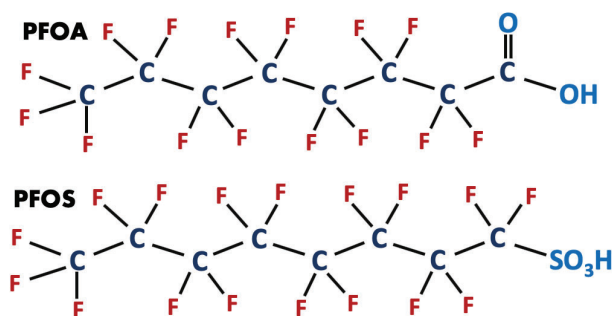


WHAT is PFAS?

PFAS—Per- and PolyFluoroAlkyl substances—is a large group (thousands) of man-made, fluorinated chemicals manufactured and used since the 1940s. PFAS do not occur naturally in the environment. Because PFAS are designed to be stable and unreactive to water, grease, heat, and ‘dirt’; they have earned the moniker of **Forever Compounds**.



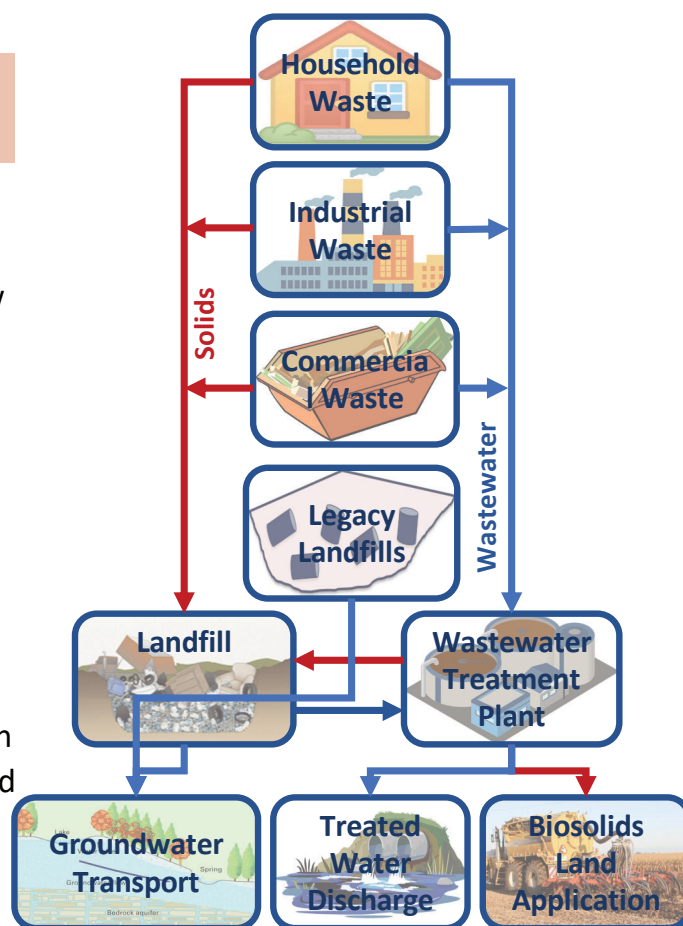
Chemical structures of perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS)

WHY do we Care about PFAS?

Studies have found that certain PFAS compounds have been linked to various cancers, thyroid problems, low birth weights, and affect other health issues including cholesterol levels, our auto-immune system, fertility, and childhood behavior. Drinking water samples collected from City of Rhinelander Well No. 8 on October 2, 2019 showed that a PFAS compound (perfluorohexanesulfonic acid, PFHxS) was detected at a concentration of 90.1 parts per trillion (ppt), well above the WI *recommended* groundwater standard of 20 ppt established to protect women who are or who may become pregnant, breastfeeding mothers, and infants who are bottle feeding. Similar concentrations have been measured in City of Rhinelander Well No. 7. That PFAS is showing up at **potentially unsafe levels in City of Rhinelander Wells** is of concern to our community's health and wellbeing.

PFAS and Groundwater Protection, Objectives of this White Paper

1. What is PFAS, where does it come from? A little on PFAS chemistry 101.
2. What are the potential sources of PFAS, how does PFAS get into the water?
3. What is the fate of PFAS in the environment and how is PFAS transported?
4. What are PFAS test results specific to Rhinelander, what do the test results mean?
5. Why did the City of Rhinelander proactively shut down two of the City's groundwater wells?
6. Can I remove PFAS from my drinking water in my home? Can we treat PFAS in our sand and gravel aquifer?
7. What's next? Is there State and/or Federal help to guide and assist Rhinelander to addressing this issue?



Inspired by Michigan Statewide Study on Landfill Leachate PFOA and PFOS Impact Technical Report. 2019.

Where are PFAS Found?

✓ Class B Fire-Fighting Foams

1. Airports
2. Refineries
3. Training Facilities
4. Residuals from Fires

Fire-Fighting Foams⁽¹⁾



Foam on Water⁽²⁾



Sludge



✓ Wastewater Treatment Sludge

1. Paper Mills
2. Publicly Owned Treatment Works (POTW)
3. Industrial Wastewater



Non-Stick Cookware

PFAS are a family of human-made chemicals in many products used by consumers and industry



Food Packaging

✓ Textiles and Clothing

1. Stain-resistant Carpet
2. Leather Products
3. Stain- and Water-resistant Gear



Domestic Water



Landfills



Rain Gear

✓ Consumer Products

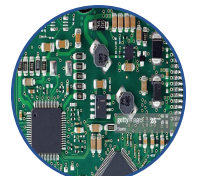
1. Sunscreen
2. Waxes and Polishes
3. Cosmetics, Lipstick
4. Shaving Cream
5. Ski Wax



Personal Care Products



Oil-resistant Food Packaging



Electronics

✓ Household

1. Carpeting, Furniture
2. Non-stick Cookware
3. Bakery Paper

✓ Manufacturing Byproducts

1. Surfactants
2. Resins and Molds
3. Metal-plating
4. Photolithography

✓ Landfills

1. Industrial Waste
2. Sludge
3. Consumer Products

✓ Food Packaging

1. Pizza Boxes
2. Fast-food Wrappers
3. Oil-resistant Packaging

Photo Credits: Wisconsin Department of Natural Resources, Steven Verburg (Wisconsin State Journal), James Tinjum

Key Points, History and Use of PFAS Compounds:

- Used in industry and commercial products since the 1940's
- At the time of 3M's phaseout of *long-chain* PFAS
 - 41% for paper and packaging protectors
 - 36% for fabric protectors, leather, and carpet treatment
 - 19% as industrial surfactants, additives, and coatings
 - 3% for fire-fighting foam
- PFAS releases to the environment commonly from
 - **Industrial facilities** that produce, process, use
 - **Class B fire-fighting foam** (storage, use, release)
 - Waste management facilities (i.e., **landfills**)
 - **Wastewater treatment** residuals and **Biosolids** application
- As a result, PFAS compounds are **Ubiquitous in nature** due to their resistant properties

⁽¹⁾PFAS-containing fire-fighting foams have been legislatively banned in Wisconsin, unless in emergency

⁽²⁾An indication that PFAS are present in a water body is often presence of foam floating on the water

Public Concern is Growing!



pubs.acs.org/journal/estlc

Detection of Poly- and Perfluoroalkyl Substances (PFASs) in U.S. Drinking Water Linked to Industrial Sites, Military Fire Training Areas, and Wastewater Treatment Plants

Xindi C. Hu,^{*,†,‡} David Q. Andrews,[§] Andrew B. Lindstrom,^{||} Thomas A. Bruton,[⊥] Laurel Philippe Grandjean,[†] Rainer Lohmann,[@] Courtney C. Carignan,[†] Arlene Blum,^{⊥,‡,§} Christopher P. Higgins,[⊙] and Elsie M. Sunderland^{†,‡}

New report shows high levels of PFAS in Madison airport runoff

Chris Hubbsch | Wisconsin State Journal | May 7, 2020

Rhinelanders Spread Tons Of Sludge Near Site Of Contaminated Wells, WXPR Investigation Finds

By BEN MEYER (PEOPLE/BEN-MEYER) • 5 HOURS AGO



Tony Evers
Governor

Andrea Palm
Secretary



State of Wisconsin
Department of Health Services

DIVISION OF PUBLIC HEALTH
1 WEST WILSON STREET
PO BOX 2659
MADISON WI 53701-2659

November 27, 2019

Christopher Frederickson
Mayor
City of Rhinelander
135 S. Stevens St
Rhinelander, WI 54601

Rhinelanders shuts down a second well due to PFAS contamination

© NOVEMBER 26, 2019 / 0

Subject: PFAS, drinking water and surface water testing results for the City of Rhinelander

From West Virginia to Wisconsin?

The Oscar-nominated film, *Dark Waters*, conveys the real-life story of attorney Rob Bilott (played by Mark Ruffalo) who sued DuPont for environmental and health damages related to their disposal of PFOA outside of one of their plants in West Virginia. This crusade led to the very important C8⁽¹⁾ Health Study. If this level of contamination and health impacts occurred in West Virginia, could this type of scenario also play out here in Wisconsin?



⁽¹⁾The C8 Health Study was a series of exposure and health studies in the Mid-Ohio Valley communities, which had been potentially affected by the releases of PFOA (or C8) emitted since the 1950s from the Washington Works plant in Parkersburg, West Virginia. C8 signifies that the study looked at selected long-chain PFAS.

Key Points, PFAS in the News:

- Public concern is growing
- However, COVID-19 has stolen the headlines of late
- State of Wisconsin is behind our neighboring states (especially Michigan and Minnesota) in developing standards and conducting statewide testing
- Exposures are likely widespread

I Live in Rhinelander, is PFAS of Concern?

PFAS has been found in Wells 07 and 08 at concentrations of concern. Among the PFAS detected, PFHxS was found at a level (90.1 ppt) higher than most of the health-based values for PFAS established in other states. The Wisconsin DNR has recommended a standard of 20 ppt for PFOA and PFOS (individually or combined). Wisconsin's recommended standard is less than the 70 ppt advisory standard of the U.S. Environmental Protection Agency (US EPA). Given this, the Wisconsin Department of Health Services (DHS) supported the City's decision to shut down Well 08 to protect public health.

High
Cholesterol

Ulcerative
Colitis

In the C8 Health Project, 70,000 residents with drinking water exposure to PFOA concentrations had a variety of poor health outcomes⁽¹⁾, including:

Thyroid
Hormone
Disruption

Testicular
and Kidney
Cancer

Pregnancy-induced
Hypertension

⁽¹⁾Health problems that may be associated with PFAS are also caused by a variety of factors (lifestyle, environmental, social, genetic). It is possible that PFAS contributed, but there is no way to know if PFAS exposure caused these outcomes or made them worse.

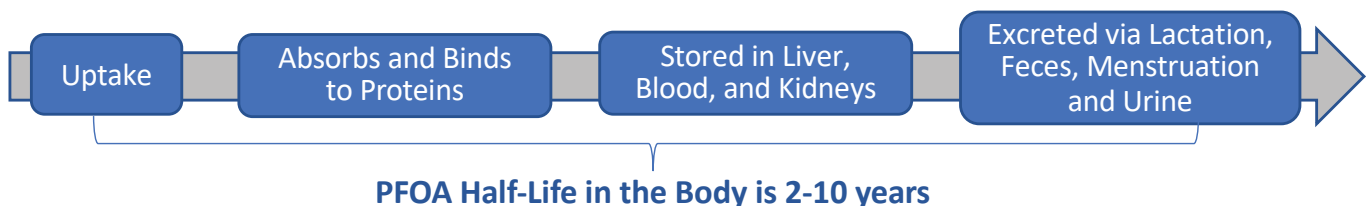
Do I have PFAS in my Body?

Unfortunately, almost everybody has some level of PFAS compounds in their body because PFAS have been ubiquitous in our society for decades and even after being absorbed (binding to tissue proteins, accumulating in the blood and, at lower levels, to the liver, kidneys, and brain) into our body, they are slow to biodegrade or to be excreted. What does that mean? Well, alcohol as an example has a half life in our body (a half life is the time that it takes for half of the substance to be degraded or removed) of 4–5 hours;; for PFAS that half life might be 2–10 years (<https://www.cdc.gov/nchs/nhanes/index.html>). Average blood levels for the general population in 2015-16 (National Health and Nutrition Examination Survey, NHANES, data) were as follows:

PFOA: 1.56 parts per billion, with 95% at or below 4.17 parts per billion

PFOS: 4.72 parts per billion, with 95% at or below 18.3 parts per billion

PFHxS: 1.18 parts per billion, with 95% at or below 4.90 parts per billion



What are my Main Source(s) of Exposure to PFAS?

⇒ **Ingestion:** eating and drinking PFAS-contaminated material is the primary exposure pathway for the general public

- Eating fish and shellfish exposed to PFAS-contaminated water or sediments
- Eating food packaged in materials that have historically contained PFAS such as popcorn bags, fast-food containers, and pizza boxes
- Drinking contaminated water

⇒ **Inhalation:** breathing PFAS-contaminated dust and particles

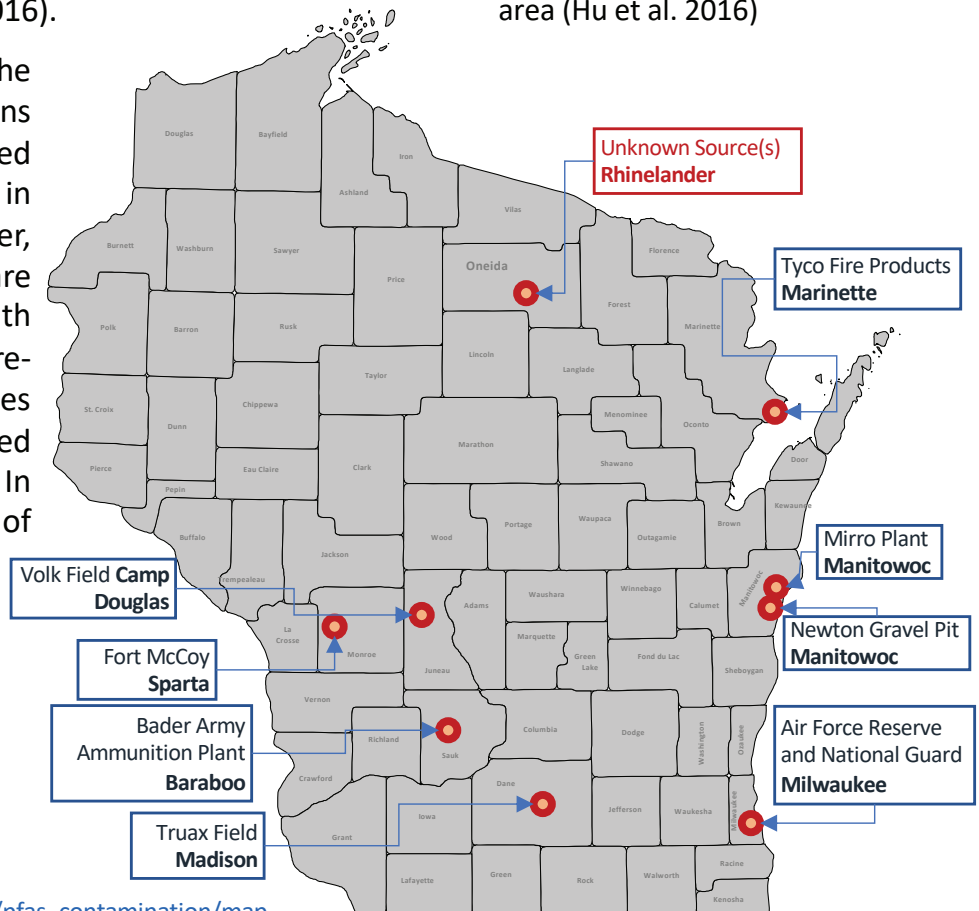
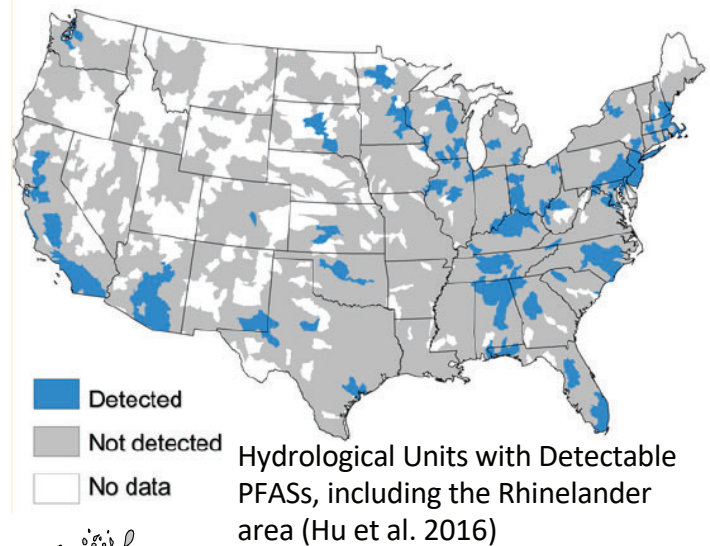
- Particles and fibers from carpets, upholstery, clothing, and PFAS-treated products

⇒ **Transplacental:** PFAS may cross the placenta and enter umbilical cord blood

What about the Nation and the Rest of Wisconsin, do they have PFAS Problems?

In 2016, Hu et al. reported that drinking water supplies for 6 million U.S. residents exceed US EPA's lifetime health advisory (70 ng/L) for PFOS and PFOA. The number of industrial sites that manufactured or use these compounds, the number of military fire training areas, and the number of wastewater treatment plants were all significant predictors of PFAS detection frequencies and concentrations in public water supplies (Hu et al. 2016).

In Wisconsin, map to the right, we know that locations with elevated measured PFAS concentrations⁽¹⁾ in drinking water, groundwater, or surface water are primarily associated with military and airport fire-training areas and facilities that manufactured or used PFAS components. In Rhinelander, the source(s) of PFAS are not known.



⁽¹⁾www.ewg.org/interactive-maps/pfas_contamination/map

Expectations of PFAS in Rhinelander and Elsewhere?

⇒ What are the biggest predictors of groundwater and surface water impacted by PFAS?

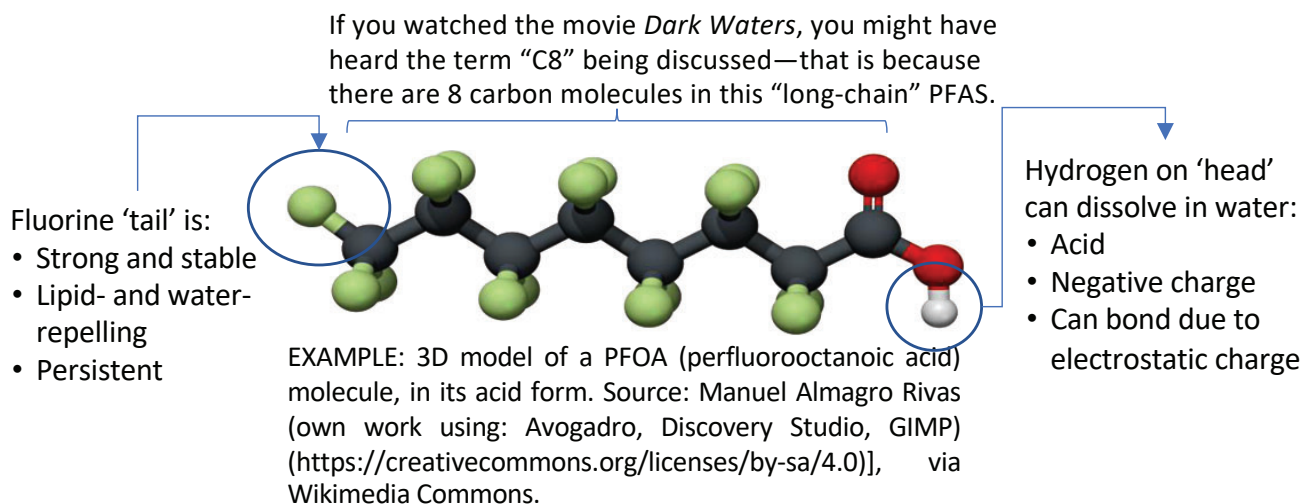
- Proximity of **industrial sites** that manufactured or used PFAS compounds
- Proximity of **military** and **airport fire-training areas**
- Proximity of **wastewater treatment plants**

⇒ **In Wisconsin:** Military sites and manufacturing facilities account for many of the known PFAS-impacted sites.

⇒ **In Rhinelander:** We do not definitively know what the source(s) of PFAS materials are.

PFAS are Per and Polyfluoroalkly Substances

PFAS includes a large group of fluorinated compounds that were produced because of their stable, non-reactive properties. Per-fluoroalkyl substances generally **cannot be degraded** as the fully fluorinated tail (some being hydrophilic) is very stable, C-F is the strongest covalent bond in organic chemistry (fluorine effectively *shields* the carbon), the structure is hydrophobic and lipophobic (i.e., not soluble in grease or oils), and has surfactant properties (reduces surface tension just like your dishwashing detergent, thus repelling dirt). These unique properties of fluorine give many PFAS their mutually hydro- and lipophobic (stain resistant) and surfactant properties. PFAS such as PFOA and PFOS are extremely stable, thermally and chemically, and resist degradation and oxidation. Thermal stability is a key property to predict how long a chemical will persist in the environment.



Key Points, PFAS Chemistry:

- **Manmade chemicals** designed to reduce friction and to be stable and unreactive to water, grease, and heat; thus earning the moniker of **Forever Compounds**.
- Historically used as water-, grease-, stain-, and ‘dirt’-resistant products
- **No degradation** of basic perfluorinated compounds
- **Highly mobile**: migration occurs easily and rapidly in groundwater, surface water, and air

Major PFAS Compounds ⁽¹⁾		Examples/Acronyms
Perfluoroalkyl Substances (most common)	Perfluoroalkyl Carboxylic Acids / Perfluoroalkyl Carboxylates (PFCAs)	Perfluorooctanoic Acid (PFOA)
		Perfluorooctanoate (PFOA)
	Perfluoroalkane Sulfonic Acids / Perfluoroalkane Sulfonates (PFSA)	Perfluorooctane Sulfonic Acid (PFOS)
		Perfluorooctane Sulfonate (PFOS)
Poly-fluorinated Compounds	Perfluoroalkane Sulfonamides (FASAs)	Perfluorooctane Sulfonamide (FOSA)
	Fluorotelomer Alcohol	8:2 FTOH
	FT Carboxylic Acids	8:2 FTCA
	FT Sulfonic Acids	8:2 FTSA
	FT Alkyl Phosphate Esters	8:2 diPAP

⁽¹⁾There are more than 4000 compounds of PFAS!



Wisconsin State
Laboratory of Hygiene
UNIVERSITY OF WISCONSIN-MADISON

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 - FAX (608)224-6213
<http://www.slh.wisc.edu>

Laboratory Report

D.F. Kurtycz, M.D., Medical Director - Prof. James J. Schauer, Ph.D., Director

PFAS in Water

Analyte	Analysis Method	Result	Units	LOD	LOQ
Prep Date: 10/10/19 00:00	Analysis Date: 10/21/19 11:56				
PFOA (335-67-1)	Modified ISO 21675	6.4	ng/L	0.13	0.43
PFHpS (375-92-8)	Modified ISO 21675	5.6	ng/L	0.092	0.31
PFOS (1763-23-1)	Modified ISO 21675	4.5	ng/L	0.16	0.52
PFNA (375-95-1)	Modified ISO 21675	5.7	ng/L	0.093	0.31
9CI-PF3ONS (756426-58-1)	Modified ISO 21675	4.5	ng/L	0.075	0.25
8:2 FTSA (39108-34-4)	Modified ISO 21675	5.2	ng/L	0.15	0.49
PFDA (335-76-2)	Modified ISO 21675	4.6	ng/L	0.18	0.60
PFNS (68259-12-1)	Modified ISO 21675	4.3	ng/L	0.061	0.20
N-MeFOSAA (2355-31-9)	Modified ISO 21675	4.3	ng/L	0.079	0.27
N-EtFOSAA (2991-50-6)	Modified ISO 21675	3.7	ng/L	0.20	0.66

The **analysis method** is a standard that all certified laboratories must follow to a "T". In this lab method, 36 PFAS compounds that would quantify in a landfill aqueous sample. The compounds include carboxylic acids, sulfonic acids, telomers, and sulfonamides.

The **analyte** with the CAS (Chemical Abstract Service) number in parentheses. In this case, PFOA = Perfluorooctanoic Acid, one of the most common PFAS compounds.

The **result**, to be compared against a health or regulatory limit. In Wisconsin, the recommended max level for PFOA in groundwater (GW) is 20 ng/l.

The **unit** is nanograms per liter, also known as parts per trillion (ppt). For perspective, 20 ppt is equivalent to one drop of water in an Olympic-size swimming pool.

LOD = Level of Detection, or the lowest concentration that the method can detect.

LOQ = Level of Quantification, or the concentration for which a quantity can be confidently expressed.

Important Information in Laboratory Analytical and Investigation Reports

- Regulatory guidance is often for the **sum of PFOA and PFOS**:
 - The USEPA *Health Advisory level*⁽¹⁾ for PFOA and PFOS is 70 ppt
 - The Wisconsin Department of Human Services (DHS) has *recommended* a GW standard of **20 ppt for PFOA and PFOS**
- DHS is developing GW standard recommendations for up to 20 other PFAS compounds.

⁽¹⁾A **Health Advisory Level** is a non-regulatory recommendation that is not enforceable and is intended as technical information for state and public health officials.



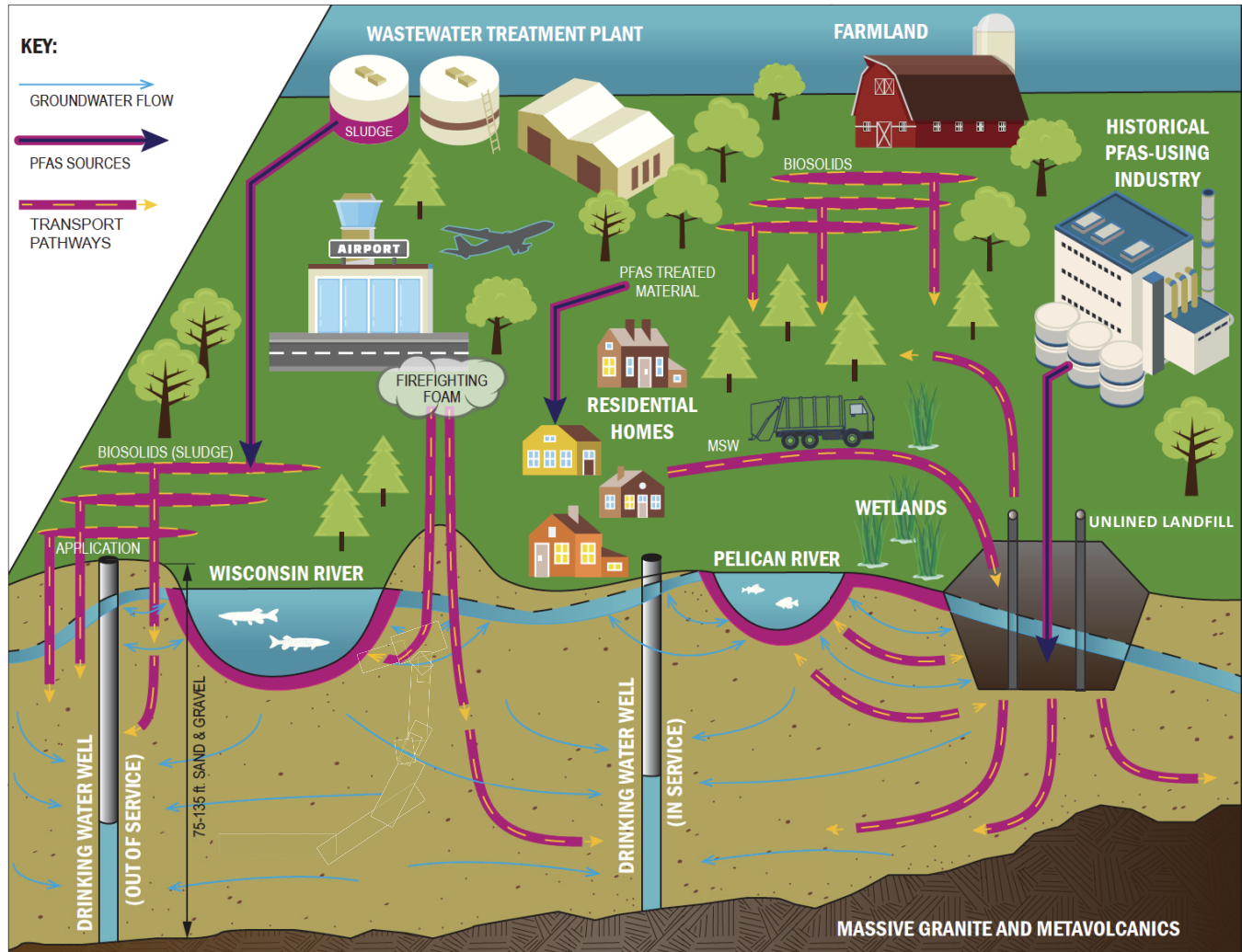
Geo Engineering Laboratory®
WISCONSIN
UNIVERSITY OF WISCONSIN-MADISON

v1. July 13, 2020

Water Action Team Rhinelander



An initial **Conceptual Site Model** depicts known and potential PFAS source areas, transport mechanisms, and pathways on a simplified physical setting. These diagrams conceptualize the origination of chemicals of interest, how they might get into the environment, and if they might be chemically transformed in the process. Note that there are many PFAS sites without an identified source (ATSDR 2018). Fate and transport processes provide the basis for predictions on PFAS occurrence, migration, persistence, and potential for exposure. Relevant site characteristics include soil type, depth to groundwater, precipitation/infiltration rates, and surface water and groundwater flow. We use this predictive knowledge to find the chemicals in the first place and then remediate them if necessary.



Initial **Conceptual Site Model** of the potential sources, nature, and fate of PFAS in a geo setting similar to that of Rhinelander. Graphic created by Jenny Bonardelli of Nicolet College.

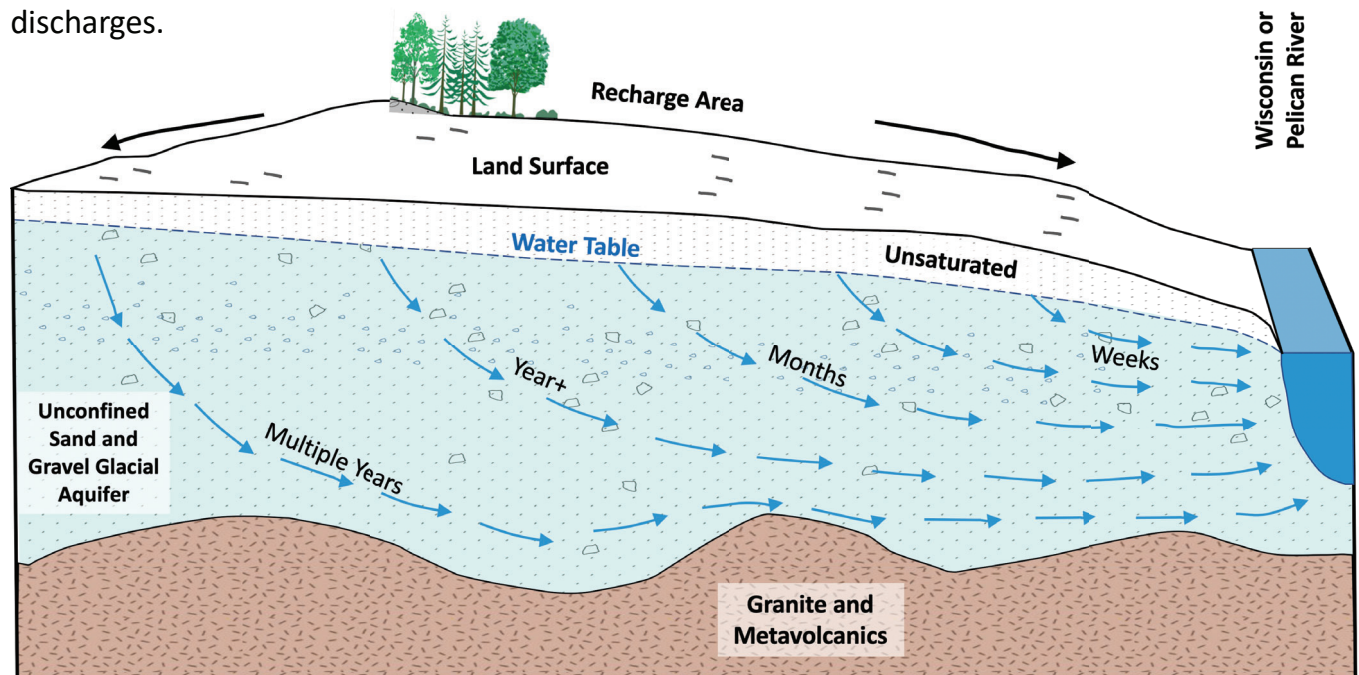
Fate and Transport of PFAS in the Environment:

- Many chemicals, including PFAS, end up in our lakes, streams, and rivers (and sediments therein); wetlands; and groundwater
- If we can conceptualize where PFAS compounds may be, we can develop a plan on how to confirm their existence, calculate the risk to human health and the environment, and design systems to remediate them if necessary.

Rhinelanders Geology and Hydrogeology

Rhinelanders rests in an area characterized by glacial sediments with rolling ground moraine, hills and ridges of end moraines, and pitted outwash. The subsurface consists of a relatively thin and variable thickness of glacial drift overlying Precambrian rock. The glacial drift around Rhinelander consists of an interlayered mixture of (sometimes) clay-rich glacial tills, outwash sands and gravels, and silty glacial lake deposits. The bedrock, typically at around 70 to 130 feet below ground surface, but sometimes as deep as 300 feet in the northeast part of town, consists of granite and metavolcanic rock. Drillers routinely report silt and clay layers within the outwash; however, they are discontinuous. Therefore, it is assumed that the glacial deposits constitute a single aquifer, under water table conditions. In the vicinity of Rhinelander, the water table generally slopes toward the Wisconsin and Pelican Rivers, into which groundwater normally discharges.

Well Construction Report WISCONSIN UNIQUE WELL NUMBER		WK851		Drinking Water and Groundwater - DG/6 Department of Natural Resources, Box 7921 Madison WI 53707	
Property Owner: CITY OF RHINELANDER		Phone #: (715)365-8609		1. Well Location: City of RHINELANDER	
Mailing Address: 135 S STEVENS ST		City: RHINELANDER State: WI Zip Code: 54501		Fire # (if avail.):	
County: Oneida Co. Permit #: Notification #: Completed: 02-08-2008		Subdivision Name: Lot #: Block #			
Well Constructor (Business Name): C T W CORP		Lic. #: 364 Facility ID # (Public Wells): 744012610		Method Code: GPS008	
Address: 21500 W GOOD HOPE RD LANNON WI 53046-9729		Well Plan Approval #: 2007-0624 Approval Date (mm-dd-yyyy): 08-31-2007		or Govt Lot #: Section: 10 Township: 36 N Range: 8 E	
Hicap Permanent Well #: 69572 Common Well #: 007 Specific Capacity: 16.60		2. Well Type: New Well of previous unique well # constructed in Reason for replaced or reconstructed well ?			
3. Well serves # of City: Municipal/Community: Heat Exchange # of drillholes:		Hicap Well ? Yes Hicap Property ? Yes Hicap Potable ?		Construction Type: Drilled	
4. Potential Contamination Sources - ON REVERSE SIDE					
5. Drillhole Dimensions and Construction Method				6. Geology Type, Caving/Noncaving, Color, Hardness, etc...	
Dia. (in.) From (ft.) To (ft.) Upper Enlarged Drillhole Lower Open Bedrock				From (ft.) To (ft.)	
24 Surface 88				T - S G Surface 88	
No Rotary - Mud Circulation No					
No Rotary - Air No					
Yes Rotary - Air & Foam No					
No Drill-Through Casing Hammer					
No Reverse Rotary					
No Cable-tool Bit in dia. No					
Yes Dual Rotary					
Yes Temp. Outer Casing 24in. dia					
Yes Removed? 88depth ft. (if NO explain on back side)					
7. Casing, Liner, Screen				8. Static Water Level	
Dia. (in.) Material, Weight, Specification From (ft.) To (ft.)				17 ft. below ground surface	
18 SEAH STEEL 70.59# ASME A53 WELDED 59.84 0.375" WALL Surface 59.84				10. Pump Test	
Dia. (in.) Screen type, material & slot size From (ft.) To (ft.)				Pumping level 52 ft. below surface	
18 SS WELDED 30 SLOT 59.84 87.75				Pumping at 580 GPM for 24 Hrs.	
7. Grout or Other Sealing Material				Pumping Method ?	
Method Tremie Pipe - Pumped				12. Notified Owner of need to fill & seal ?	
Kind of Sealing Material From (ft.) To (ft.) # Sacks Cement				Filled & Sealed Well(s) as needed? No	
Neat cement grout Surface 50.50 100				SCHEDULED FOR SPRING 2008	
GROUT SEAL 50.50 55.84					
#30 AMERICAN MATERIALS GRAVEL PACK 55.84 88 61					
13. Constructor / Supervisory Driller Lic # Date Signed					
NJ 02-26-2008					
Drill Rig Operator Lic or Reg # Date Signed					
TP 02-26-2008					



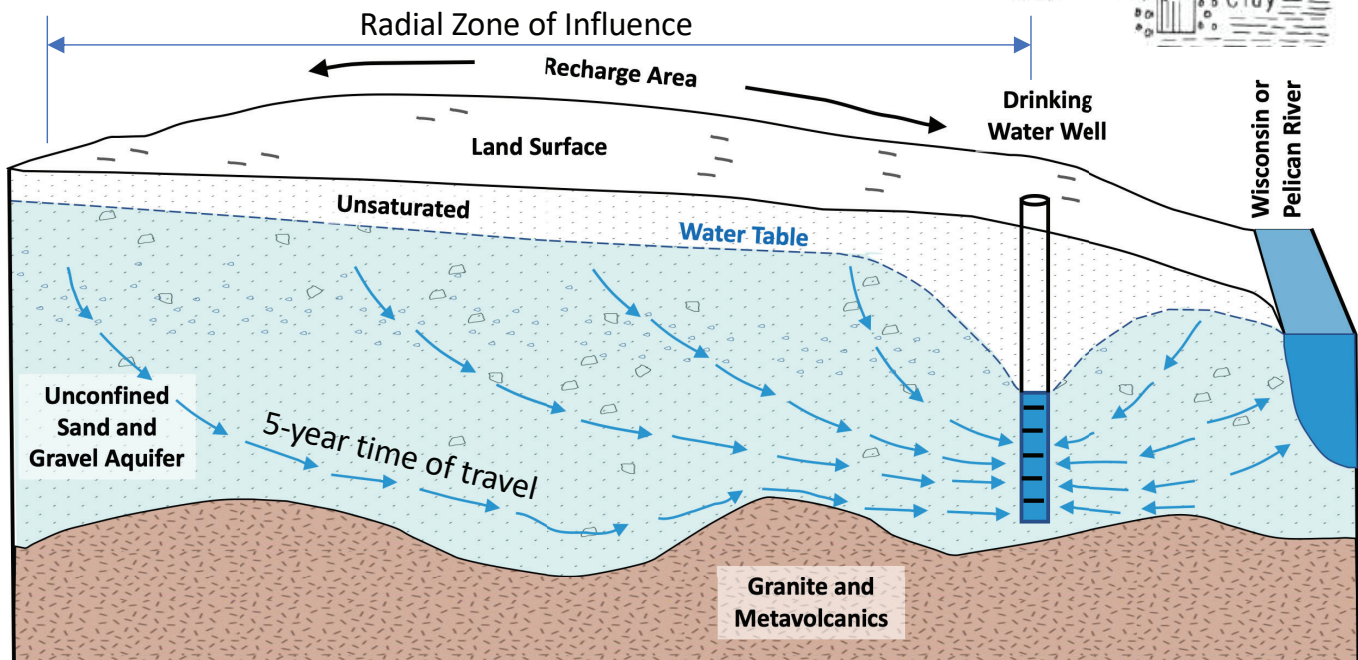
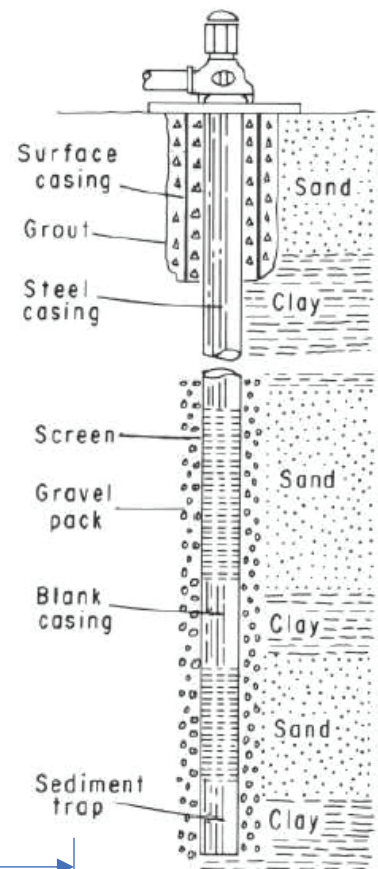
Conceptual Model of Groundwater Flow in Rhinelander Area.

Drinking Water Aquifers

The five City of Rhinelander wells are located in the shallow Sand and Gravel Aquifer. This aquifer is vulnerable to contamination due to its shallow, unconfined depth, highly permeable sands and gravels, and discontinuous fine-grained silts and clays.

Wellhead Protection Zones

Groundwater captured by the Rhinelander municipal wells is recharged by infiltration of precipitation in areas extending up-gradient from each well to the groundwater divides. However, the groundwater flow path is unpredictable due to irregular glacial outwash deposits, till, and lake silts. For Well #7, the radial zone of influence (i.e., 5-year time of travel) is 1913 feet based on DNR-accepted calculations. If this radius is impacted by surface contamination, then there is the very real possibility that the drinking water well will 'draw in' this contamination at a concentration that is significantly less than the source area due to dilution, retardation, biodegradation, dispersion, and other groundwater and contaminant-transport dynamics.



Conceptual Model of Drinking Water Well in Rhinelander Area.

Key Takeaways on the Source of the City of Rhinelander's Drinking Water:

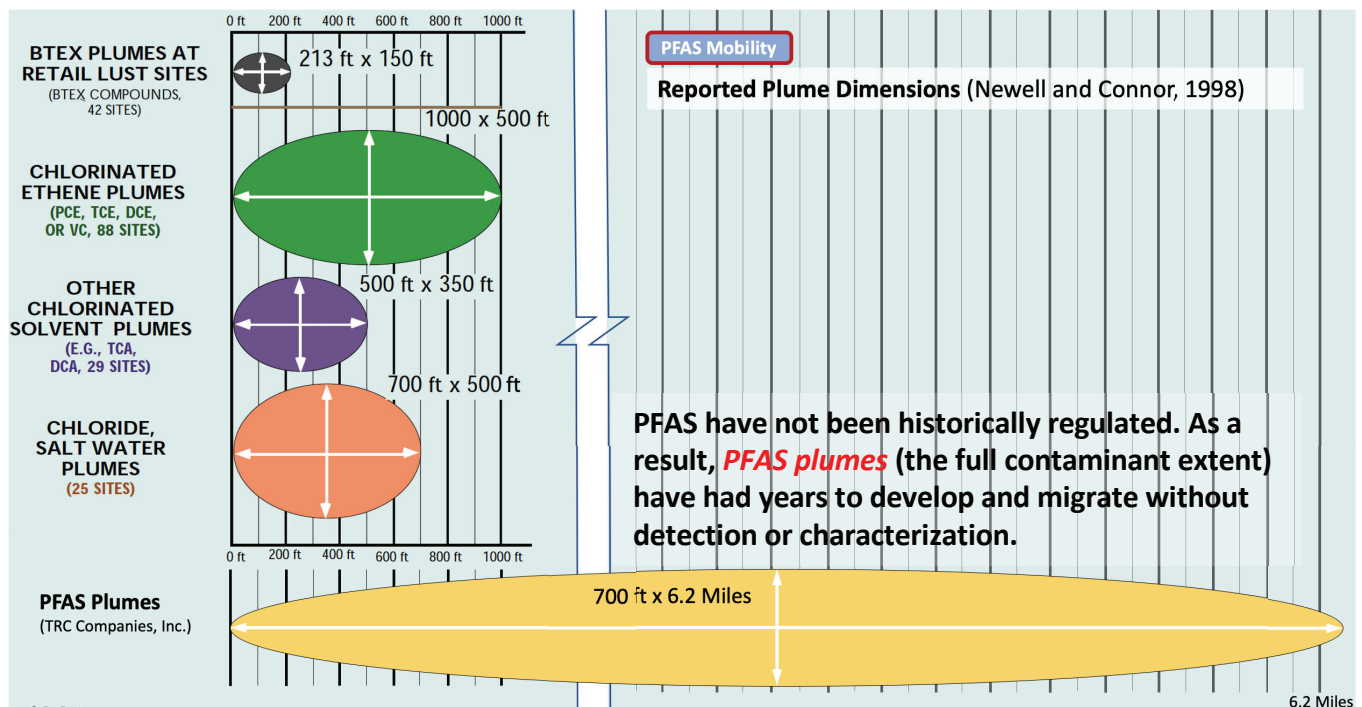
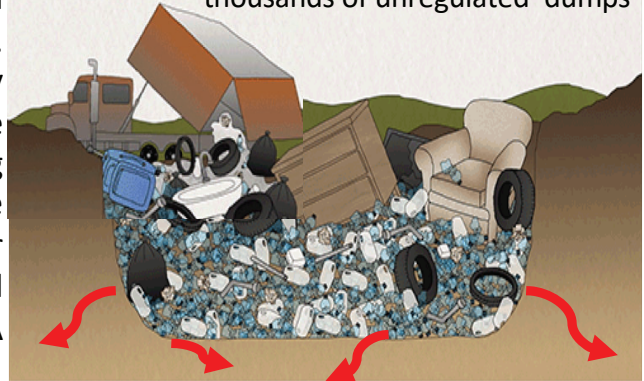
1. There are dozens of private and public drinking water wells in the vicinity of Rhinelander
2. Because of the massive crystalline bedrock at approximately 70–130 feet below ground surface, **drinking water wells are typically screened in the glacial sands and gravels**
3. The Rhinelander **Sand and Gravel Aquifer is vulnerable to contamination** due to its shallow, unconfined depth, highly permeable sands and gravels, and discontinuous fine-grained units

Solid Waste Management Facilities

Landfills, such as the old City of Rhinelander Landfill, may be repositories of PFAS-contaminated industrial waste, biosolids, and consumer waste. PFAS concentrations in landfills vary widely depending on if they contain municipal solid waste (MSW) or industrial waste. As PFAS manufacturing existed long before enactment of Federal and State regulations, environmental and drinking water impacts from disposal of legacy PFAS industrial and consumer waste have been documented (MPCA 2017, Shin et al. 2011). Most landfills in Wisconsin

that were constructed before the 1980s were not required to have composite liners (geomembrane plus compacted soil) or leachate collection systems, causing waste to be in direct contact with underlying soil and groundwater. Therefore, unlined landfills have a higher potential of contributing PFAS to groundwater (Oliaei et al. 2013). Properly constructed and operated modern landfills provide one of the few available disposal/management options for PFAS-containing waste. Once PFAS gets into the subsurface—as they exhibit relatively high solubility in water and generally only sorb to organic carbon via hydrophobic interactions and other compounds via electrostatic interactions—long transport distances are possible, see below.

Prior to 1980, Wisconsin had thousands of unregulated 'dumps'



Old City of Rhinelander Landfill:

1. Constructed and filled before modern landfill design principals were employed
2. Does **not** have a composite clay-geomembrane liner or a low-permeability cover
3. Both industrial waste and municipal solid waste was disposed of in this facility
4. To date, it is unknown if or at what levels PFAS compounds may exist in the landfill
5. Leachate from some landfills has been a source of PFAS release to the environment.

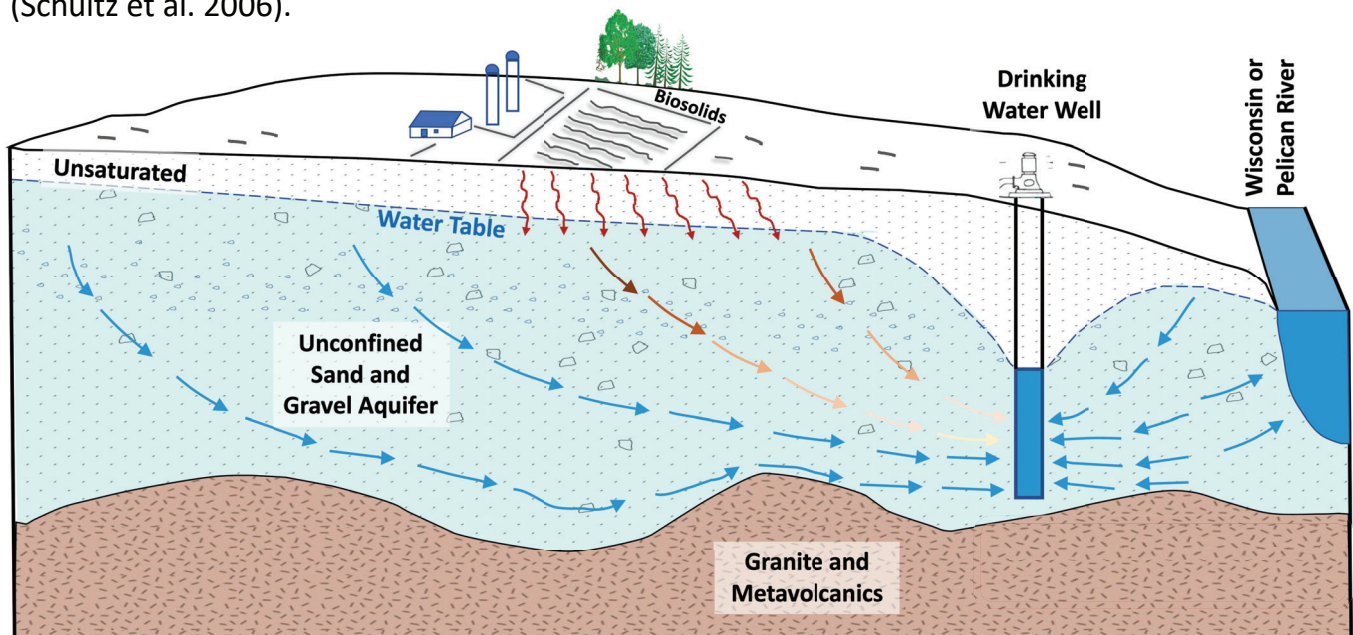
What are Biosolids or Sludges?



Biosolids and septage—the organic-, nutrient-rich, high-liquid solids remaining after wastewater (WW) treatment and processing—contain traces of PFAS because they come from WW that comes from our daily living environments—where carpets, food packaging and food, cosmetics, cleaners, waxes, fabric treatments, and other products contain PFAS. The PFAS composition and concentration in WW biosolids is dependent on the type and concentration of PFAS received by the WW treatment plant, particularly if from industry. PFAS may be concentrated in WW bio-solids (Schultz et al. 2006).

What is Landfill Leachate and Where does it Go for Treatment?

Leachate from landfills—the liquid that occurs in a landfill when infiltrating precipitation or inflowing groundwater combines with moisture in the waste—is typically discharged to a WW treatment plant for treatment. PFOA and PFOS concentrations in landfill leachate vary considerably in different regions of the world and likely reflect the nature of the consumer products and industrial materials used, produced, and disposed (MWRA 2020). In published studies of landfill leachate in the U.S., PFOA was 3–5000 ppt and PFOS 3–800 ppt. PFAS with < 8 carbons (e.g., FTCA) tend to dominate landfill leachate because they are less hydrophobic and therefore more likely to partition to the aqueous phase. Leachate from the City of Rhinelander Landfill was historically discharged to the Rhinelander WWTP.



Key Takeaways on Sludge Disposal at the City of Rhinelander Airport:

1. WXPB revealed that 390 tons of sludge was spread or injected at Rhinelander-Oneida County Airport prior to 1993.
2. PFAS from land-applied biosolids may enter surface water bodies through runoff or to groundwater via infiltration (see above figure).
3. WWTP effluent is a major source of PFAS to surface waters because conventional treatment does not remove PFAS.

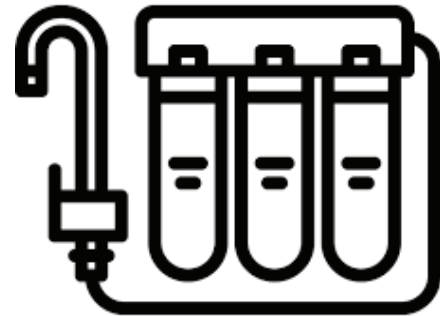
There are Reported Levels of PFAS in my Water. What can I Do?

If the PFAS detected in your drinking water is above the EPA's health advisory level (70 ng/L) or Wisconsin's proposed limit, consider reducing your exposure by



1. Installing home filtration

- If proper model installed, monitored, maintained, and used properly, can reduce PFAS levels (see <https://www.epa.gov/science-matters/reducing-pfas-drinking-water-treatment-technologies> for more detail)
- Three factors determine how much PFAS is removed by filtration
 - PFAS contaminant levels
 - Type of filter
 - How well the filter is maintained



- To optimize removal of PFAS, filtration device manufacturers recommend either more sophisticated media cartridges or increased frequency of switching out the filter media
- Granular activated carbon (GAC) and reverse osmosis are common types of treatments recommended for PFAS compounds, and ion exchange is also an available technology

2. Using an alternative water source for drinking, food preparation, cooking, teeth brushing, or any other activity that might result in ingestion of water

Visit the Environmental Working Group webpage for more information on Water Filters.

<https://www.ewg.org/tapwater/water-filter-technology.php>



How do we Remediate PFAS if found at Levels of Concern in the Environment?

❑ **\$\$ Source Control / Containment⁽¹⁾**

- Surface Controls
- Phytoremediation
- Capping
- Vertical Barriers
- Wellhead Protection

❑ **\$\$\$ Excavation-Removal-Disposal⁽³⁾**

❑ **Treatment^(4,5)**

1. **\$\$\$ Water Treatment Technologies**

- Nanofiltration
- Sorption/Ion Exchange
 - Activated Carbon (can be inefficient)
 - Ion Exchange Resins (expensive)
 - Need to remove all other organics before PFAS treatment

2. **\$\$\$\$ In Situ Technologies**

- Carbon Injection
- Electro-chemical Oxidation
- ART In-Well Circulation
- Zero Valent Iron

3. **\$\$\$\$ Emerging Ex-Situ Technologies**

- Thermal Treatment
 - Can lead to formation of radicals
 - High-temperature thermal oxidation for more complete fluorine removal
- Surface Activation Foam Fractionation
- Plasma arc technology (emerging)

⁽¹⁾Assuming we know where source is

⁽²⁾Methods that limit access to contaminated media, area, or sites

⁽³⁾Excavate, remove, and place contaminated media in secure enclosure or disposal location such as a modern, composite-lined landfill

⁽⁴⁾Reduction or elimination of toxicity, mobility, or volume of contamination by physical, chemical, biological, or thermal methods

⁽⁵⁾Typically very expensive and/or difficult for large volumes of low-level contamination.

❑ **\$ Institutional Controls⁽²⁾**

- Decommission drinking water wells
- New drinking water wells or water source (e.g., bottled water)
- Restrict access to contaminated areas

Why not Treat PFAS in the Environment?

1. Perfluorinated alkyls are very slow to degrade
2. Challenges
 - Low Volatility
 - Moderate Solubility
 - Strong C-F Bond
3. Treatment efficiency must be very high as PFAS typically at part per trillion levels
4. Potentially very large, dilute contamination plumes



Granular Activated Carbon (GAC) Treatment System, Oakdale, MN. Source: Minnesota Department of Health via ITRC (2020).



Regenerable and Polish IX Resin Vessel Skids. Source: Steve Woodard, ECT2, and Nathan Hagelin, Wood Group, PLC via ITRC (2020).



Well at closed Rhinelander Landfill



Source: Rhinelander Area Chamber of Commerce

What Might the Next Steps Be?

1. **Sample Leachate (\$)** in closed City of Rhinelander Landfill following approach from Michigan Department of Environmental Quality (MDEQ).
2. **Field Research (\$\$)** of the Rhinelander–Oneida County Airport property with history of sludge disposal for evaluation of fate and transport mechanisms via
 - Geophysical techniques
 - Infiltration studies
 - Groundwater flow direction and gradient.
3. As appropriate, pursue **State and Federal funding (\$\$\$)** for a PFAS-specific Risk Assessment, Remedial Investigation, and Feasibility Study
4. Study of nature and fate of **PFAS in Sediments** in various waterways (\$\$) similar to that currently being conducted by Dr. Christy Remucal near Marinette, WI.

GENERAL PFAS SAMPLING GUIDANCE

Michigan
Department of
Environmental
Quality



Standard Sampling Protocol

1. Dedicated high-density polyethylene (HDPE) bailers, tubing, and containers
2. Cotton clothing and natural products such as DEET
3. Ballpoint pens
4. Avoid
 - Sharpies
 - Sunscreen, insect repellent
 - Tyvek® PPE
 - Teflon® equipment & materials
 - Waterproof labels
 - Glass sample containers
 - Aluminum foil

Water is one of our communities most valuable natural resources, being vitally important to our health and to the economy. We need clean, affordable, and abundant water not only to protect public health and our environment, but also to power tourism and manufacturing. **Water Action Team Rhinelander (WATR)** was formed in 2020 to address emergent issues with PFAS contamination in our community. We seek to inform the community about potential hazards in our groundwater and in the environment, encourage people to take precautions to reduce exposure to PFAS, communicate potential risks to human health and the environment to facilitate community participation and decision-making, and advocate to our public officials at all levels of government (City–County–State–Federal) for support in our mission to ensure long-term access to clean water resources for the Rhinelander community. Our overall approach focuses on (1) preventing future discharges and exposures, (2) inventorying and minimizing current PFAS exposures, (3) identifying and addressing historic/legacy PFAS discharges, and (4) educating and communicating about risks associate with PFAS. As we empower the community through education and outreach on PFAS research, we encourage:

- Research to understand PFAS compounds in the environment and impacts to the environment
- Elected officials and government agencies to develop solution-oriented policies
- Industry development of remediation and treatment solutions
- Solutions that benefit not only Rhinelander, but other communities with similar concerns.



For more information, please follow WATR on Facebook:

<https://www.facebook.com/groups/529877514627983>

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Typical PFAS Compounds Tested For

Perfluoro-n-pentanoic acid (PFPeA)	N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)
Perfluoro-1-butanefulfonate (PFBS)	N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)
1H,1H,2H,2H-Perfluorohexane sulphononic acid (4:2 FTSA)	Perfluorooctanesulphonamide (FOSA)
Perfluoro-n-hexanoic acid (PFHxA) 0.140 0.40	Perfluoro-n-undecanoic acid (PFUnA)
Perfluoro-1-pentanesulfonate (PFPeS)	Perfluoro-1-decanesulfonate (PFDS)
Perfluoro-n-heptanoic acid (PFHpA)	Perfluoro-n-dodecanoic acid (PFDoA)
Perfluoro-1-hexanesulfonate (PFHxS)	1H,1H,2H,2H-Perfluorododecane sulphononic acid (10:2 FTSA)
Dodecafluoro-3H-4,8-dioxanoanoate (DONA)	Perfluoro-1-dodecanesulfonate (PFDoS)
Perfluoro-n-octanoic acid (PFOA)	N-Methyl Perfluorooctanesulfonamide (N-MeFOSA)
Perfluoro-1-heptanesulfonate (PFHpS)	2-(N-methylperfluoro-1-octanesulfonamido)-ethanol (N-MeFOSE)
Perfluoro-1-octanesulfonate (PFOS)	2-(N-methylperfluoro-1-octanesulfonamido)-ethanol (N-MeFOSE)
Perfluoro-n-nonanoic acid (PFNA)	N-Ethyl Perfluorooctanesulfonamide (N-EtFOSA)
1H,1H,2H,2H-Perfluorodecanesulphononic acid (8:2 FTSA)	Perfluoro-n-tetradecanoic acid (PFTeDA)
Perfluoro-n-octadecanoic acid (PFODA)	Perfluoro-n-hexadecanoic acid (PFHxDA)

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