek mouth going into the Androscoggin are still 6,300 times higher health advisory level.

Table 2: PFAS comparisons - Pond 3 outlet hotspot and that creek mouth entering the river

Compound	BNAS Pond 3 Outlet Stream 12/21	BNAS-W. Creek Mouth 8/22
PFHxA	78	106
PEPeA	66	122
PFOS	363	126
6:2 FTS	886	406
Totals (including analytes other than those above)	1661	922

PFOS and PFOA have both been nominated by the EPA for the CERCLA Hazardous Substance list. Both of these chemicals are associated with fire-fighting foam but because of their hydrophobic and oil repellent characteristics these chemicals have also been used in: surface protection products such as carpet and clothing treatments; coatings for paper, cardboard packaging and leather products; industrial surfactants, emulsifiers, wetting agents, additives and coatings; processing aids in the manufacture of fluoropolymers such as nonstick coatings on cookware; membranes for clothing that are both waterproof and breathable; electrical wire casing; fire and chemical resistant tubing; and plumbing thread seal tape (ATSDR 2015). These two chemicals and others were used until 2001 to produce aqueous film-forming foam (AFFF) to effectively suppress and extinguish liquid hydrocarbon fires.

As PFOS was phased-out of its key fire-fighting foam role, it was replaced with 6:2 FTS, the major surfactant in Ansulite, the new foam. By the early 2000's most active military air bases including BNAS, had both older (3M Light Water) and new (Ansulite) foams. (ITRC: https://pfas-1.itrcweb.org/3-firefighting-foams/) At BNAS, PFAS were detected in ribbed mussels from Mere Creek/Harpswell Cove, downstream from the storm water flow from the southern part of the former base (Page, 2020). PFOS is generally the dominant PFAS species in environmental samples from the southern end of the former base draining into Harpswell Cove, while 6:2 FTS dominates northerly base areas draining into the Androscoggin. Compared with perfluorooctane sulfonate (PFOS), 6:2 fluorotelomer sulfonate (6:2 FTS) is supposedly less toxic and environmentally persistent, and is not as bioaccumulative.

Environmental monitoring studies suggest that 6:2 FTS occurs at relatively low levels in most sites, the exception being point sources. Unlike many PFAS, 6:2 FTS can be degraded under certain conditions to short-chain perfluorcarboxlic acids, such as perfluorohexanoic acid and perfluoropentanoic acid. Still, our environmental toxicology history is full chemicals initially thought benign that in the long run proved the opposite.

Relatively strong PFOS and 6:2 FTS signals indicate past and current inputs of legacy fire-fighting foam concentrate, inherited by MRRA from the Navy and stored on the former base, is still the likely source of contamination. This is true at BNAS, as both are present in old plastic AFFF concentrate storage tanks in the hangars. When BNAS was closed, quantities of the PFAS-based foam concentrate were also sent to various state fire departments spreading the contamination problem to various rural parts of the state certainly not prepared to deal with potential toxic spills or leakage.

PFAS chemicals are more or less the new kids on the block. Under the Toxic Substances Control Act (TSCA) of 1976, the EPA lists over 70,000 chemicals. Only in 2014 was the EPA required to select 10 chemicals to undergo risk evaluation. These 10 chemicals were announced on December 19, 2016. The agency has a ways to go. Like technology being far ahead of public policy, the release and use of chemicals into our environment has been ongoing for years without adequate risk analysis. Of the thousands of PFAS chemicals, less than a handful have any sort of regulation.

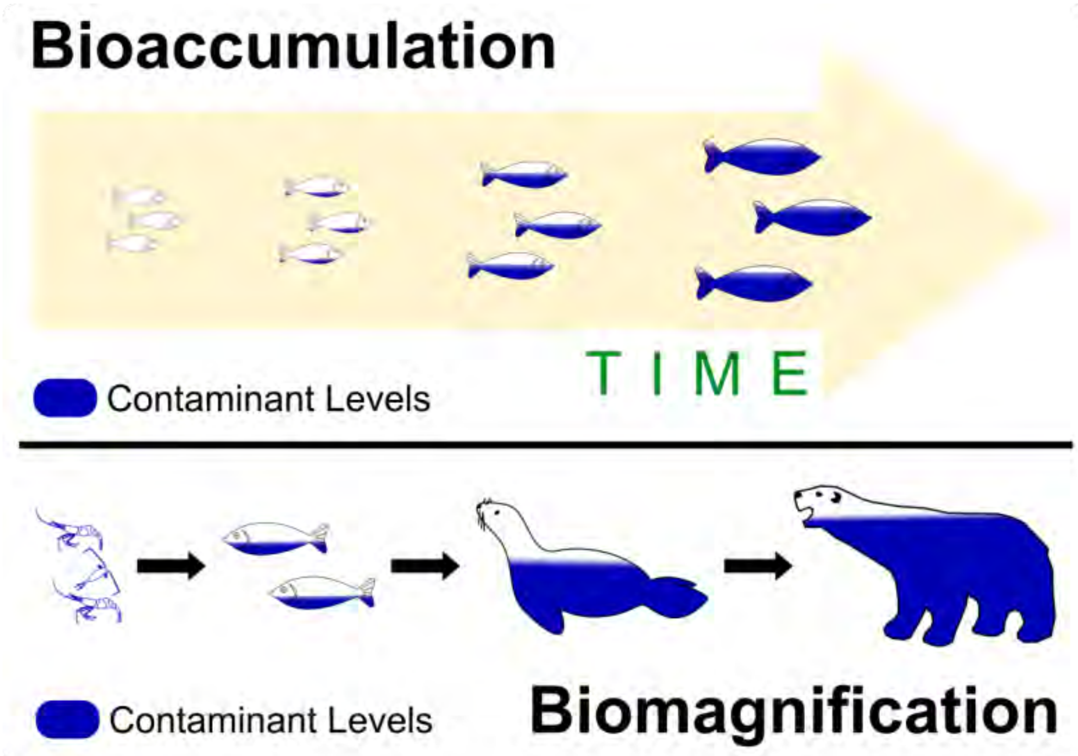
Limitations

Surface water testing for PFAS or for that matter other chemicals found in low concentrations, can be of limited use in large part because of the dilution factor. Of course if we drink that water we do know what we are being exposed to. Isolated and irregular grab sampling can give us some idea of what may be present in the water but results can also be largely hit or miss. In this study we have very reliable results showing high PFAS concentrations in the three tiny creeks draining the former BNAS, but not far downstream at Brunswick Bay Bridge (A-BBB), levels are dramatically lower and some PFAS chemicals found in the BNAS creeks are not even present. In addition, our study rules out PFAS sources in the Androscoggin River upstream from the former BNAS as being responsible for the elevated PFAS levels observed, since all of the upstream PFAS concentrations were far lower.

On the Kennebec River, the Hallowell (K-HLK) site showed no PFAS present but this site is downstream of the Augusta wastewater treatment plant (WWTP) which discharges through a diffuser into the middle of the river. It would be shocking if no PFAS were being discharged from Augusta, a previously discovered major hotspot for PCB contamination. If this was the only sample showing no PFAS one might consider a possible lab error but it was one of several including K-ABK and KTH. K-CHP just above the Chops, was of all sites with PFAS, the only one with just one compound found and this is located between ABK and KTH. All of these and Hallowell are deep water sites. Yet Gardiner (K-GRK) and Richmond Nash Marina (K-RNM) all had PFAs present with Gardiner showing reasonably high levels. Other variables, certainly in “big water” sites include time of year, precipitation/runoff, currents, tides, upwelling and wind.

In contrast to big water or open water sites, sample sites on small streams or shallow bodies of water should yield far more reliable indications of PFAS concentrations. As would sampling directly from a suspected source. The BNAS creek mouths, Rte 201 on the Cathance and head of tide on the Abbagadasset are all good examples. While concentrations in water tell us what is there, they don’t necessarily tell us what is what is actually biologically available, taken up into the food chain, biomagnified and bio-accumulated. If this is the goal than tissue testing is required and here, age of an individual and trophic level on the food chain will give varying results.

Figure 7: Bioaccumulation vs. Biomagnification



In Maine, at the federal level and in other states beginning to investigate PFAS, the focus is on drinking water testing and the EPA health advisory levels can be extremely low as they are for PFOA (.0004 ppt) and PFOS (.02 ppt) and a fairly common PFAS total maximum dose is often recommended to be no more than 20 ppt. And yet testing and advisories for fish and other food is almost entirely lacking and it is here, as a result of bioaccumulation and biomagnification that the problem is most acute.

In the town of Chesapeake Beach, MD not far from a Naval Research Laboratory several fish were sampled by Military Poisons in 2021. A perch had total PFAS levels of 9,470 ppt, a rockfish had levels of 2,450 and an oyster had levels of 1,060 ppt. In FL oysters were sampled at three locations and PFAS concentrations were found to be more function of location rather than oyster size (Lemos, et al. 2022 American oysters as bioindicators of emerging organic contaminants in Florida, United States).

In Maine and Michigan, PFAS-contaminated deer have made the news in 2021 and 2022. In Maine eight deer were sampled, five of which were in close proximity to fields on which sludge had been spread. 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. The 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.

Pat Elder, Director of Military Toxins gave an excellent presentation at the October 12, 2022 Friends of Merrymeeting Bay Winter Speaker Series. The recorded presentation focusses on the disconnect between advisories for drinking water of 20 ppt and levels found in fish for which there generally are no consumption advisories for PFAS. Elder provided the Maine example of a brook trout caught in the vicinity of the former Loring Air Force Base with levels of 1,080,000 ppt, 6.13 million times the EPA advisory level for water ad a great example of bioaccumulation.

PFAS testing remains very expensive, which if nothing else provides an economic disincentive to test. While Cyclopure offers an inexpensive water test suitable for screening (although generally not regulatory purposes because they are not certified for this), no such option exists for tissue testing. State and federal agencies have a long way to go in this area and with virtually every state dependent to some extent on hunting and or fishing whether for commercial catch or for their tourist industries, the economic disincentive for thorough testing may be even more acute than for the average homeowner concerned with state of their tap water. Perhaps non-governmental organizations will need to step in where agencies may fear to tread. Time will tell.

Our surface water screening survey found some levels of PFAS contamination throughout most of the study area. Highest levels were associated with the former Brunswick Naval Air Station, discharging into the Androscoggin River and largely point to inputs from PFAS-containing firefighting foam use and storage on the former base and current Brunswick Landing. Our results paired with earlier findings from Pond 3 on the northern part of the base confirm the Pond 3 hotspot as a prime PFAS contaminant vector to the river.

Commonly referred to as “forever chemicals”, PFAS seem also to be “everywhere chemicals” Cyclopure water test kits are relatively inexpensive at about $80/test vs $400-$700 at certified labs. Previous testing has validated the Cyclopure methodology and these tests can and should be more widely used as screening tools for PFAS. That said, there are many variables and limitations to testing surface waters. Any program must understand these and attempt to minimize them if deciding surface water sampling, as opposed to some sort of tissue testing, is still appropriate and will achieve the desired goals.

Thanks to: Sayuri Alwis, Katie and Frank Cassou, Pat Elder, Chris Gutscher, Yuhan Ling, Dave Mention, David Page, Martha Spiess, Vance Stephenson and Ri Wang

Appendix 1 PFAS Survey Results by River & Site

Appendix 2 PFAS Sample Site Data

Appendix 1-PFAS Results by River & Site

FOMB Merrymeeting Bay PFAS Testing September 2022 - **30 Sites**

Detects Highlighted in Yellow

Format part per trillion (ng/L); LOQ 1.0 ppt all PFAS, except Genx 2.0 ppt

Highest Level Sites in **Bolded Red** (5), Medium Level in **Blue** (1)

KEY							
A - ANDROSCOGGIN		**K-KENNEBEC**		**C-CATHANCE**		**WB-WEST BRANCH OF CATHANCE**	
A-PBL	Falls	**K-ABR**	August Boat Ramp	**C-201**	bridge	**WBD/S**	Denham Stream/Sedgely
A-FPD	Below Pejepscot Dam	**K-HLK**	Hallowell Boat Ramp	**CHT**	Just above head tide falls	**WBSC**	West Branch School Creek
A-BCP	Park?]	**K-GRK**	slips]	**C-BTL**	off end of long float	**WBTB**	Bridges
A-BWS	Water St. Boat Launch	**K-RNM**	Richmond Nash Marina [below Richmond Wastewater Plant]	**CMRM**	Cathance/Muddy River confluence Mouth		
A-BSD	Brunswick Sewer District Outfall	**K-ABK**	Off Abbagadessett Pt.				
A-BNAS-W	Westerly of three creeks draining north side of BNAS	**K-CHP**	Several hundred yards above the Chops in confluences of all rivers				
A-BNAS-M	Middle of three creeks draining north side of BNAS	**KTH**	In middle of narrows of Thorne Head				
A-BNAS-E	Easterly of three creeks draining north side of BNAS						
A-BBB	Brunswick Bay Bridge-end of bridge jetty						
M-MUDDY		**E-EASTERN**		**AB-ABBAGADASSETT**			
MRFR	Muddy River Foreside Rd. Bridge	**EKRD**	Eastern River Kelley Rd. [actually below Kelley Rd. on Old Country Rd. First accessible head of tide on main stem]	**ABHT**	Abby head of tide [below head tide pond to catch drainages from old dump]		
		EDRM	Eastern-Dresden Mills [off bridge]	**AB1L**	Abby 1-lane bridge on Browns Pt. Rd.		
		ERM	Eastern River Mouth just inside end of Training Wall jetty	**ARM**	Abby River Mouth in channel just inside "Sands."		

A - ANDROSCOGGIN									
WTK_ID	WTK_PFAS_1560	WTK_PFAS_1564	WTK_PFAS_1563	WTK_PFAS_1562	WTK_PFAS_1559	WTK_PFAS_1539	WTK_PFAS_1542	WTK_PFAS_1561	WTK_PFAS_1541
Name	FOMB	FOMB	FOMB	FOMB	FOMB	FOMB	FOMB	FOMB	FOMB
Sampling Location	Lisbon Falls - **A-PBL**	Brunswick - **A-FPD**	Brunswick - **A-BCP**	Brunswick - **A-BWS**	Brunswick - **A-BSD**	Brunswick - **A-BNAS-W**	Brunswick - **A-BNAS-M**	Brunswick - **A-BNAS-E**	Brunswick - **A-BBB**
Coordinates	N44°59.440'; W70°02.910'	N43°57.327'; W70°01.449'	N43°54.881'; W69°58.567'	N43°55.343'; W69°57.308'	N43°55.000'; W69°56.658'	N43°54.766'; W69°55.525'	N43°54.680'; W69°55.336'	N43°54.875'; W69°55.070'	N43°56.162'; W69°53.414'
Filtered/Unfiltered	Unfiltered	Unfiltered	Unfiltered	Unfiltered	Unfiltered	Unfiltered	Unfiltered	Unfiltered	Unfiltered
Sampling Date	8/16/2022	8/16/2022	8/16/2022	8/16/2022	8/16/2022	8/16/2022	8/16/2022	8/16/2022	8/16/2022
Order ID	5688	5688	5688	5688	5688	5688	5688	5688	5688
PFBA	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	1.2	10.1	1.8	< 1 ng/L	< 1 ng/L
PFPeA	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	5.5	122.5	17.5	3.6	< 1 ng/L
PFHxA	1	1.1	1.1	1.2	13.6	105.7	19.4	7	1.5
PFHpA	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	1.7	28.1	8.6	5.4	1.8
PFOA	1	< 1 ng/L	1.1	1.2	5.6	22.2	8.1	6.5	1.6
PFNA	< 1 ng/L	< 1 ng/L	< 1 ng/L	1.6	< 1 ng/L	1.5	< 1 ng/L	< 1 ng/L	< 1 ng/L
PFDA	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L
HFPO-DA (GenX)	< 2 ng/L	< 2 ng/L	< 2 ng/L	< 2 ng/L	< 2 ng/L	< 2 ng/L	< 2 ng/L	< 2 ng/L	< 2 ng/L
PFBS	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	1.6	6.7	2.4	9.4	< 1 ng/L
PFHxS	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	4.4	60.3	13.1	29	< 1 ng/L
PFOS	1.7	1.9	2.1	2.7	9.9	126.7	31	57	2.9
Total PFAS (Primary 11)	3.7	3	4.3	6.7	43.5	483.8	101.9	117.9	7.8
Additional PFAS									
5:3 FTCA	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	3	7.5	1.6	< 1 ng/L	< 1 ng/L
4:2 FTS	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	1.2	< 1 ng/L	< 1 ng/L	< 1 ng/L
6:2 FTS	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	5.6	406.3	40.6	< 1 ng/L	1.3
PFPeS	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	8	1.5	5.2	< 1 ng/L
PFHpS	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	3.8	< 1 ng/L	1.9	< 1 ng/L
FBSA	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	6	< 1 ng/L	< 1 ng/L	< 1 ng/L
FHxSA	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	1.1	5.1	< 1 ng/L	< 1 ng/L	< 1 ng/L
N-EtFOSAA	3.9	3.5	3.8	3.6	1.2	< 1 ng/L	1.4	< 1 ng/L	3.1
N-MeFOSAA	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	1.9	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L
Total PFAS (All Detected)	7.6	6.5	8.1	10.3	56.3	921.7	147	125	12.2

K - KENNEBEC

WTK_ID	WTK_PFAS_1537	WTK_PFAS_1547	WTK_PFAS_1536	WTK_PFAS_1535	WTK_PFAS_1543	WTK_PFAS_1544	WTK_PFAS_1549
Name	FOMB	FOMB	FOMB	FOMB	FOMB	FOMB	FOMB
Sampling Location	Augusta, ME **KABR**	Hallowell, ME **KHLK**	Gardiner, ME **KGRK**	Richmond, ME 04357 **KRNM**	Bowdoinham, ME 04008 **KABK**	Bath, ME 04530 **KCHP**	Bath, ME 04530 **KTH**
Coordinates	N44°18.839'; W69°46.315'	N44°16.981'; W69°47.420'	N44°13.754'; W69°46.162'	N44°04.913'; W69°47.967'	N44°00.003'; W69°49.430'	N43°58.925'; W69°49.918'	N43°57.090'; W69°48.990'
Filtered/Unfiltered	Unfiltered	Unfiltered	Unfiltered	Unfiltered	Unfiltered	Unfiltered	Unfiltered
Sampling Date	8/29/2022	8/29/2022	8/29/2022	8/29/2022	9/1/2022	9/1/2022	9/1/2022
Order ID	5688	5688	5688	5688	5688	5688	5688
PFBA	< 1 ng/L	< 1 ng/L	< 1 ng/L	1.1	< 1 ng/L	< 1 ng/L	< 1 ng/L
PFPeA	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L
PFHxA	< 1 ng/L	< 1 ng/L	1.1	1.2	< 1 ng/L	< 1 ng/L	< 1 ng/L
PFHpA	1.5	< 1 ng/L	4.4	5.2	< 1 ng/L	< 1 ng/L	< 1 ng/L
PFOA	< 1 ng/L	< 1 ng/L	2.2	1.9	< 1 ng/L	< 1 ng/L	< 1 ng/L
PFNA	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L
PFDA	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L
HFPO-DA (GenX)	< 2 ng/L	< 2 ng/L	< 2 ng/L	< 2 ng/L	< 2 ng/L	< 2 ng/L	< 2 ng/L
PFBS	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L
PFHxS	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L
PFOS	1.2	< 1 ng/L	44.6	< 1 ng/L	< 1 ng/L	1.2	< 1 ng/L
Total PFAS (Primary 11)	2.7	0	52.3	9.4	0	1.2	0

C - CATHANCE				
WTK_ID	WTK_PFAS_1548	WTK_PFAS_1550	WTK_PFAS_1556	WTK_PFAS_1546
Name	FOMB	FOMB	FOMB	FOMB
Sampling Location	Topsham, ME 04086 **C-201**	Topsham, ME 04086 **CHT**	Bowdoinham, ME 04008 **CBTL**	Bowdoinham, ME 04008 **CMRM**
Coordinates	N43°57.372'; W69°58.109'	N43°57.722'; W69°55.806'	N44°00.475'; W69°53.694'	N43°59.066'; W69°52.834'
Filtered/Unfiltered	Unfiltered	Unfiltered	Unfiltered	Unfiltered
Sampling Date	8/29/2022	8/29/2022	9/2/2022	9/1/2022
Order ID	5688	5688	5688	5688
PFBA	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L
PFPeA	< 1 ng/L	1.3	< 1 ng/L	< 1 ng/L
PFHxA	1.1	3	1.6	1.3
PFHpA	< 1 ng/L	2.6	< 1 ng/L	< 1 ng/L
PFOA	1.3	5.4	1.7	1.4
PFNA	< 1 ng/L	2	< 1 ng/L	< 1 ng/L
PFDA	< 1 ng/L	< 1 ng/L	< 1 ng/L	< 1 ng/L
HFPO-DA (GenX)	< 2 ng/L	< 2 ng/L	< 2 ng/L	< 2 ng/L
PFBS	< 1 ng/L	1.1	< 1 ng/L	< 1 ng/L
PFHxS	< 1 ng/L	1.9	< 1 ng/L	< 1 ng/L
PFOS	1	3	2.4	1.8
Total PFAS (Primary 11)	3.4	20.3	5.7	4.5
Additional PFAS				
N-EtFOSAA	< 1 ng/L	< 1 ng/L	1.9	2.2
Total PFAS (All Detected)	3.4	20.3	7.6	6.7

WB - WEST BRANCH OF CATHANCE			
WTK_ID	WTK_PFAS_1552	WTK_PFAS_1557	WTK_PFAS_1555
Name	FOMB	FOMB	FOMB
Sampling Location	Bowdoinham, ME 04008 **WBD/S**	Bowdoinham, ME 04008 **WBSC**	Bowdoinham, ME 04008 **WBTB**
Coordinates	N44°01.433'; W69°52.809'	N44°01.047'; W69°53.345'	N44°00.661'; W69°59.380'
Filtered/Unfiltered	Unfiltered	Unfiltered	Unfiltered
Sampling Date	9/2/2022	9/2/2022	9/2/2022
Order ID	5688	5688	5688
PFBA	< 1 ng/L	< 1 ng/L	< 1 ng/L
PFPeA	< 1 ng/L	< 1 ng/L	< 1 ng/L
PFHxA	1.6	1.9	1.7
PFHpA	< 1 ng/L	< 1 ng/L	< 1 ng/L
PFOA	1.7	1.7	2
PFNA	< 1 ng/L	< 1 ng/L	< 1 ng/L
PFDA	< 1 ng/L	< 1 ng/L	< 1 ng/L
HFPO-DA (GenX)	< 2 ng/L	< 2 ng/L	< 2 ng/L
PFBS	< 1 ng/L	< 1 ng/L	< 1 ng/L
PFHxS	< 1 ng/L	< 1 ng/L	< 1 ng/L
PFOS	2.3	1.8	3
Total PFAS (Primary 11)	5.6	5.4	6.7
Additional PFAS			
N-EtFOSAA	1.2	1.3	2.1
Total PFAS (All Detected)	6.8	6.7	8.8

M - MUDDY	
WTK_ID	WTK_PFAS_1558
Name	FOMB
Sampling Location	Topsham, ME 04086 **MRFR**
Coordinates	N43°57.927'; W69°53.584'
Filtered/Unfiltered	Unfiltered
Sampling Date	9/2/2022
Order ID	5688
PFBA	< 1 ng/L
PFPeA	< 1 ng/L
PFHxA	1.5
PFHpA	< 1 ng/L
PFOA	1.2
PFNA	< 1 ng/L
PFDA	< 1 ng/L
HFPO-DA (GenX)	< 2 ng/L
PFBS	< 1 ng/L
PFHxS	< 1 ng/L
PFOS	2.2
Total PFAS (Primary 11)	4.9
Additional PFAS	
N-EtFOSAA	1.5
Total PFAS (All Detected)	6.4

E - EASTERN			
WTK_ID	WTK_PFAS_1540	WTK_PFAS_1538	WTK_PFAS_1545
Name	FOMB	FOMB	FOMB
Sampling Location	Pittston, ME 04345 EKRD	Dresden, ME 04342 EDRM	Dresden, ME 04342 ERM
Coordinates	N44°09.328'; W69°41.193'	N44°06.528'; W69°43.596'	N44°02.113'; W69°47.873'
Filtered/Unfiltered	Unfiltered	Unfiltered	Unfiltered
Sampling Date	8/29/2022	8/29/2022	9/1/2022
Order ID	5688	5688	5688
PFBA	< 1 ng/L	< 1 ng/L	< 1 ng/L
PFPeA	< 1 ng/L	1.2	< 1 ng/L
PFHxA	1.8	3.4	1.1
PFHpA	< 1 ng/L	< 1 ng/L	< 1 ng/L
PFOA	1.7	1.9	< 1 ng/L
PFNA	< 1 ng/L	< 1 ng/L	< 1 ng/L
PFDA	< 1 ng/L	< 1 ng/L	< 1 ng/L
HFPO-DA (GenX)	< 2 ng/L	< 2 ng/L	< 2 ng/L
PFBS	< 1 ng/L	< 1 ng/L	< 1 ng/L
PFHxS	< 1 ng/L	< 1 ng/L	< 1 ng/L
PFOS	< 1 ng/L	1	< 1 ng/L
Total PFAS (Primary 11)	3.5	7.5	1.1

AB - ABBAGADASSETT			
WTK_ID	WTK_PFAS_1551	WTK_PFAS_1554	WTK_PFAS_1553
Name	FOMB	FOMB	FOMB
Sampling Location	Bowdoinham, ME 04008 ABHT	Bowdoinham, ME 04008 AB1L	Bowdoinham, ME 04008 ARM
Coordinates	N44°03.094'; W69°49.837'	N44°00.614'; W69°51.102'	N43°59.438; W69°51.063'
Filtered/Unfiltered	Unfiltered	Unfiltered	Unfiltered
Sampling Date	9/2/2022	9/2/2022	9/1/2022
Order ID	5688	5688	5688
PFBA	< 1 ng/L	< 1 ng/L	< 1 ng/L
PFPeA	1.1	< 1 ng/L	< 1 ng/L
PFHxA	2.6	1.1	1
PFHpA	< 1 ng/L	< 1 ng/L	< 1 ng/L
PFOA	2.3	1	1
PFNA	< 1 ng/L	< 1 ng/L	< 1 ng/L
PFDA	< 1 ng/L	< 1 ng/L	< 1 ng/L
HFPO-DA (GenX)	< 2 ng/L	< 2 ng/L	< 2 ng/L
PFBS	< 1 ng/L	< 1 ng/L	< 1 ng/L
PFHxS	< 1 ng/L	< 1 ng/L	< 1 ng/L
PFOS	2.8	1.3	1.1
Total PFAS (Primary 11)	8.8	3.4	3.1
Additional PFAS			
N-EtFOSAA	1	1.2	1.1
Total PFAS (All Detected)	9.8	4.6	4.2

Appendix 2- FOMB PFAS Sampling Site Data

Site: A-PBL. Pejepscot Boat Launch, Lisbon Falls. Upstream of Ramp Parking. **Factors**: Lisbon WWTP, points upstream

Coordinates: N44°59.440'; W70°02.910'

Site: A-FPD. Below Pejepscot Dam Brunswick Fish Park Canoe Carry on Gravel Bar. **Factors**: Grimmel's scrap yard, mixing from dam.

Coordinates: N43°57.327'; W70°01.449'

Site: A-BCP. Brunswick Canoe Portage [Mill St. Park] above dam.
Factors: Agriculture, Closed landfill.

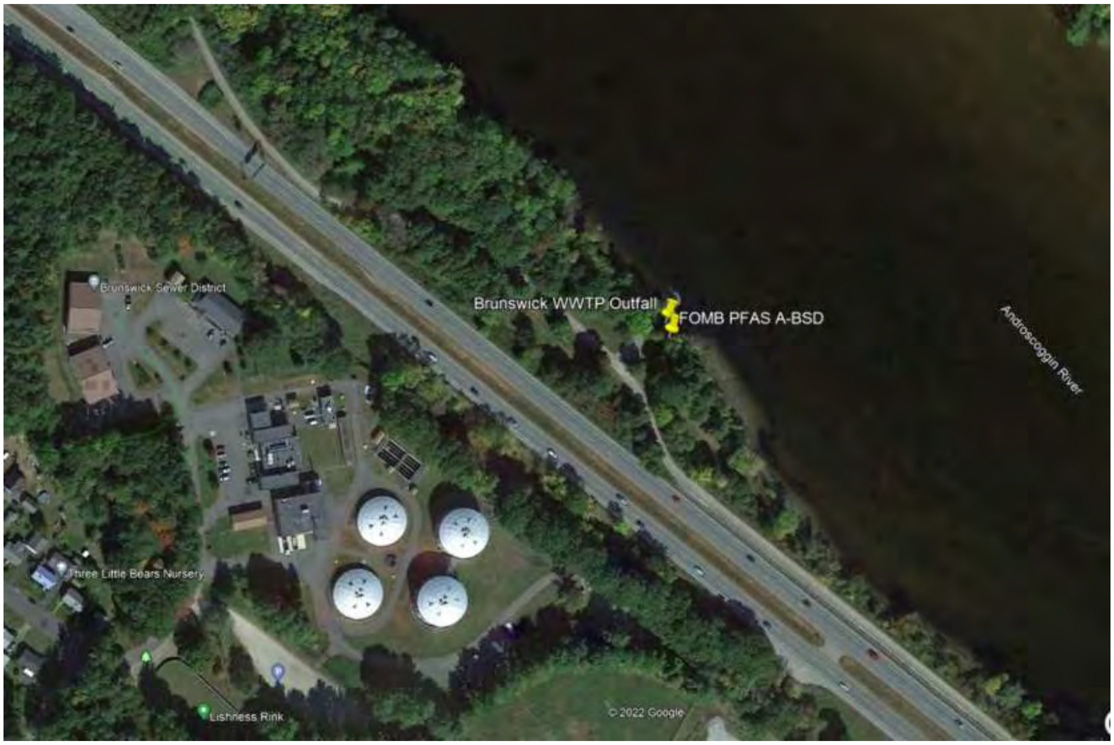
Coordinates: N43°54.881'; W69°58.567'

Site: A-BWS. Water St. Boat Launch on Float. **Factors:** Urban run-off, TMDL Stream

Coordinates: N43°55.343'; W69°57.308'

Site: A-BSD. Brunswick Sewer District Outfall. **Factors:** WWTP

Coordinates: N43°55.000'; W69°56.658'



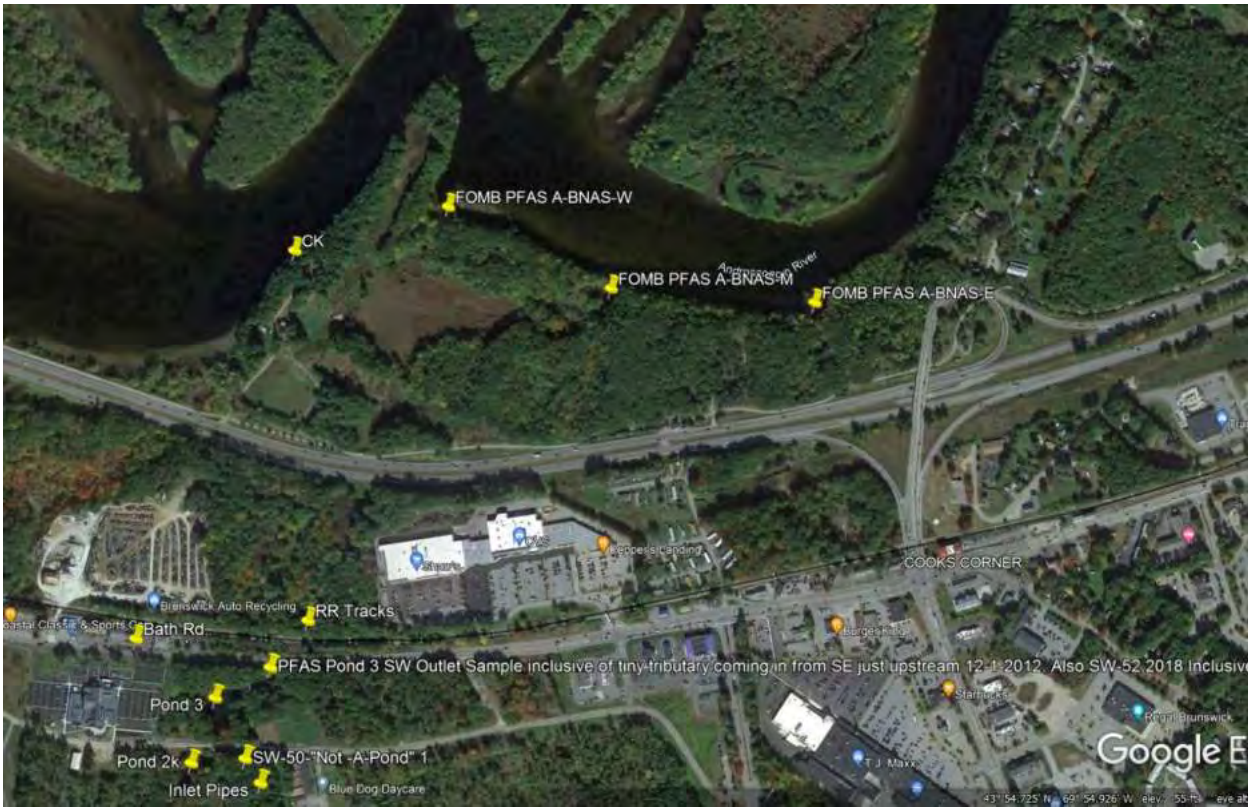
Site: A-BNAS-W. Westerly creek draining from Pond 3 on BNAS-Outlet by site of former Humphrey's Shipyard. **Factors:** Know military toxics, CERCLA site.

Coordinates: N43°54.766'; W69°55.525'

Photo: Chris Gutscher

Site: A-BNAS-M. Middle of 3 creeks draining north end of BNAS-This also from Pond 3. **Factors:** Know military toxics, CERCLA site.

Coordinates: N43°54.680'; W69°55.336'



Site: A-BNAS-E. Easterly of 3 creeks draining north end of BNAS into the Androscoggin. **Factors:** Know military toxics, CERCLA site.

Coordinates: N43°54.875'; W69°55.070'

Photo: Chris Gutscher

Site: A-BBB. Brunswick Bay Bridge-End of Jetty. **Factors:** Mobile home park wastewater discharge system.

Coordinates: N43°56.162'; W69°53.414'

Looking west to Mustard Island

Looking north

Looking South

Site: K-ABR. Augusta Boat Ramp off northerly float. **Factors:** Municipal run-off, upstream industrial sites.

Coordinates: N44°18.839'; W69°46.315'

Site: K-HLK. Hallowell Boat Launch & Park. Off Float. FOMB water test site. **Factors:** Augusta WWTP upstream.

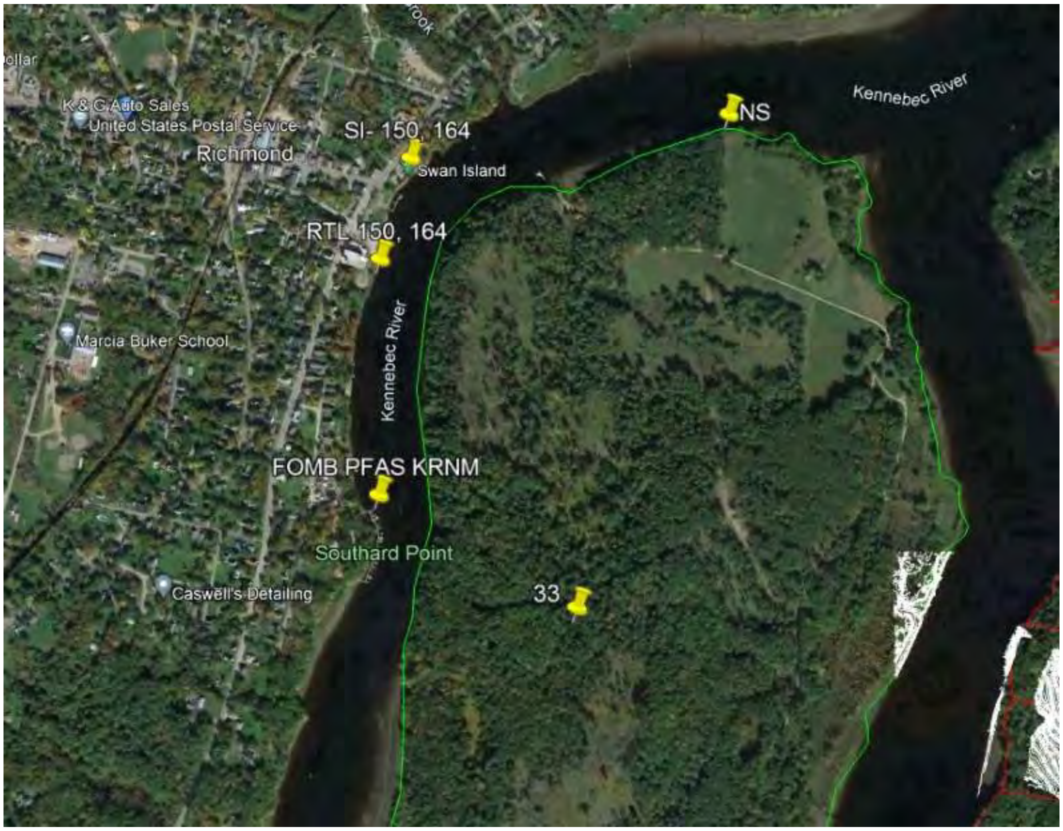
Coordinates: N44°16.981'; W69°47.420'

Site: K-GRK. Gardiner Boat Launch. Off north finger float.
Factors: Urban run-off, Cobboseecontee drainage. FOMB water test site.

Coordinates: N44°13.754'; W69°46.162'

Site: K-RNM. Richmond Nash Marina off northerly finger float (to right of big boat in photo). FOMB water test site. **Factors:** Downstream of Richmond WWTP and Town Landing.

Coordinates: N44°04.913'; W69°47.967'



Site: K-ABK. Off south Abbagadassett Point a bit south of power lines. By skiff. FOMB water test site from shore. **Factors:** Agriculture.

Coordinates: N44°00.003'; W69°49.430'

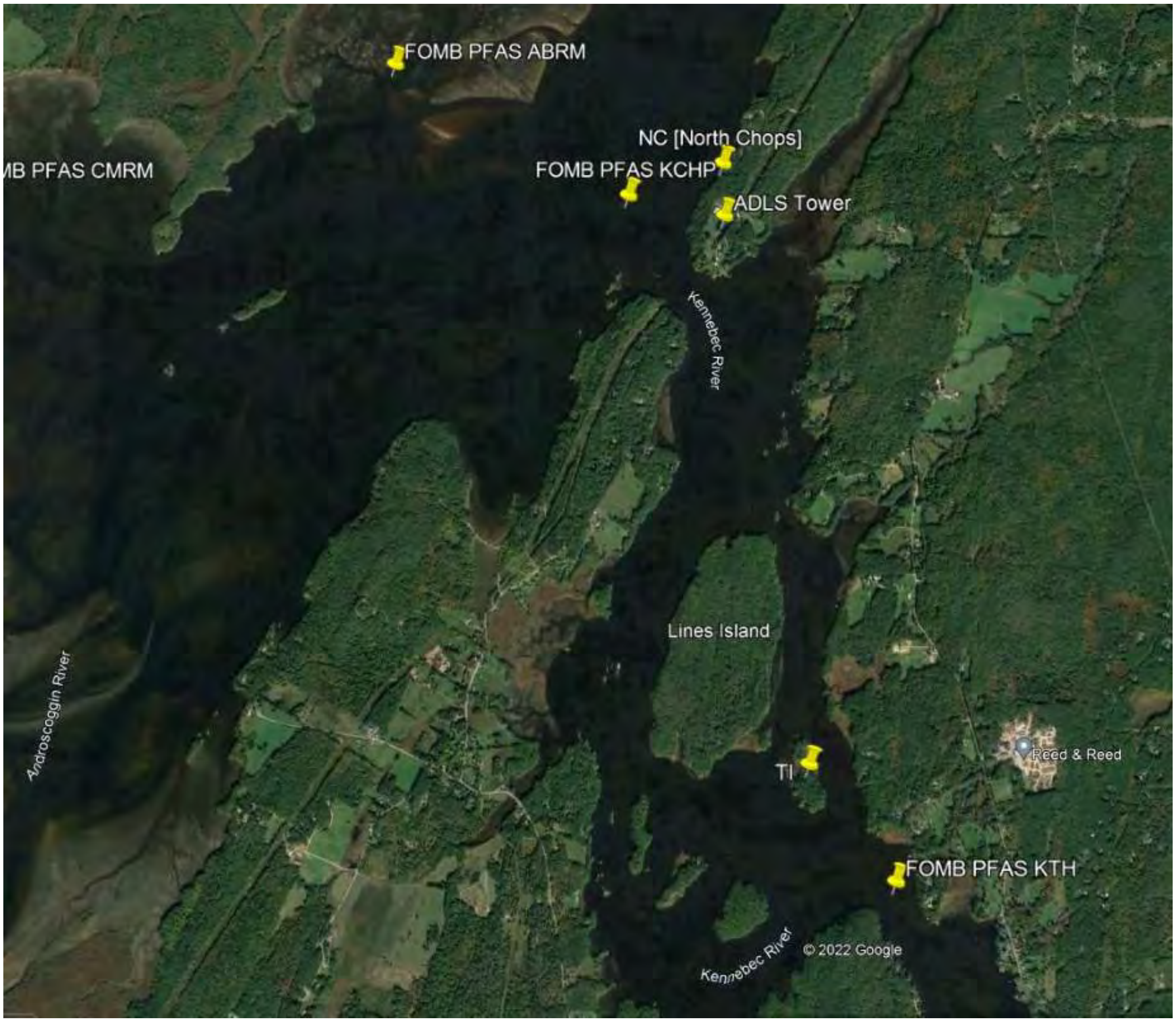
This is N of powerlines looking SW. Site was S. of lines.

Site: K-CHP. Above the Chops in confluence of Kennebec, Androscoggin, Muddy and Abbagadasset currents. By skiff.
Factors: The middle Bay.

Coordinates: N43°58.925'; W69°49.918'

Site: K-KTH. Thorne Head mid-river. **Factors:** Lower Bay, possible Bath landfill drainage.

Coordinates: N43°57.090'; W69°48.990'

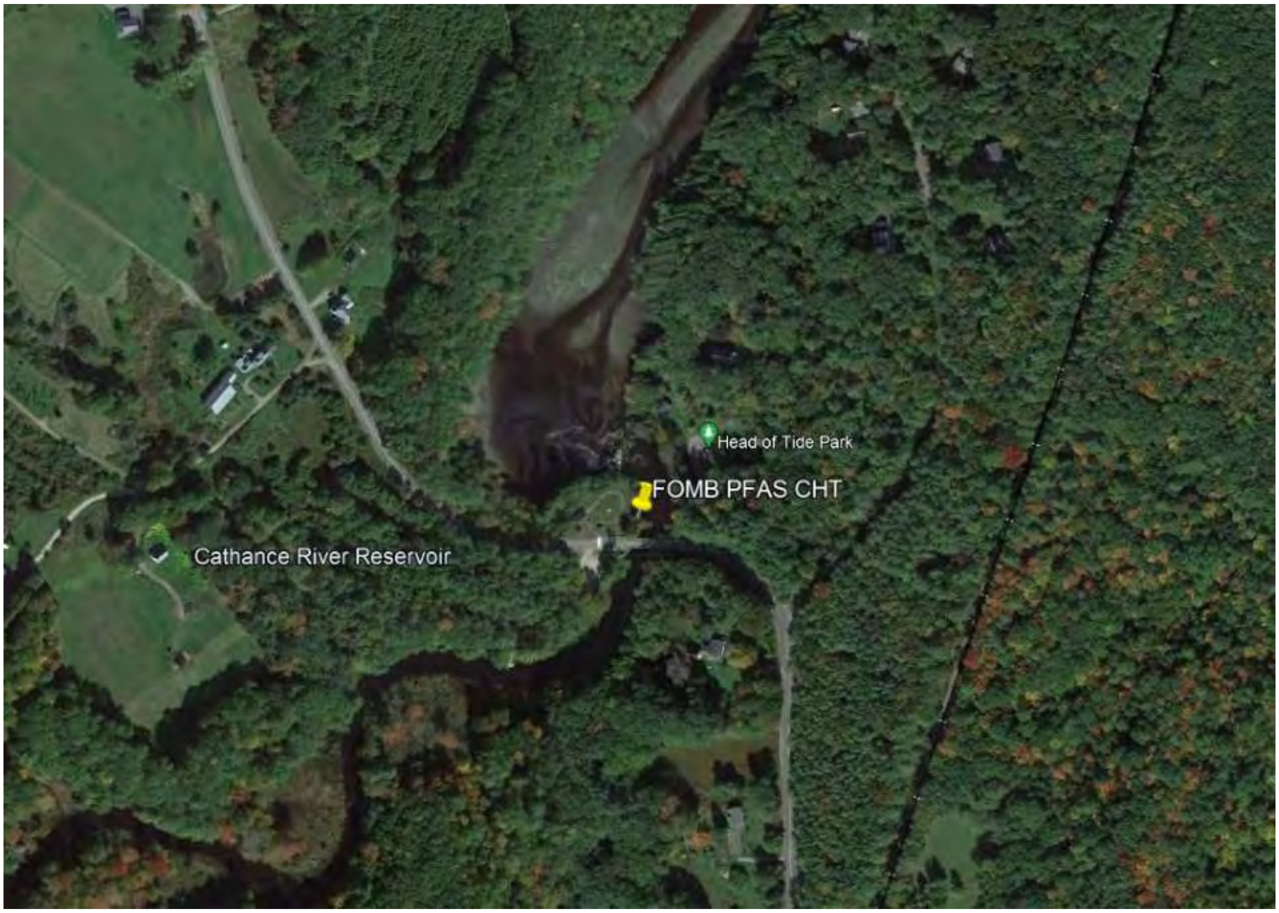


Site: C-201. Under 201 bridge. **Factors:** Bissen's agriculture.

Coordinates: N43°57.372'; W69°58.109'

Site: C-CHT. Just above Head Tide dam, Just below Cathance Rd. bridge. **Factors:** The Highlands, Cathance Gorge.

Coordinates: N43°57.722'; W69°55.806'



Site: C-BTL. Bowdoinham Town Landing off end of long float. FOMB water test site. **Factors:** Cathance, Jim's Marina, town seepage. All individual septic.

Coordinates: N44°00.475'; W69°53.694'

Site: WB-WBD/S. West Branch of Cathance-Junction of Denham Stream and Sedgley Brook. **Factors:** Agricultural fields-sludge spreading, old Bowdoinham dump.

Coordinates: N44°01.433'; W69°52.809'

Looking up Denham Stream

Site: WB-WBSC. West Branch-School Creek. First fork to west above Twin Bridges and Mayo's. **Factors:** Ridge Rd., School drainage.

Coordinates: N44°01.047'; W69°53.345'

Site: WB-WBTB. West Branch-A bit above Twin Bridges. Good mix of West Branch. **Factors:** Ridge Rd., School wastewater drainage.

Coordinates: N44°00.661'; W69°59.380'

Site: M-MRFR. Muddy River off Foreside Rd. bridge. **Factors:** Agriculture, Topsham Solid Waste Facility

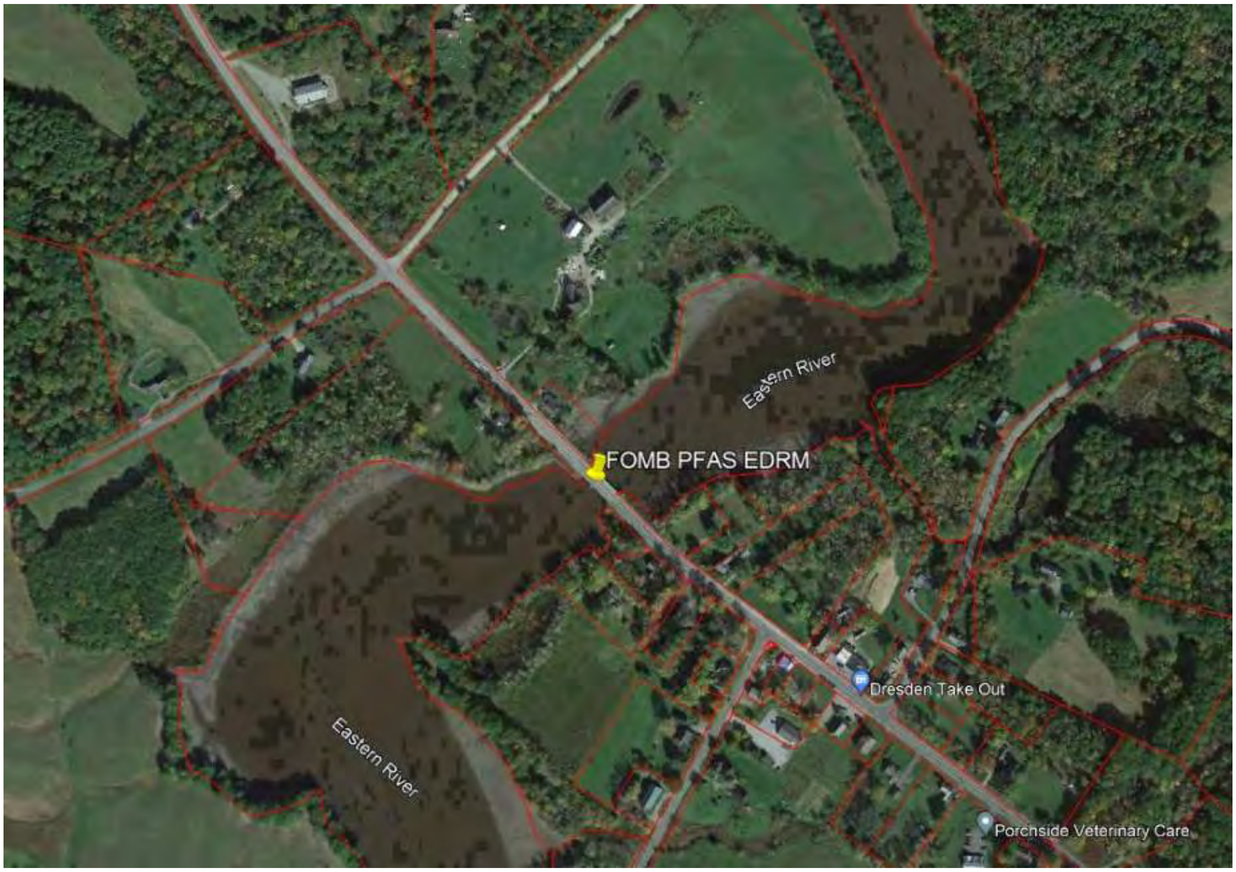
Coordinates: N43°57.927'; W69°53.584'

Site: E-KRD. Below Kelly Rd opposite 160 Old County Rd. First accessible area of main stem below Head Tide. **Factors:** Agriculture.

Coordinates: N44°09.328'; W69°41.193'

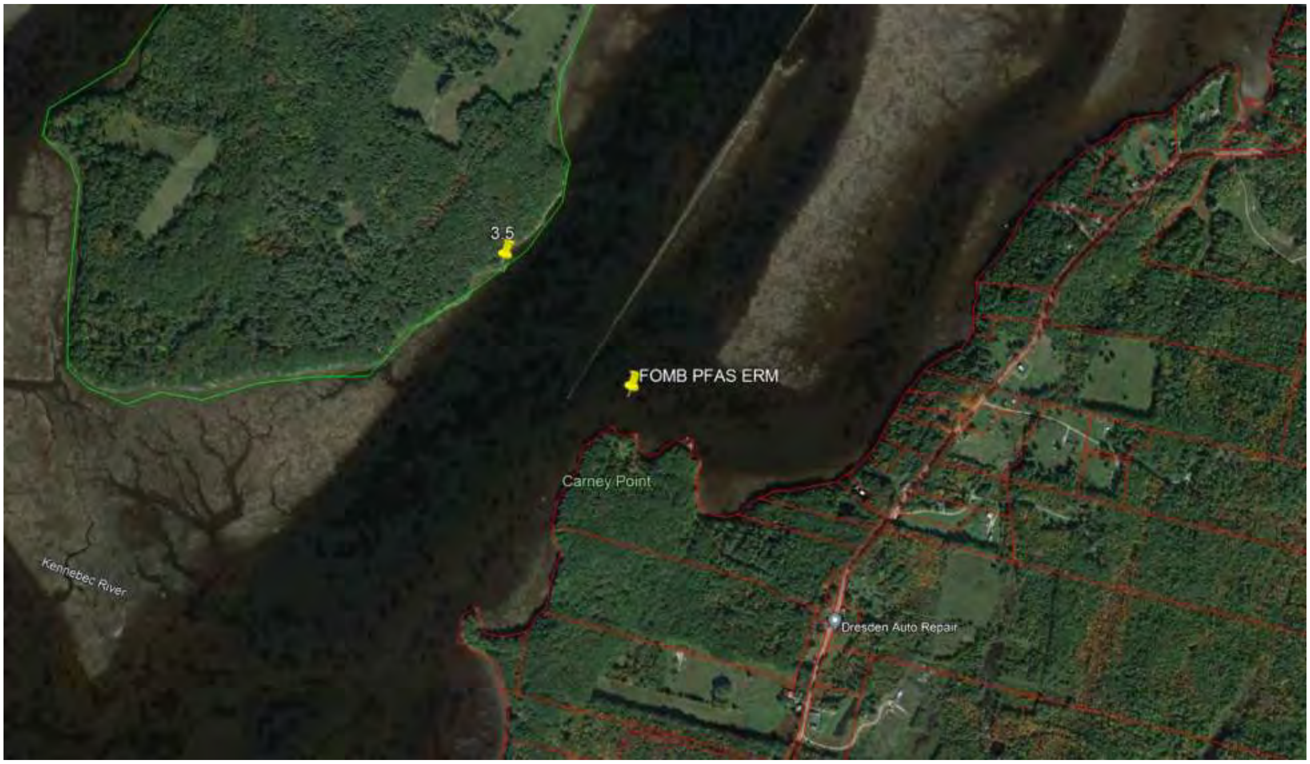
Site: E-DRM. Dresden Mills bridge Rte 27, downstream side.
Factors: Agriculture.

Coordinates: N44°06.528'; W69°43.596'



Site: E-ERM. Eastern River mouth just inside end of training wall jetty. By skiff. **Factors:** Agriculture, Dresden Mills down.

Coordinates: N44°02.113'; W69°47.873'

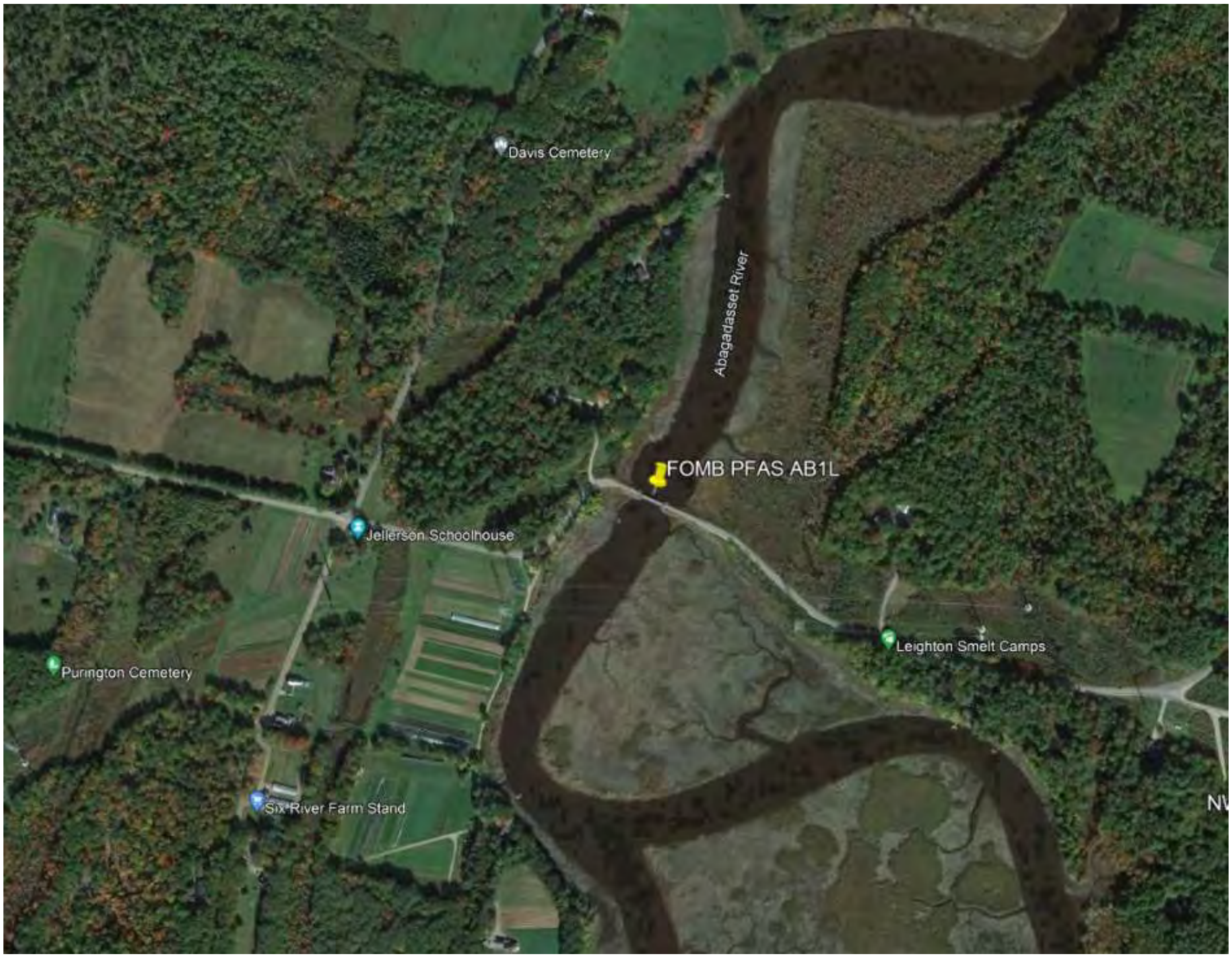


Site: AB-ABHT. Abbagadassett just below head tide pond and phragmites creek/ Detweiler easement. **Factors:** Upper Abby, old Bowdoinham dump (our last one).

Coordinates: N44°03.094'; W69°49.837'

Site: AB- AB1L. One lane bridge on Browns Pt. Rd. **Factors:** Tidal Abby, Agriculture, Smelt camps.

Coordinates: N44°00.614'; W69°51.102'



Site: AB-ARM. Abby River mouth just inside the Sands. By skiff. **Factors:** Lower river agriculture.

Coordinates: N43°59.438; W69°51.063'

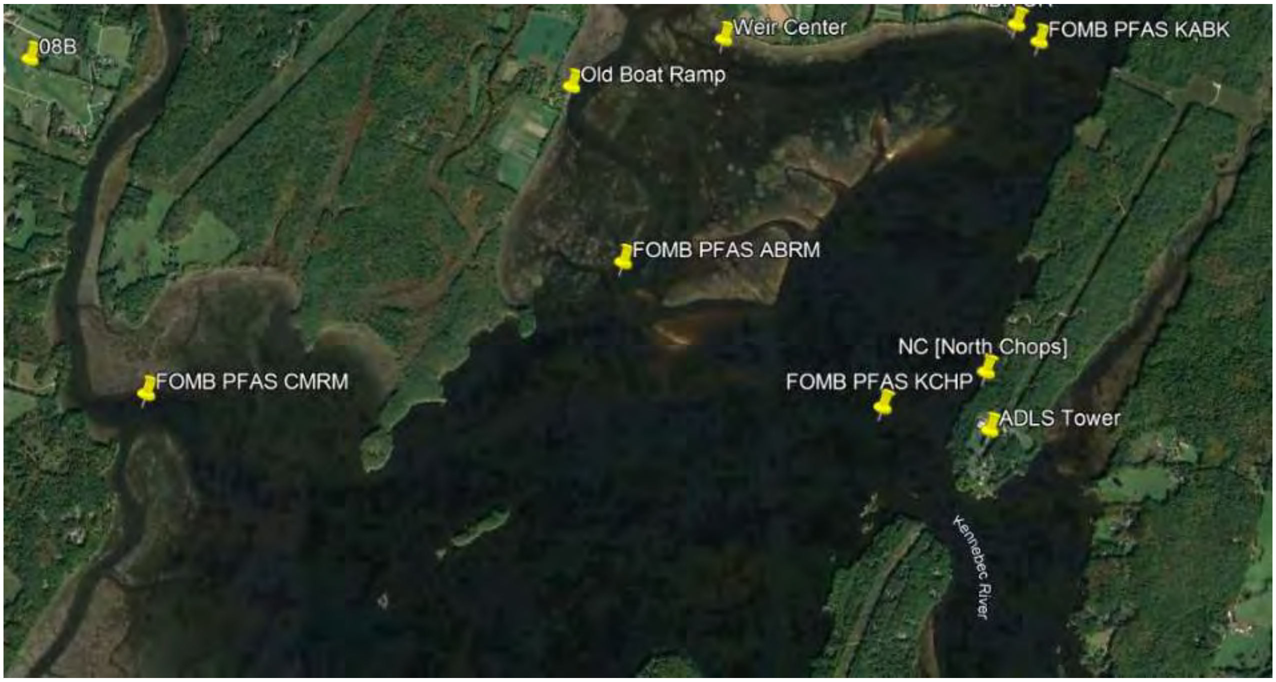


Photo: Dave Mention