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MCEA

MINNESOTA CENTER FOR ENVIRONMENTAL ADVOCACY

Forever Chemicals in our Wastewater

How Minnesota can build on the PFAS source reduction laws passed in 2023

Report Authors: Carly Griffith, *MCEA Water Program Director*, Jay Eidsness, *MCEA Staff Attorney*, Heidi Guenther, *MCEA Legal Fellow*

Feature Section Author: Dr. Matt Simcik, *University of Minnesota, School of Public Health*

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Minnesota Center for Environmental Advocacy

Introduction

This report outlines why wastewater streams are critical to the broader per- and polyfluoroalkyl substances ("PFAS") contamination crisis, what legal tools are available to help address this problem, and proactive steps other states have taken to better prevent PFAS contamination from wastewater streams. Minnesota can learn from these approaches and implement a regulatory framework that better protects Minnesota's waters, land, and wildlife from PFAS contamination, and helps secure Minnesota's communities from further damage caused by the toxic effects of PFAS on human health.

MCEA recommendations include:

• Add PFAS as a pollutant under the Minnesota Sewage Sludge Management Rule;

• Require wastewater treatment plants to monitor influent, effluent, and land applied biosolids for PFAS so we can better understand the scope of contamination;

• Use pretreatment programs to require industrial dischargers to use best management practices and treatment options to reduce and remove PFAS from industrial wastewater before it reaches municipal wastewater treatment plants;

• Label Class A EQ biosolids sold for public distribution as potential sources of PFAS;

• Investigate sensitive sites (based on soil type/hydrology) where biosolids have been land applied for decades for legacy soil and groundwater contamination;

• Require PFAS data in the environmental review (Minnesota Environmental Policy Act) process, such as the Met Council wastewater treatment plant's proposed addition of a fourth incinerator;

• Monitor ambient groundwater for PFAS contamination from landfill leachate and land applied biosolids;

• Develop strong statewide Class 1 Water Quality Standards that mirror the proposed federal Maximum Contaminant Levels (MCLs) for 6 PFAS compounds.

PFAS are the emergent contaminants of our time. Known colloquially as "forever chemicals," PFAS are a family of over 1,000 synthetic chemicals that have been used for decades to make products that resist heat, oil, stains, grease, and water. One of the largest corporate manufacturers of these chemicals, 3M, is based here in Minnesota, and since the 1950s, 3M has been at the epicenter of the production and global circulation of these substances.[1]

Today, PFAS are ubiquitous in our environment and have been detected at dangerous levels in water, soils, and wildlife across the world. PFAS dissolve in water and bioaccumulate, which means that they build up in humans, fish, and animals over time.[2] Elevated levels of PFAS have been correlated with human health impacts such as adverse birth outcomes, thyroid disease, various forms of cancer, and more. In a recent proposed rule, the EPA determined that two of the most common PFAS compounds, PFOA and PFOS, are "likely to be carcinogenic" to humans, with safe levels measured in shockingly small amounts of parts per trillion.[3]

Minnesota took a decisive step forward on PFAS contamination in the 2023 legislative session, when the state passed some of the strongest source reduction laws in the country.

Pictured: MCEA Legislative Director Andrea Lovoll speaking at a press conference after the passage of Amara's law, which banned the non-essential use of PFAS and required reporting of the use of PFAS.

The laws passed in 2023 will "turn off the tap" on intentionally added PFAS in common consumer products such as carpets/rugs, cookware, cosmetics, dental floss, and juvenile products.[4] They will also require manufacturers to disclose to the Minnesota Pollution Control Agency when PFAS has been intentionally added to their products.[5]

PFAS is incredibly difficult to remove once it's in the environment, so Minnesota's source reduction laws are a critical step forward in our statewide approach to PFAS contamination. However, more work remains to be done. The next frontier is to use our bedrock environmental laws, such as the Clean Water Act, to regulate PFAS pollution from wastewater streams and remediate the PFAS that is already in the environment.

Why are wastewater streams so important? We need to better regulate wastewater streams for PFAS pollution because wastewater treatment plants are one of the primary pathways of PFAS into the environment.

There are two main ways this happens:

1) through direct discharge of PFAS-contaminated wastewater to lakes, rivers, and streams; and

2) through soil and groundwater contamination from the land application of sewage sludge, or biosolids, produced in the wastewater treatment process or through landfill leachate.

In a report released in June of 2023, MPCA said that clean-up costs for PFAS contamination in wastewater streams across Minnesota over the next twenty years are likely to range from $14 to 28 billion[6]. We need to ensure that those costs are borne by the responsible parties to the extent possible, through tools like PFAS pollution limits in wastewater permits and pre-treatment programs that require industrial dischargers to treat PFAS contaminated wastewater before it is sent to municipal wastewater treatment plants.

When these sources of contamination are not regulated, the public ends up bearing the costs of contamination. We can see the brunt of these costs in the exorbitant treatment costs that water utilities across the country face to make water safe for human consumption, in the tragic stories of "cancer clusters" at places like Tartan High School in the East Metro region, and in rural communities that have had to deal with the forced closure of farms because of soil and groundwater contamination from biosolids.

Two primary paths for ongoing PFAS pollution

Direct discharge

Influent refers to the raw, untreated wastewater that flows into the wastewater treatment plants, and effluent refers to the treated water that is discharged from the wastewater treatment plants into surface waters like lakes and rivers. In Minnesota, wastewater treatment plants discharge effluent into waterbodies like the Mississippi River and Lake Superior.

TREATED WASTEWATER DISCHARGED INTO WATERBODIES

Land application

In the wastewater treatment process, the liquids are separated from the solids. The solids are either incinerated or chemically treated to produce a nutrient-rich product known as biosolids or sewage sludge. This product is then sold to the public as garden/lawn fertilizer or farmers can apply for a land application permit to apply biosolids in bulk as a crop fertilizer. Landfills are another disposal method for sewage sludge.

BYPRODUCT OF WASTEWATER TREATMENT SPREAD AS FERTILIZER

I. The PFAS Problem

Why these synthetic chemicals have created a public health threat across the state, across the nation, and across the world.

PFAS compounds replace the common carbon-hydrogen bond with a carbon-fluorine bond—one of the strongest bonds in organic chemistry—which makes them resistant to heat, water, and oil.[7] For decades, PFAS have been added to raincoats, cookware, dental floss, carpets, medical devices, mascara, and thousands more consumer products. PFAS has also been a key component of firefighting foams used for fire suppression across the country.

However, the same characteristics that made PFAS a prized chemical in industry also allow them to remain stable in the natural environment. PFAS chemicals do not degrade in the environment, are water soluble, and bioaccumulate in humans, fish, and animals. These compounds have been found in the blood of polar bears, Norwegian arctic ice, and rainfall in Antarctica and the Tibetan Plateau. In addition to their ubiquity, elevated levels of PFAS have been correlated with impacts to human memory,[8] heart development,[9] and myriad other adverse health effects such as thyroid disease,[10] kidney cancer,[11] hypercholesterolemia,[12] and more.[13]

In August of 2023, the U.S. Geological Survey released a study that tested tap water from 716 private wells and public water supplies across the country and found PFAS in at least 45% of the faucets it sampled from.[14] *PFAS is a national and a global problem.*

PFAS in Minnesota

Here in Minnesota, the most prominent PFAS hotspot is the groundwater near 3M's global headquarters in the East Twin Cities Metro region. This area is now home to one of the country's largest PFAS contamination plumes, caused by waste disposal from four nearby 3M sites in Washington County.[15] In addition, discharges from the 3M wastewater treatment plant in Cottage Grove have polluted the Mississippi River.[16] The human toll from PFAS in Minnesota is evident in places like Tartan High School, which drew its water from the contaminated aquifer, and where a group of high school students who suffered from various forms of cancers called themselves the "cancer cluster." One of those students, Amara Strande, passed away in April of 2023 from a rare form of cancer. She was 20 years old.

Unfortunately, the impacts of PFAS in Minnesota extend far beyond the Twin Cities Metropolitan Area and affect nearly every corner of the state. PFAS has been detected in groundwater at 100 closed landfill sites across the state. At 62 of those landfills, the detection level exceeded state health standards, while at 10 landfills located from Northeastern to Southern Minnesota PFAS levels were over 10 times the state health standard.[17] Parts of the Mississippi River, Lake Elmo, and dozens more waterways across the state have fish consumption advisories that caution people not to eat fish due to PFAS contamination.[18] PFAS has even reached our region's most pristine water resource, Lake Superior, where fish consumption advisories are in place for smelt due to high concentrations of PFOS, one of the legacy PFAS best understood by the scientific community.

In 2013, MPCA tested nearly 200 wells across the state through its ambient groundwater program and found one or more types of PFAS in 69% of sample sites, with detection clustered in urban areas like the Twin Cities Metropolitan Area, Brainerd, and St. Cloud.[19]

PFAS Drinking Water Regulation

The Minnesota Department of Health ("MDH") has a voluntary program to monitor community water systems across the state for PFAS contamination. Approximately 95% of community water systems chose to participate in this program, which found at least four communities in Greater Minnesota that exceed the state's current Health Risk Index ("HRI") for PFAS: Roosevelt Court, Swanville, Waite Park, and Sauk City.[20] The MDH monitoring program did not include tribal water systems, and new sites of contamination continue to be discovered: in February of 2023, the Leech Lake Band of Ojibwe had to shut down one of its school water systems because of PFAS contamination discovered by the EPA.[21]

In March of 2023, the U.S. Environmental Protection Agency ("EPA") proposed national drinking water standards, called Maximum Contaminant Levels ("MCLs"), for six PFAS compounds at near non-detection levels under the Safe Drinking Water Act. If the rule is adopted as proposed, all public water systems–which serve approximately 90% of Americans–must deliver drinking water that is nearly free from the most toxic and well-studied PFAS. The proposed standards are much lower than Minnesota's current Health Based Values ("HBV"). The proposed MCL for PFOS and PFOA is 4 parts per trillion ("ppt"), and the EPA has recommended a Hazard Index approach to look at the additive risk from mixtures of four additional PFAS: GenX, PFBS, PFNA, and PFHxS.[22] The public health benefits of this proposed rule are enormous.

MDH has since begun to re-evaluate its guidance values for PFOS and PFOA, which means that the number of community water systems above the state Health Risk Index will likely be much higher than the four identified above.

Fish consumption advisories are put in place to notify the public that specific contaminants have been found in a water body and its organisms at levels that are unsafe to eat for certain populations. PFAS, like other contaminants such as mercury, can bioaccumulate in different species. This means that the further up the food chain a species is, the more likely it is to have larger amounts of these contaminants in its system. Because of this, humans increase their exposure rate if they eat fish from contaminated waters. Most recently, in July of 2023, the Minnesota Department of Health released fish consumption guidance for two Twin Cities area waterbodies - Pool 2 of the Mississippi River and Lake Rebecca - because of PFAS contamination.[23]

MINNESOTA STANDARDS

MDH uses three metrics to assess the health risk of contaminants in drinking water: Health Based Values , Health Risk Limits, and a Health Risk Index.

A Health Based Value ("HBV") ") is the concentration of a chemical (or a mixture of chemicals) that is likely to pose little to no human health risk. HBVs are technical guidance values rather than regulatory rules. They are updated as new toxicology data becomes available. MDH has HBVs for PFBS, PFHxS, PFHxA, PFOA, and PFOS.[24]

A Health Risk Limit ("HRL") is a numeric limit adopted as a rule under the Groundwater Protection Act when a contaminant is detected in the groundwater. Like the HBV, it is the concentration of a contaminant that is likely to pose little to no human health risk. MDH has HRLs for PFBS, PFBA, PFOA, and PFOS.[25]

A Health Risk Index ("HRI") is used when more than one contaminant is found in the water to evaluate the combined risk from chemicals that have similar health effects. MDH relies on its Health Based Values and Health Risk Limits for individual substances to base this "additive" numerical assessment.

FEDERAL STANDARDS

EPA sets Maximum Contaminant Levels ("MCLs") and Hazard Indexes to establish standards for the levels of pollutants that can be in drinking water.

In March of 2023, EPA proposed MCLs and a Hazard Index for 6 PFAS compounds: PFOA, PFOS, PFHsX, GenX, PFNA, and PFBS. If these proposed regulations are adopted as rules, they will become enforceable standards for water utilities across the country.

Maximum Contaminant Level Goals ("MCLGs"): Establishes the level at which there are no known or anticipated adverse health effects and includes a margin of safety. The EPA has proposed a MCLG of 0 parts per trillion (ppt) for both PFOS and PFOA.

Maximum Contaminant Levels ("MCLs"): The enforceable standard at which EPA sets drinking water contaminant levels. MCLs are set as technologically and feasibly close to the MCLGs as possible. The EPA has proposed an MCL of 4 ppt for PFOS and PFOA.

Hazard Index: An enforceable standard that uses an additive risk framework to evaluate the health risks from exposure to chemical mixtures. The EPA has proposed a Hazard Index of 1.0 that aggregates numeric limits for PFHsX, GenX, PFNA, and PFBS.

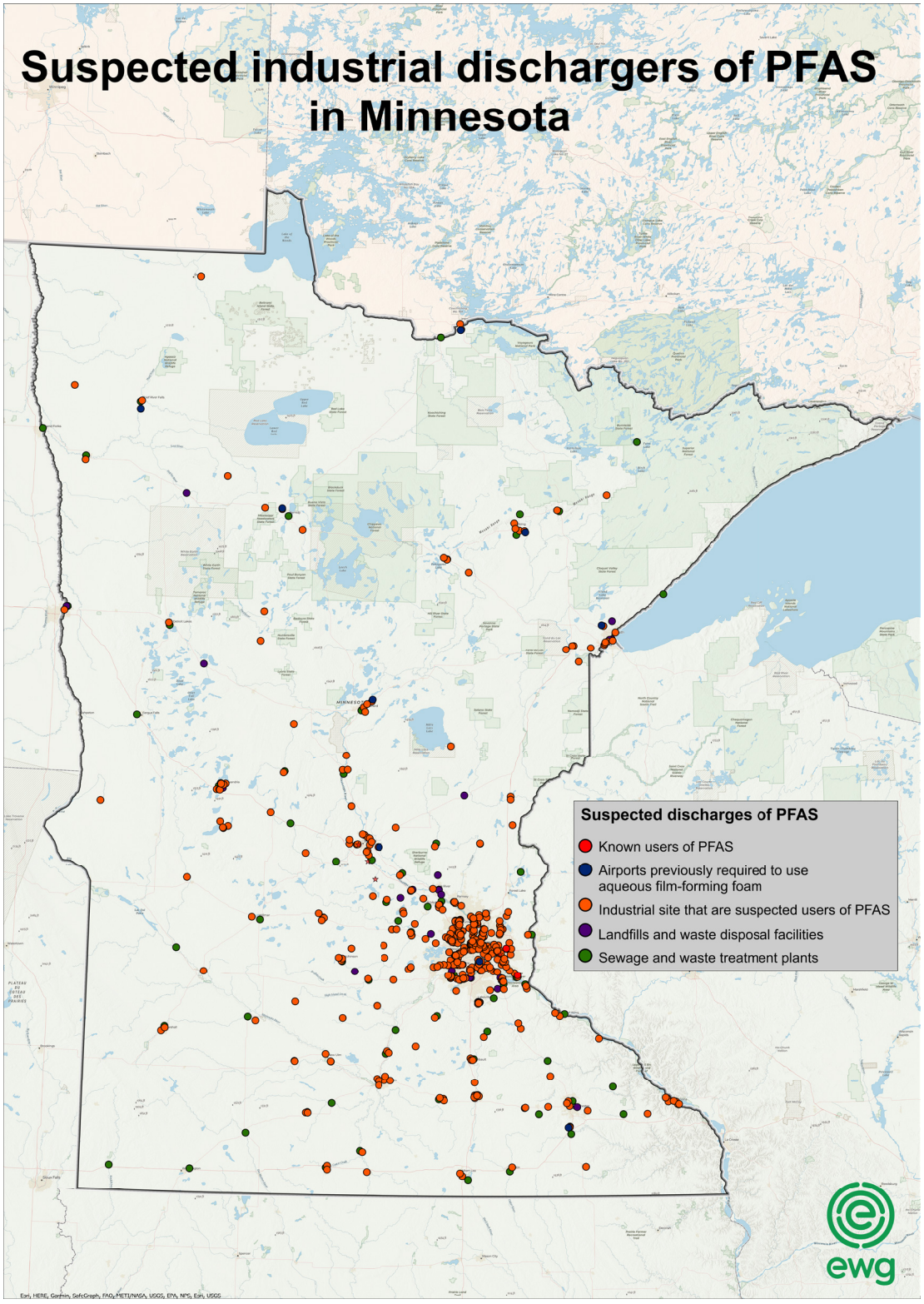
II. PFAS in Wastewater

Wastewater treatment plants are one of the primary pathways for PFAS contamination in our waterways, because they collect and process wastewater from industrial users that are themselves suspected dischargers of PFAS. State and federal regulators have identified 50 classifications of businesses that are "likely to use, emit, or discharge PFAS," including chrome plating facilities, textile mills, paint and varnish manufacturers, and waste treatment facilities.[26] Some of these facilities, like chrome plating facilities and certain manufacturers, are deemed "sources" of PFAS because PFAS is used as a part of the manufacturing or industrial process. Other facilities, such as landfills and wastewater treatment plants, are considered "conduits" of PFAS because they receive PFAS waste from other sources.

The wastewater treatment process was designed to remove pollutants such as heavy metals and pathogens like E. Coli and salmonella from our water. However, traditional treatment technologies are not able to remove PFAS substances because of the strength of their carbon fluorine bond. Even traditional incineration facilities do not generate high enough heat to break apart PFAS' signature bond.

St. Louis Park Chrome Plating Facility Agrees to Pay $1.375 Million for Polluting Minneapolis Chain of Lakes

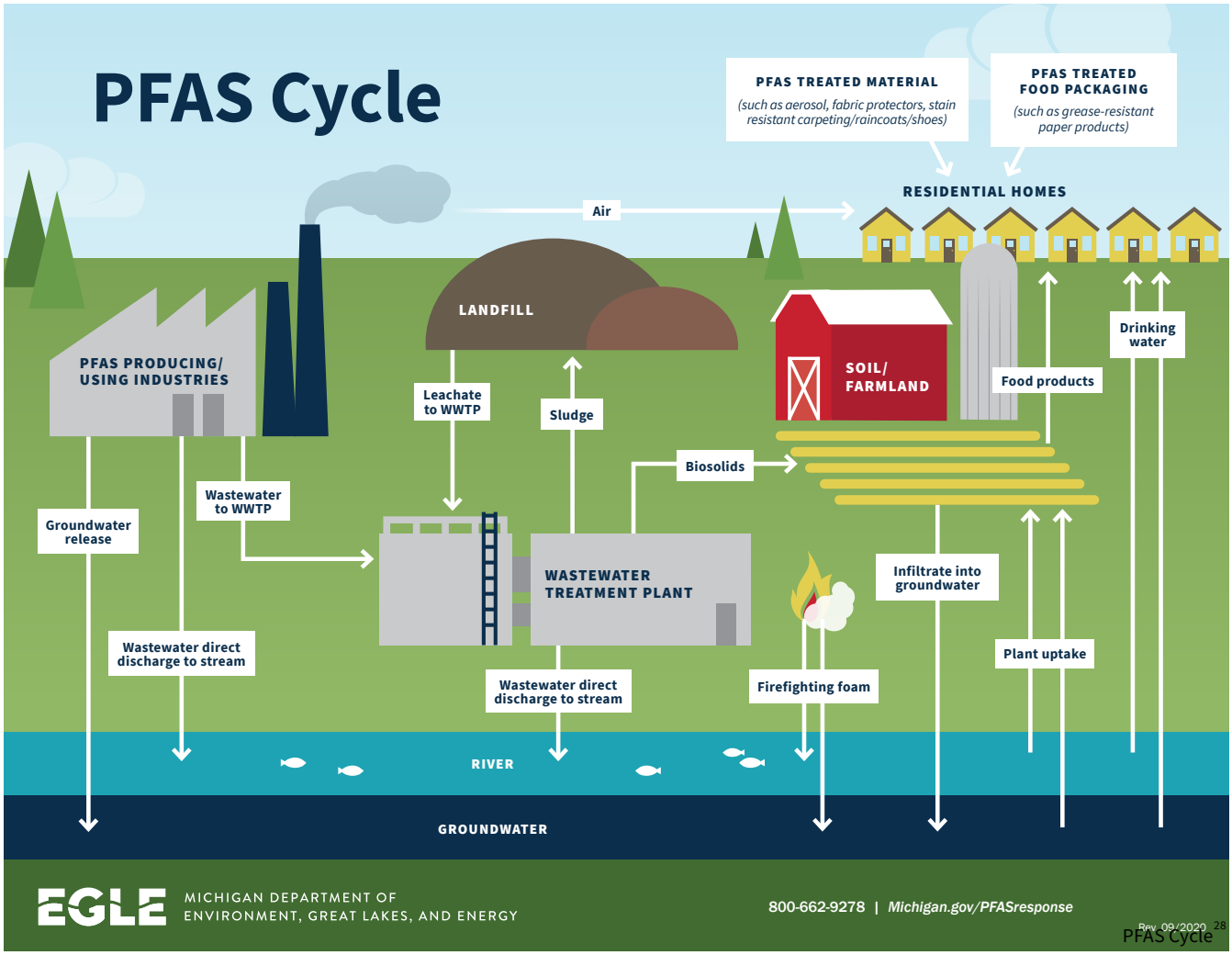
In May of 2023, Douglas Corporation agreed to settle charges that PFAS escaped from its St. Louis Park facility and damaged natural resources, including Bde Maka Ska and Lake Harriet. PFAS are widely used in the metal plating and finishing industries to inhibit corrosion and protect base materials. The investigation began in 2004, where regulators detected elevated levels of PFOS in Bde Maka Ska. Through investigation of nearby stormwater systems, regulators believe that PFOS passed through Douglas Corporation's heating and ventilation system and settled on the roof, where it was eventually brought down to the ground through stormwater and snow melt.[27]


Suspected industrial dischargers of PFAS in Minnesota
Suspected discharges of PFAS
Known users of PFAS
Airports previously required to use aqueous film-forming foam
Industrial site that are suspected users of PFAS
Landfills and waste disposal facilities
Sewage and waste treatment plants
ewg

The Wastewater Treatment Process: Nuts and Bolts

Influent refers to the raw, untreated wastewater that flows into the wastewater treatment plants, and effluent refers to the treated water that is discharged from the wastewater treatment plant into surface waters like lakes and rivers.

In the wastewater treatment process, the liquids are separated from the solids. The solids are either incinerated or chemically treated to produce a nutrient-rich product known as biosolids or sewage sludge. This product is then sold to the public as garden/lawn fertilizer (Class A EQ biosolids) or farmers can apply for a land application permit to apply biosolids in bulk as a crop fertilizer. Landfills are another disposal method for biosolids.



PFAS Cycle

III. PFAS in Biosolids

In Minnesota, many wastewater treatment plants distribute biosolids in bulk to land apply on agricultural fields as a crop fertilizer. In 2018, approximately 44,300 dry tons of biosolids were distributed to the public or land applied as crop fertilizer across the state, with hot spots in areas like St. Cloud. Of that amount, 13,335 dry tons were distributed to the public as Class A EQ biosolids.[29] Overall, about 22% of biosolids in Minnesota are applied to agricultural land as a crop fertilizer, from 171 different wastewater treatment plants.[30]

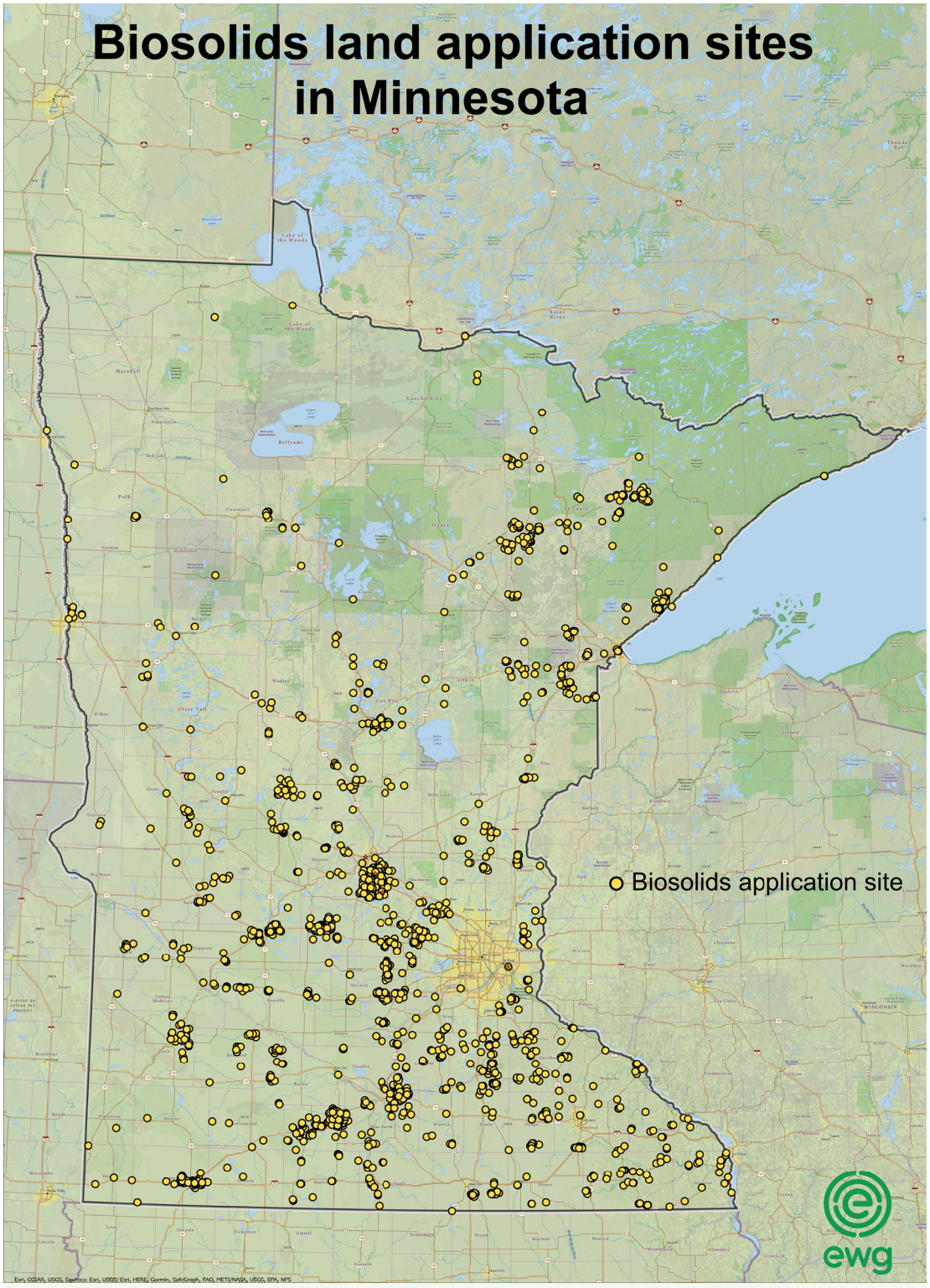
When a wastewater treatment plant's influent is contaminated with PFAS, so are its biosolids. In fact, the concentration of certain PFAS, like PFOS, tend to be higher in biosolids samples than in influent samples, as demonstrated by undated MPCA samples of wastewater influent, effluent, and biosolids at 31 wastewater treatment plants for PFOS concentrations. In these samples, the PFOS concentrations found in the biosolids samples jumped astronomically when compared to the influent samples (the wastewater that comes into the facilities). Across all 31 samples, the median PFOS concentration for influent was 35 ppt, and for sewage sludge it was 25,000 ppt.[31]

None of the other biosolids disposal methods currently used in Minnesota destroy PFAS. In the Twin Cities Metro Region, the majority of biosolids are incinerated, which accounts for 62% of biosolids disposal statewide.[32] However, the incineration process does not currently use high enough temperatures to destroy PFAS, so these compounds are released through incinerator stacks.[33]

To look at the role wastewater streams play as a pathway of PFAS contamination, we worked with public health scientist and University of Minnesota Professor Dr. Matt Simcik to collect water samples at four sites on or near the Mississippi River. These sites targeted two specific wastewater streams: effluent discharge to the Mississippi River, and biosolids land application on fields along tributaries to the Mississippi River.

The sites included:

- The effluent channel of the Metropolitan Wastewater Treatment Plant in Saint Paul and the Mississippi River directly upstream of the effluent channel
- Three tributaries to the Mississippi River in St. Cloud: Johnson Creek, Clearwater River, and Sauk River



Biosolids are regulated by the EPA, and states can adopt more stringent standards. Currently, there are no PFAS regulations for biosolids at the federal level or in Minnesota.

Feature Section: Wastewater Streams and Water Quality in Minnesota

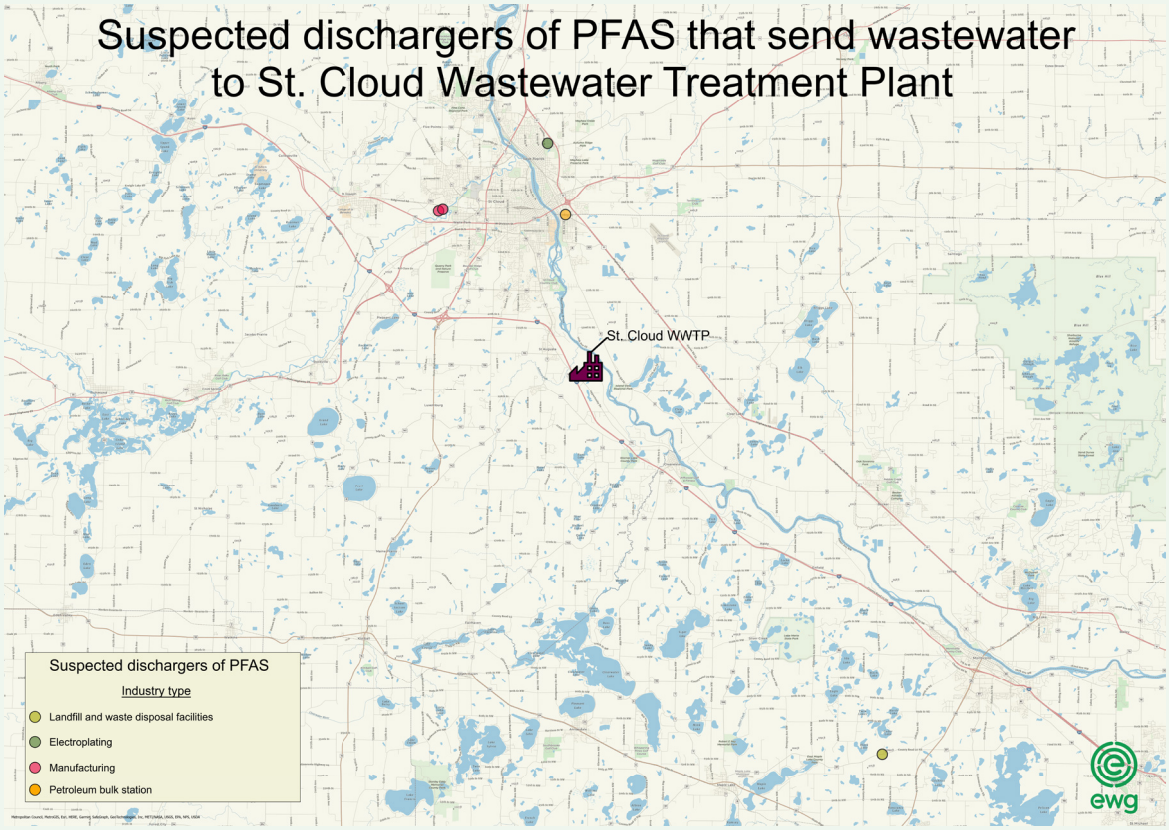
Author: Dr. Matt Simcik

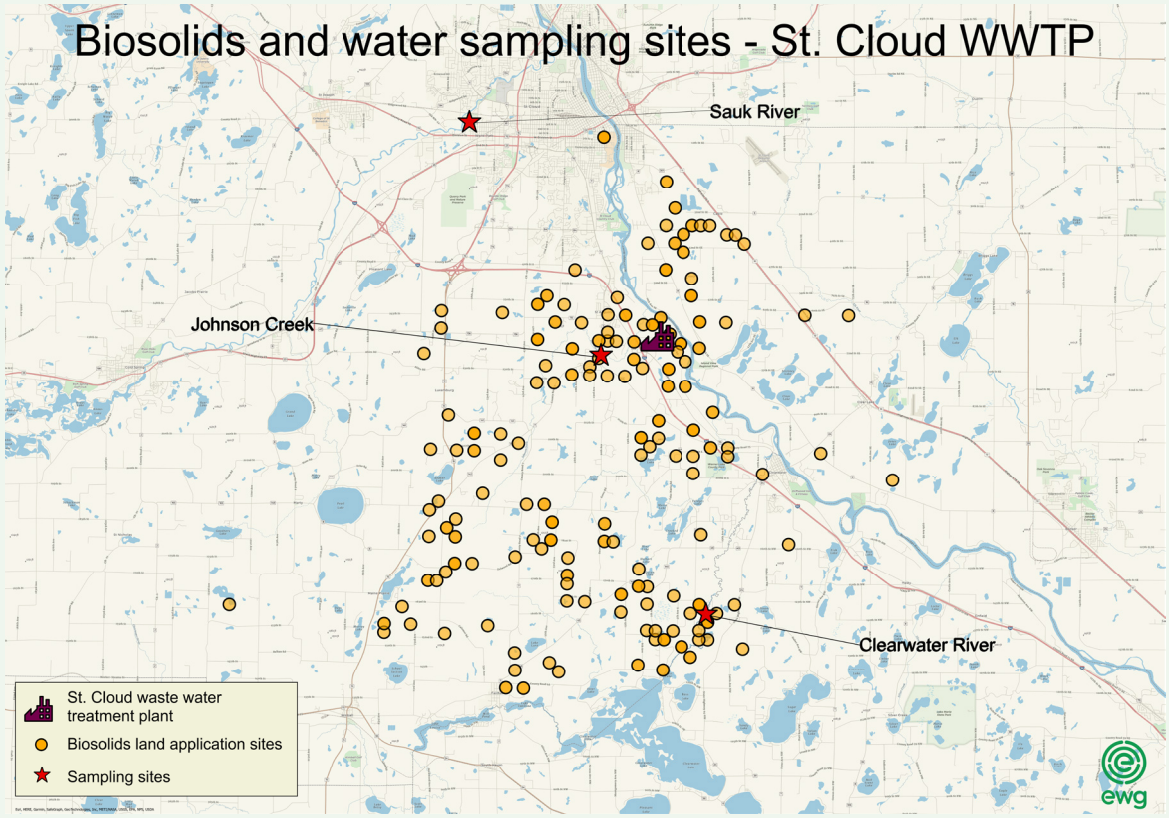
Professor, Division of Environmental Health Sciences, University of Minnesota, School of Public Health

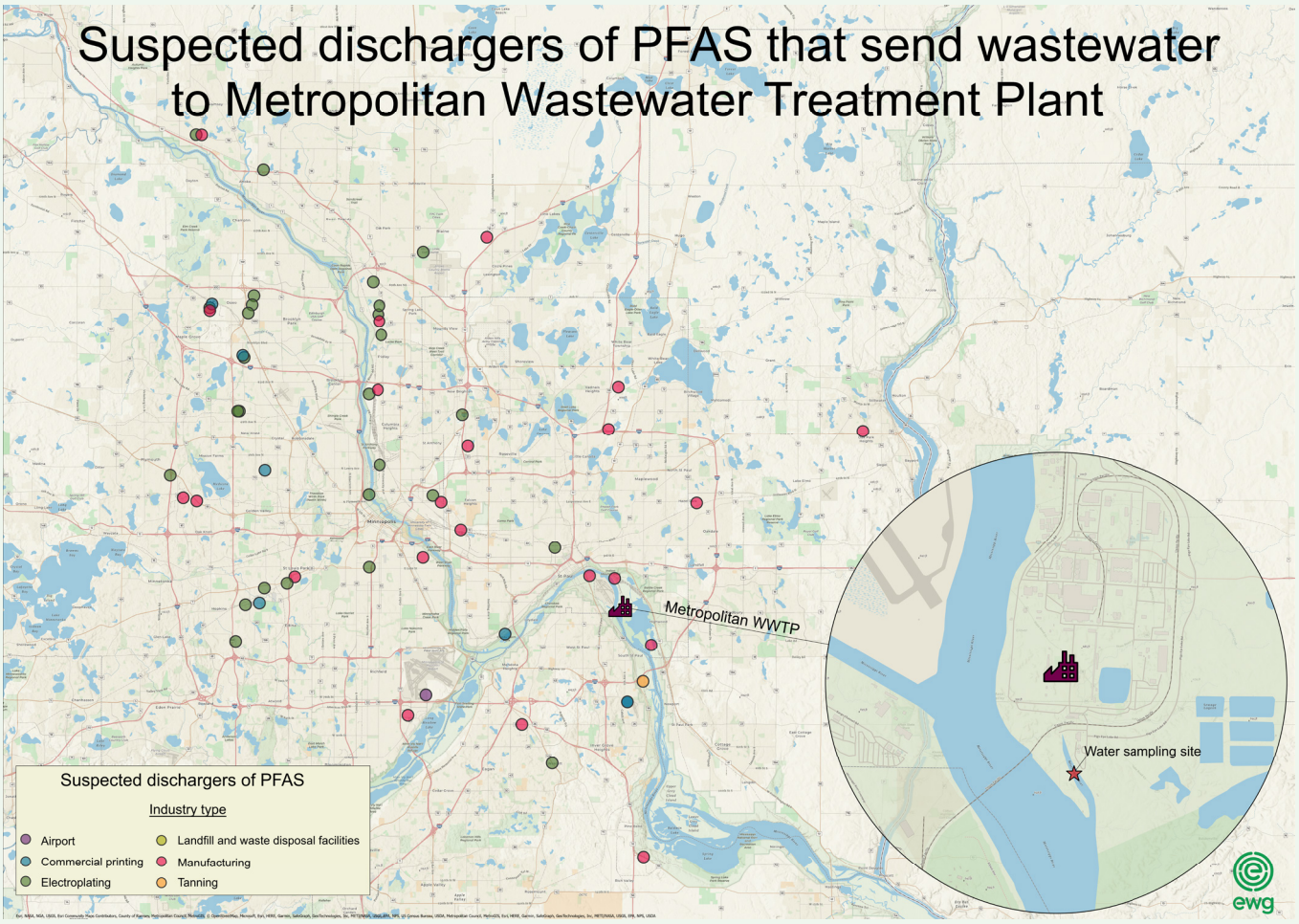
PFAS production in the United States changed earlier this century. Longer chain PFAS (with more than 8 carbon atoms) were replaced by shorter chain PFAS (with fewer than 5 carbon atoms). An example is the replacement of PFOS with PFBS. While short-chain PFAS were also produced earlier, their production increased when used as replacements. Therefore, samples higher in long-chain PFAS represent older source material, whereas samples higher in short-chain PFAS represent newer sources. Some PFAS are considered precursors and converted into others like those found in this study within the wastewater treatment plant.

Wastewater treatment plants are designed to remove three major contaminants: biochemical oxygen demand (BOD), which is essentially organic matter, particles and pathogens. The most common method for removal of these is activated sludge treatment where soil microbes are used in the plant and fed air and waste to chew up the material. This creates its own source of particles through dying microbes and digested organic matter waste. These particles settle out into sludge and are removed from the plant. The sludge can be treated to remove pathogenic organisms (usually through heat and UV by exposure to the sun) transforming it into biosolids.

Municipal wastewater treatment plants are not designed to remove anthropogenic chemicals like PFAS that are present at trace levels. In the plant, PFAS can partition between activated sludge and dissolved phase. Dissolved PFAS leaves the plant to receiving waters through the effluent. PFAS that binds to sludge remains in the biosolids. Many biosolids get applied to soils as a source of organic matter and nitrogen. These soils include agricultural fields, municipal fields, and can even be applied to residential areas as many biosolids are sold in home centers as milorganite, which gets its name from Milwaukee organic matter and nitrogen. The only readily practiced alternative is to burn biosolids. This is usually done as energy recovery, which does not destroy PFAS. No wastewater treatment plant incinerates their biosolids at a temperature high enough to destroy PFAS. A very expensive option is to landfill the biosolids in a lined landfill that would prevent leaching of PFAS into groundwater. Most wastewater treatment plants in the United States land apply their biosolids.


Suspected dischargers of PFAS that send wastewater to St. Cloud Wastewater Treatment Plant
St. Cloud WWTP
Suspected dischargers of PFAS
Industry type
Landfill and waste disposal facilities
Electroplating
Manufacturing
Petroleum bulk station
ewg


Biosolids and water sampling sites - St. Cloud WWTP
Sauk River
Johnson Creek
Clearwater River
St. Cloud waste water treatment plant
Biosolids land application sites
Sampling sites
ewg



Once applied to soils, PFAS can leach from the fields and enter receiving waters (both groundwater and surface water). PFAS can also be discharged directly from wastewater treatment plants into receiving waters through their effluent. However, because MPCA does not require wastewater treatment plants to monitor biosolids or effluent for PFAS, the extent of contamination from these wastewater sources is largely unknown. In order to try and address this question. We sampled the Mississippi River upstream of a major municipal wastewater treatment facility and directly in the channel receiving its effluent. We also sampled three small rivers in Central Minnesota that had varying degrees of biosolids application to their watersheds. Each of these rivers flow into the Mississippi River, upstream of the sampling sites on that river. The dissolved phase of these waters were analyzed from each collection point in triplicate to determine the concentration of 19 PFAS including five of the six for which there is a maximum contaminant level (MCL) proposed by the USEPA: perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS), perfluorononanoic acid (PFNA), perfluorohexane sulfonate (PFHxS) and perfluorobutane sulfonate (PFBS). The only PFAS on the list not analyzed was Gen-X.

The total PFAS concentration (sum of 19 individual compounds) varied by location. The highest concentration was observed in the channel receiving effluent from the Metro Plant in St. Paul (Figure 1). This concentration was dominated by PFBS (Figure 2), however even if one were to ignore PFBS, this site would still have the highest concentration of PFAS. The second highest concentration of total PFAS was in Clearwater River in Central Minnesota and the Mississippi River upstream of the St. Cloud wastewater treatment plant. Clearwater River receives the greatest number of biosolids applications within its watershed. It is not surprising that the Mississippi River upstream of the wastewater treatment plant would have slightly lower concentrations than Clearwater River because much of the rest of the watershed upstream of that sampling point does not contain biosolids application sites. The lowest concentration of PFAS was found for the Sauk River, a watershed that did not receive biosolids applications.

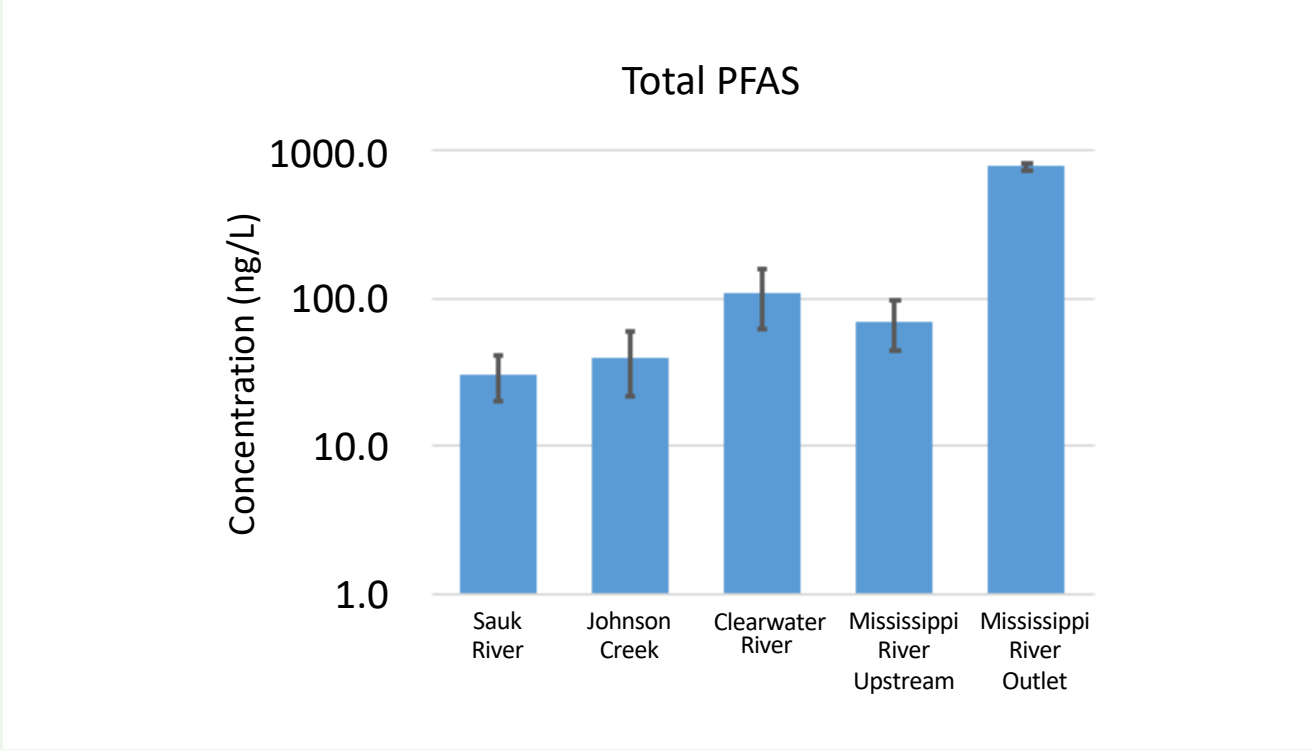


Figure 1. Concentrations (ng/L) of total PFAS (sum of 19 individual compounds) in Rivers in Minnesota.

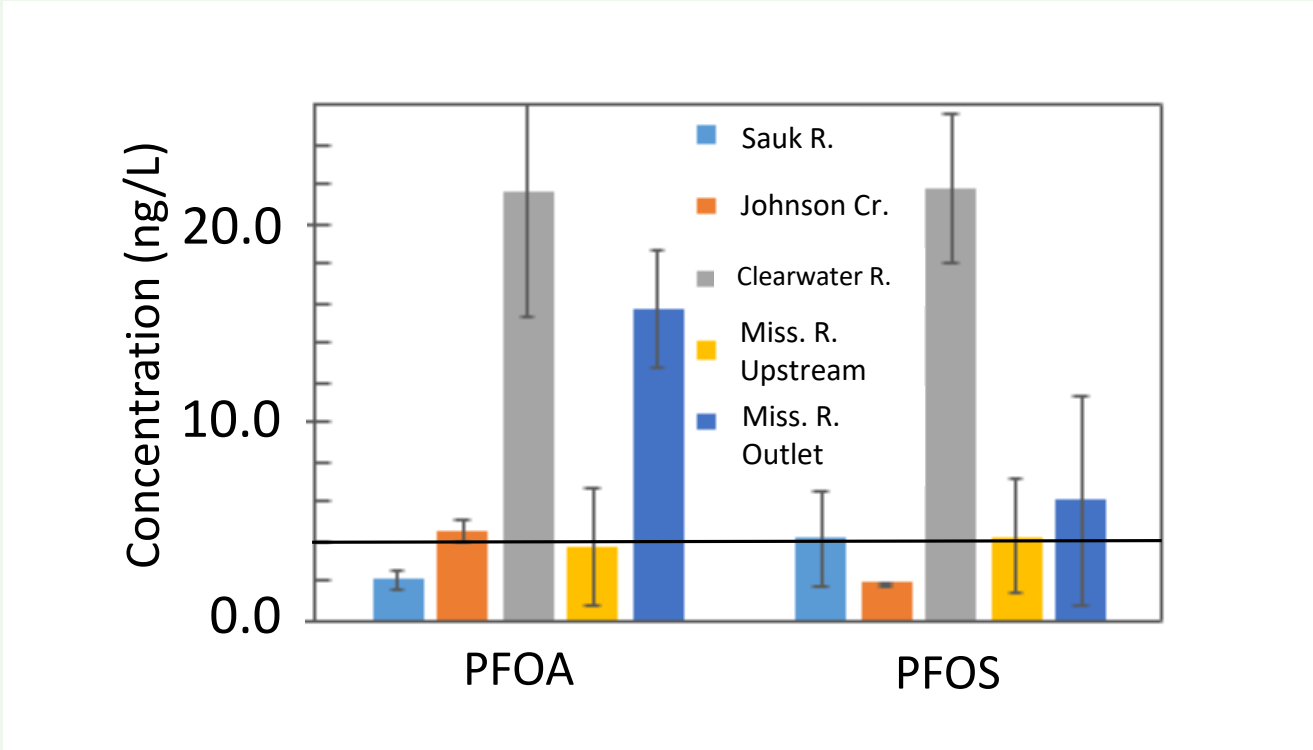


Figure 2. Concentrations (ng/L) of PFOA and PFOS (MCL of 4.0 ng/L indicated by line).

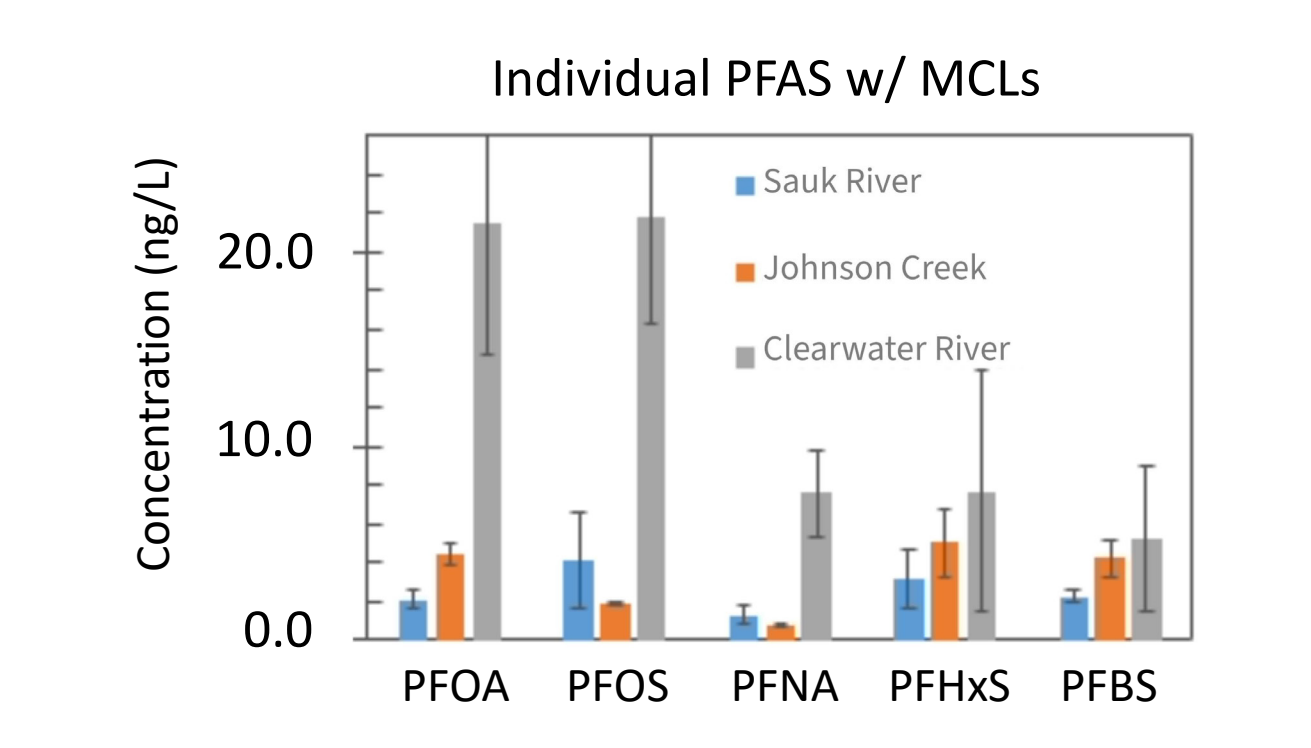


Figure 3. Concentrations (ng/L) of PFAS in St. Cloud waterbodies for which there is a MCL of 4.0 ng/L (indicated by line).

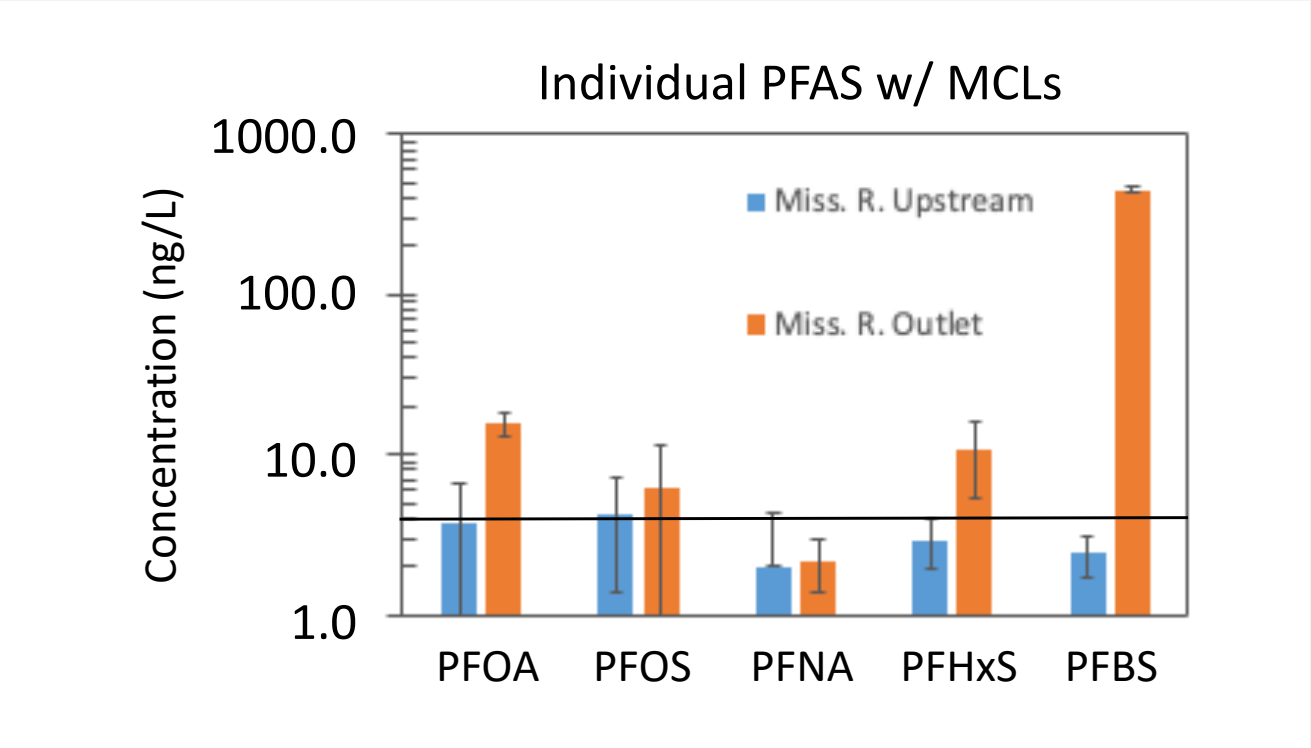


Figure 4. Concentrations (ng/L) of PFAS in the Mississippi River for which there is a MCL of 4.0 ng/L (indicated by line).

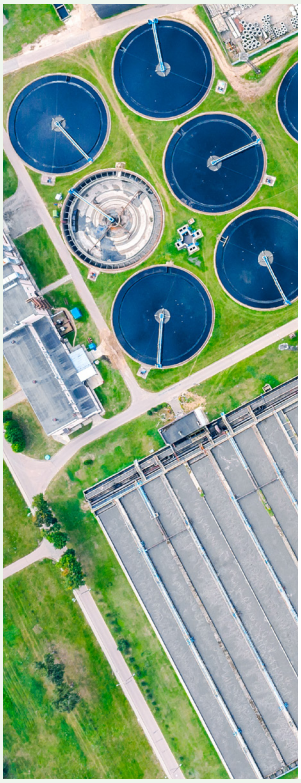
PFAS Production

Two PFAS that are of greatest environmental and toxicological concern are PFOA and PFOS. Clearwater River and the outlet of the St. Paul wastewater treatment plant are above the proposed MCL of 4.0 ng/L, while the other sites are at or below the MCL (Figure 2). In fact, Clearwater River is higher than the outlet of the St. Paul wastewater treatment plant, indicating that historical biosolids application could be a larger source of PFOA and PFOS to a watershed than current effluent from a wastewater treatment plant. The lack of PFOA and PFOS from rivers without high biosolids application in their watersheds indicates a lack of other sources to those rivers.

Many of the five PFAS for which there is a proposed maximum contaminant level (MCL) analyzed in this study were found above the proposed federal limit of 4.0 ng/L (Figure 3). The St. Cloud river with the fewest exceedances of that standard was the Sauk River, which as stated earlier does not have biosolids application in its watershed. The greatest exceedances were for Clearwater River. Again, this is not surprising given the numerous biosolids application sites in the watershed of Clearwater River.

Samples from the Mississippi River indicate a higher concentration of PFAS from the outlet of the St. Paul wastewater treatment plant with most exceeding the MCL (Figure 4). The dominant PFAS is PFBS. As mentioned earlier, PFBS is a short-chained PFAS that has been used as a replacement for PFOS. Therefore, it is not surprising that effluent from a wastewater treatment plant would be high in PFBS as it may still be in use by customers sending their waste to the plant.

It is clear from the data of this study that both wastewater treatment plant effluent and biosolids application to soils are significant sources of PFAS to watersheds in Minnesota. Because PFAS use is not limited to Minnesota, these sources are expected to be relevant across the country. It is imperative that we develop improved wastewater treatment technology to remove trace pollutants such as PFAS without diminishing the ability of the plants to remove BOD, particles and pathogens. In the interim, applying biosolids to agricultural fields where PFAS can be taken up by plants and leach into ground and surface waters should be reconsidered as a disposal technique for these materials. Furthermore, burning of biosolids is not a viable destruction technique for PFAS unless the temperatures are much higher than currently in practice.



EPA Biosolid Regulation

Biosolids have been regulated by the EPA under the Clean Water Act since 1993. Nationwide, biosolids are either land applied as fertilizer and soil amendments, placed in landfills, or incinerated.[34] The EPA regulates biosolids through 40 CFR Part 503, Standards for the Use or Disposal of Sewage Sludge. Under this rule, the EPA has the authority to set pollutant limits for hazardous or toxic components of biosolids that pose harm to human health and the environment. Currently, the EPA only sets pollutant limits for nine heavy metals. In 2018, the EPA Inspector General released a Report on the Biosolids Program that identified 352 unregulated pollutants in biosolids, of which 61 were acutely hazardous, hazardous or priority pollutants in other EPA programs.[35] The EPA conducts a review of pollutants in biosolids every two years, which includes risk assessments, public data on pollutants found in biosolids, and identification of which pollutants exceed EPA's concern levels or pose a risk to human health.[36] This review then informs whether any pollutants should be updated in Part 503. Prompted by this review process, the EPA has announced that it will finalize a risk assessment for PFOS and PFOA in sewage sludge by the winter of 2024. Until this time, there are no federal risk assessments or limits for any PFAS substances found in biosolids. Which means that it is up to states and tribal governments to address PFAS in biosolids.

IV. Soil and Groundwater Contamination from Biosolids

Over the past 10 years, data has shown that the land application of biosolids is directly tied to the PFAS contamination of soil and groundwater. At this point, we can no longer ignore the reality that when you look for PFAS contamination from wastewater streams like biosolids, you will find it.

The discovery of PFAS contamination from land applied biosolids has led to devastating consequences for rural communities across the country. In 2016, a family farm in Maine voluntarily participated in an EPA program that found PFAS contamination on their farm linked to biosolids land application. PFAS was found in their cows and their milk supply, as well as the husband and wife's blood, and they were forced to close their multi-generational farm without any compensation for the chemical contamination.[37] Maine initiated a program to test sewage sludge from different wastewater treatment plants across the state and found at least one PFAS chemical in all 44 samples they collected. The results led to the 2022 passage of a bill that banned the use of PFAS-contaminated biosolids for land application in the state.[38]

When other states have tested their own wastewater streams, the results have been similar. In Michigan, for example, a 2018 study of 42 municipal wastewater treatment plants found PFAS compounds in virtually all samples, which included influent, effluent, and biosolids.[39] Consistently, PFOA and PFOS concentrations in the effluent and biosolids were higher than in the influent, which once again indicates that the wastewater treatment process itself can increase the concentration of PFAS compounds.

Scientific studies have looked at the impact of long-term application of municipal biosolids on agricultural soils in the United States. What they have found is that biosolids from wastewater treatment plants with higher levels of industrial wastewater are connected to exponentially higher concentrations of long-chain PFAS like PFOA and PFOS in the soil.[40] These results emphasize the need to treat industrial discharges and reduce PFAS before it gets to the wastewater treatment plant, which can be done through pretreatment programs that target significant industrial users. MPCA can leverage its authority under the Clean Water Act permitting programs to require pretreatment for industrial users who send their water to wastewater treatment facilities. The objectives of the pretreatment program are to "prevent the introduction of pollutants into [publicly-owned treatment works (POTW)] which will interfere with the operation of a POTW, including interference with its use or disposal of municipal sludge."[41] Pretreatment programs are commonly used to remove the contaminants that the EPA regulates from industrial wastewater, but are not required for PFAS in Minnesota. Other states, like Michigan, have successfully leveraged this authority to address PFAS pollution from industrial sources, and Minnesota can do the same.

Academic research confirms that at sites where biosolids have been land applied for decades, PFAS substances have the ability to leach from the surface, through the soil profile, and into groundwater. In terms of whether PFAS contamination in the soil has the potential to contaminate groundwater, factors like water table depth and soil type are important drivers of risk.[42] Even though they have now largely been phased out of domestic production, legacy PFAS like PFOS and PFOA tend to be found in soil and groundwater in the highest concentrations, because they have been manufactured for the longest. This indicates that historical, long-term use of biosolids to amended soil has a positive correlation with increased levels of PFAS in the soil and in the groundwater below.[43] The research indicates that if we continue to land apply biosolids, we will see more water contamination from newer, short-chain PFAS that have had less time to impact the environment than their legacy counterparts.

PFOS and PFOA are the same two compounds that the EPA found are "likely to be carcinogenic" to humans in the proposed national drinking water regulations. Because Minnesota draws about 80% of its drinking water from groundwater, the inescapable conclusion is that the land application of biosolids can contaminate soil and groundwater with PFAS compounds that endanger public health. This is especially risky for private well owners, who tend to draw their water from shallower aquifers and do not have any of the regulatory protections that people on public water supplies have. Land-applied biosolids also pose significant risks to crops, another pathway for human consumption. Data released by the EPA shows that multiple PFAS substances can transfer into the edible portions of plants when soil is amended with biosolids.[44]

At the state level, agencies and legislatures may enact even stricter regulations for biosolids in land application. Maine and Vermont have revised their state adoption of Part 503 to require measures that address PFAS contamination from biosolids. The approach has been dramatically different in Minnesota. While Minnesota does have state regulations in place for biosolids, none address PFAS. As it currently stands, Minnesota does not consider any PFAS substances to be pollutants under its Sewage Sludge Management Rule, and Minnesota law allows biosolids produced both within and out of state to be applied on agricultural lands with no requirements to test the biosolids or the sites where they are land applied for PFAS contamination.[45] While other states like Maine have launched comprehensive investigations of sites where municipal biosolids were applied to determine the extent of soil and groundwater contamination, Minnesota does not even require municipal wastewater plants to test biosolids for PFAS before they are land applied. In other words, Minnesota is in the dark about the scope of its PFAS problem when it comes to biosolids.

This can be fixed. In its Sewage Sludge Management Rules, MPCA defines a "pollutant" to include any organic or inorganic substance that "after discharge and upon exposure, ingestion, inhalation, or assimilation into an organism either directly from the environment or indirectly by ingestion through the food chain, could, on the basis of information available to the administrator of EPA, cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions . . . or physical deformations. . . ." [46]

Given the concerns identified by the EPA in its proposed MCLs and Hazard Index for six PFAS substances, and its determination that PFOA and PFOS are "likely carcinogenic," these six PFAS compounds fit squarely within MPCA's definition of what should be included as a "pollutant" under the rule.

The data from academic research and other states is clear: until we list PFAS as a pollutant and begin to monitor and test any biosolids that are land applied, we will likely continue to contaminate our soils and groundwater with PFAS. As Minnesota and the federal government work to develop regulations to protect drinking water from PFAS pollution, it is critical that Minnesota take explicit steps available now to address PFAS contamination in biosolids. One of the most immediate and effective ways to do this is to list PFAS as a pollutant under our state Sewage Sludge Management Rules. At a minimum, Minnesota should begin to test municipal biosolids at least annually for PFAS substances that are determined to pose a risk to human health and start to develop more comprehensive data on the risk of PFAS contamination in groundwater from land applied biosolids in different regions of the state.

V. Regulatory Frameworks for Wastewater

Minnesota's Response to PFAS in Wastewater Falls Short of EPA Guidance

At the federal level, EPA has committed to move on multiple fronts to provide regulatory tools to remove PFAS from wastewater streams.[47] One tool, effluent limitation guidelines, will restrict PFAS discharges from industrial sources. Once finalized, industrial sources will be required to institute technology-based pollution limits to remove PFAS from their wastewater discharges. However, it is unclear when EPA will finalize effluent limitation guidelines. In the interim, the agency has encouraged states to use their full authority under the Clean Water Act to control and ultimately reduce the amount of PFAS discharged from permitted facilities.

In December of 2022, EPA released a guidance Memorandum to states as part of its own PFAS Strategic Roadmap. The memo stresses the need for states to use their authority under the Clean Water Act to help wastewater treatment plants reduce PFAS in waste systems. EPA recommends that wastewater treatment plants:

• Monitor influent, effluent, and biosolids for the presence of PFAS at least quarterly;

• Inventory all industrial facilities that are expected or suspected discharges of PFAS. Once the industrial sources are identified, require these industrial sources to monitor their discharges quarterly for the presence of PFAS;

• Use pretreatment program authority to develop local limits, best management practices, or other controls at the industrial facility to control PFAS before it is discharged to the wastewater treatment facility.[48]

States with Clean Water Act authority can **require** wastewater treatment plants to monitor influent, effluent, and biosolids on a quarterly basis – information that will help determine whether pretreatment programs are necessary to reduce and remove PFAS from wastewater influent. Finally, EPA recommends that states with Clean Water Act authority consider site-specific technology-based treatment requirements on a best professional judgment basis and/or water-quality based effluent limits to meet state water quality criteria for PFAS.

The Minnesota Pollution Control Agency is the Clean Water Act Authority in Minnesota

The Clean Water Act is the main federal law governing water pollution, and in Minnesota, the regulatory authority is MPCA. The Clean Water Act functions primarily through a permitting system known as the National Pollutant Discharge Elimination System ("NPDES") permit, which authorizes a facility to discharge pollution into surface water. This permitting system, and the Clean Water Act more broadly, only applies to "point sources," discrete conveyances such as a pipe, ditch, or container. These permits include limits for pollution discharges, monitoring and reporting requirements, and other provisions to ensure the surface water receiving the discharge does not degrade in quality. Minnesota also uses the State Disposal System ("SDS") permitting system to regulate water discharges to protect groundwater, which includes similar limitations, monitoring requirements, and other provisions to ensure groundwater is not adversely impacted from pollution.

In Minnesota, MPCA regulates the design, construction, and operation of industrial and municipal wastewater treatment facilities. Through the NPDES/SDS permit program of the Clean Water Act, MPCA can establish specific limits and requirements to protect Minnesota's surface and groundwater from industrial contamination. This means that MPCA can leverage its NPDES/SDS authority now to ensure that wastewater treatment facilities test and monitor influent, effluent, and biosolids for contaminants like PFAS. MPCA can also require pretreatment programs for industrial users who send their water to wastewater treatment facilities.

Minnesota has declined to follow all of EPA's suggestions. Currently, MPCA does not have any mandatory PFAS pollution control terms in wastewater permits, and MPCA is asking wastewater treatment plants to voluntarily monitor their influent. MPCA's approach is spelled out in a Memorandum of Understanding, where MPCA asks facilities to collect four samples of influent by the end of 2024; inventory industrial users that may be potential contributors of PFAS to the wastewater collection system by the end of 2023; and submit a PFAS Pollutant Management Plan to MPCA by March of 2024 to identify pollution prevention strategies. MPCA is not, however, requiring these facilities to test their effluent or biosolids or requiring any PFAS limits be included directly in the NPDES permit. Additionally, either MPCA or the wastewater treatment facility can terminate the MOU at any time for any reason, eroding what little confidence there is that MPCA is doing everything to tackle this problem.

Despite federal guidance and success stories from places like Michigan (detailed Section VI), Minnesota's approach to controlling PFAS discharges from wastewater treatment plants is inadequate for four main reasons.

First, the wastewater treatment process does not destroy the fluorine-carbon bond that is the hallmark of PFAS' durability. PFAS that enter the wastewater treatment plant, therefore, are either discharged in the effluent–which is frequently discharged directly into surface waters that are sources of drinking water for millions of Minnesotans–or are present in the biosolids that are spread on agricultural fields across the state. Relatedly, certain PFAS transform into "terminal" PFAS, like PFOS or PFOA, as the chemicals proceed through the wastewater treatment process. This means that influent sampling presents an incomplete picture about the PFAS that are being released into the environment. In Michigan, for example, regulators found higher concentrations of certain PFAS in the effluent of the wastewater treatment plant than in the influent.[49]

The second primary issue is when Minnesota is addressing PFAS in wastewater. MPCA currently possesses the regulatory authority to require certain industrial users to pretreat their industrial wastewater before discharging to the wastewater treatment plant. Under the Clean Water Act, wastewater treatment plants are empowered to establish pretreatment programs to help prevent "pass through" discharge of pollutants.

This program works by requiring the industrial user to take steps to remove PFAS from their wastewater before it is discharged to the wastewater treatment plan. Michigan has been requiring PFAS source reduction at locations that knowingly use PFAS to great success, and federal guidance recommends wastewater treatment plants develop best management practices to limit PFAS discharges from industrial sources. Minnesota should do the same, and require industrial facilities known to discharge PFAS to implement pollution management practices on-site before discharging their wastewater to the treatment plant.

Third, MPCA's approach relies solely on voluntary agreements to monitor PFAS. Rather than placing treatment and monitoring requirements in the permits it issues to wastewater dischargers, the MPCA has entered into voluntary "memorandums of understanding" with certain large wastewater treatment systems suspected of processing fluids and solids contaminated with PFAS. Because it has not included limits for PFAS discharges or required PFAS reduction strategies in the permits, MPCA has not exercised its regulatory authority to control PFAS discharges from wastewater treatment plants. The Memorandum of Understanding "can be nullified by either party at any time."[50] MPCA should instead include limits or controls to reduce PFAS discharges directly in the permits it issues to wastewater treatment plants. By placing such requirements in permits, MPCA retains regulatory authority to ensure adequate steps are taken to monitor and reduce PFAS contamination in the effluent and biosolids coming from our state's wastewater treatment plants.

Finally, MPCA's decision not to sample biosolids for PFAS means that agricultural fields, adjacent surface waters, and the crops growing on the fields are at risk of being contaminated with PFAS. By failing to collect this important data, MPCA is ignoring a major PFAS pathway with the potential to contaminate drinking water and our environment. Some states, like neighboring Wisconsin, are sampling effluent and biosolids to better inform the state's pollution reduction strategies.[51] And guidance from the EPA recommends states monitor wastewater effluent and biosolids for the presence of PFAS. Minnesota must start monitoring effluent and biosolids to better understand where PFAS are entering our environment.

Haw River Assembly settlement w/ Burlington Wastewater Treatment Plant

In 2019, the Southern Environmental Law Center ("SELC") and a local group in Burlington, North Carolina filed a "notice of intent to sue" letter with the City for unauthorized PFAS discharges from its wastewater treatment plant into the Haw River. The letter included public data about historical concentrations of PFAS in the wastewater treatment plant's influent and independent sampling from several sites in the Haw River and the wastewater treatment plant's effluent. The testing revealed extreme differences in PFAS contamination in the Haw River upstream and downstream of the facility, with downstream PFAS concentrations nearly 40 times greater. This data, the letter asserted, evidenced that the facility was discharging PFAS directly into the Haw River without a permit in violation of the Clean Water Act.

In August of 2023, the city of Burlington agreed to settle the matter. The agreement documented three likely industrial sources that were discharging PFAS to the wastewater treatment plant and explained steps Burlington would take to ensure the facilities either ceased using PFAS or implemented pretreatment programs to control their discharge.[52] These are tools presently available to wastewater treatment plants under the Clean Water Act and recommended by the EPA. Importantly, the costs of implementing these treatment technologies are levied upon the industrial user, who must limit PFAS in the wastewater it discharges to the wastewater treatment plant.

VI. Models from Other States

- What approaches have other states taken to proactively address PFAS contamination from wastewater streams?

Maine

Effective August 8, 2022, Maine became the first state to place a ban on the land application of biosolids.[53] This ban was in response to an increase in testing and data, finding that biosolids land application was a critical pathway to PFAS exposure leading to contaminated water, milk, and food. While Maine had already passed a PFAS non-essential use ban and PFAS specific water quality standards, the Maine legislature recognized that exposure to PFAS through biosolids still presented a public health threat because biosolids land application was directly linked to soil and groundwater contamination in several rural communities.[54]

Maine's biosolids ban requires that no new licenses be issued for land application of biosolids that are either septic sludge themselves or come from products, such as compost, where septic sludge has been incorporated. The ban additionally prohibits the sale of these biosolids intended for land application. For those who already hold land application licenses, the ban requires that groundwater and drinking water near the land application location be tested for PFAS. If testing finds an exceedance of water quality standards, land application is prohibited. PFAS substances are defined to include any "fluorinated organic chemicals containing at least one fully fluorinated carbon atom" that can reasonably be quantified in a laboratory.

As part of its response to the PFAS crisis, in January of 2023, Maine's legislature also enacted S.P. 92, an emergency order requiring the testing of wastewater effluent for PFAS. The order requires that any entity who is licensed to discharge effluent into groundwater or any waters of the state, must not only test for PFAS, but also pay the cost to test themselves. There are caveats in the order where the cost burden may shift to the State of Maine, but at its crux, this is an example of PFAS producers, rather than taxpayers, bearing the burden of PFAS contamination.

Vermont

In 2019, Vermont passed Act 21, which requires its water providers to test for PFAS. The Act then mandates a continuous testing schedule, dependent on initial results. Vermont also has some of the strictest drinking water standards for PFAS. On March 17, 2020, a revised Vermont Water Supply Rule was issued to limit the concentrations for PFOA, PFOS, PFHxS, PFHpA, and PFNA to not exceed 20 ppt in aggregate. The rule also requires the public to be notified when these limits are exceeded. One of the most progressive actions Vermont has taken to address PFAS from wastewater streams has been through its biosolids regulations. Vermont requires that all Environmental Quality ("EQ") biosolids be labeled as potentially containing PFAS.[55] EQ biosolids are those solids derived from domestic waste or dairy waste that have been screened for pathogens and are intended for sale and land application.

Additionally, any biosolids, septage, or EQ biosolids must be tested at least annually for PFAS substances that are either already regulated or are determined to pose a risk to human health or the health of living organisms.[56] And depending on the facility's certification, soil, groundwater, and plant tissue must also be tested for PFAS at least once per year.[57]

Michigan

Michigan is addressing the PFAS problem on multiple fronts. In 2020, the Michigan Department of Environment, Great Lakes, and Energy (EGLE) promulgated the strictest rules regulating PFAS in drinking water in the nation. After the rules became effective, 3M sued, arguing that the rules should be invalidated because the Department failed to consider the costs for businesses to comply with related groundwater-cleanup standards that automatically resulted from the new drinking water rules, in other words – the costs of compliance.[58] The Michigan Court of Appeals agreed with 3M and invalidated the rules, concluding that the state failed to properly consider costs before finalizing the rules. After the ruling, a spokesperson for the EGLE complained that the lawsuit is evidence of the length that 3M, one of the parties most responsible for PFAS contamination in the world, will go to avoid confronting its responsibility for the PFAS problem.

On the wastewater front, Michigan started confronting the problem in 2018, when it studied 95 wastewater treatment plants that were required by their NPDES permit to implement industrial pretreatment programs (IPP). By 2020, the EGLE concluded that "there is significant evidence to support that utilizing the established authorities under the IPP to identify and control industrial sources of PFAS (specifically PFOS) to wastewater treatment plants is highly effective at reducing the discharge of this pollutant into the environment."[59] After the study was expanded to look at PFAS in biosolids, results showed that six wastewater treatment plants produced biosolids with high levels of PFAS. Land application of biosolids from those facilities was ceased, and implementation of screening technologies upstream from the plants through pretreatment programs dramatically lowered the amount of residual PFAS that ended up in biosolids from those facilities. The study also looked at fields that had received biosolids from wastewater treatment plants and, unsurprisingly, sites that received biosolids from the six plants previously mentioned showed the greatest levels of contamination.

VII. Recommendations

Minnesota has a lot of urgent work to do to build on the PFAS-source reduction laws our state legislature passed in 2023. In June of 2023, MPCA released a report on the exorbitant costs to remove PFAS from wastewater streams across the state, which it estimates will cost $14 - 28 billion over the next 20 years.[60] The report acknowledges that wastewater streams and solid waste management systems are "key routes" for PFAS to enter the environment, and confirms that "[t]o date, none of the biosolids management techniques practiced in Minnesota destroy PFAS."[61] The report recognizes that the cost per mass of PFAS destroyed is lower for higher-concentration waste streams like biosolids, and that treatment is much more cost effective at "upstream" facilities like industrial dischargers, where the contamination is more concentrated, than at municipal wastewater treatment facilities that receive blended influent. [62]

MPCA has stated that PFAS removal and destruction from municipal wastewater will be unaffordable for the foreseeable future, and that pollution prevention and source reduction are the best path forward.[63] MCEA agrees that source reduction through the non-essential use ban is a critical step to "turn off the tap" on PFAS production. However, state agencies must also take steps to remediate the PFAS that is already pervasive in the environment and continues to be discharged from wastewater streams every day. There is also the bottom line of what we need to do to protect public health: as federal and state governments propose new regulations to protect drinking water sources, Minnesota agencies must use the tools available under our bedrock environmental laws to ensure that responsible parties bear the burden of pollution clean up to the extent possible, and that the costs aren't externalized to the public.

In this report, we have identified some of the steps that the MPCA can take now, through its Clean Water Act authority, to better understand the scope of PFAS contamination from wastewater streams and ensure that responsible parties bear the costs of pollution clean-up wherever possible. To protect Minnesota's communities from further damage caused by the toxic effects of PFAS on human health, our recommendations are to:

- Add PFAS as a pollutant under the Minnesota Sewage Sludge Management Rule;
- Require wastewater treatment plants to monitor influent, effluent, and land applied biosolids for PFAS so we can better understand the scope of contamination;
- Use pretreatment programs to require industrial dischargers to use best management practices and treatment options to reduce and remove PFAS from industrial wastewater before it reaches municipal wastewater treatment plants;
- Label Class A EQ biosolids sold for public distribution as potential sources of PFAS;
- Investigate sensitive sites (based on soil type/hydrology) where biosolids have been land applied for decades for legacy soil and groundwater contamination;
- Require PFAS data in the environmental review (Minnesota Environmental Policy Act) process, such as the Met Council wastewater treatment plant's proposed addition of a fourth incinerator;
- Monitor ambient groundwater for PFAS contamination from landfill leachate and land applied biosolids;
- Develop strong statewide Class 1 Water Quality Standards that mirror the proposed federal Maximum Contaminant Levels (MCLs) for 6 PFAS compounds.

Sources

1. Jared Hayes, Env't Working Grp., For Decades, Polluters knew PFAS Chemicals were Dangerous but Hid Risks from Public, https://www.ewg.org/research/decades-polluters-knew-pfas-chemicals-were-dangerous-hid-risks-public (last visited Nov. 6, 2023).

2. Nat'l Institute of Health, Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS), https://www.niehs.nih.gov/health/topics/agents/pfc/index.cfm (last visited Oct. 5, 2023).

3. U.S. Env't Prot. Agency, Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS), https://www.epa.gov/sdwa/drinking-water-health-advisories-pfoa-and-pfos (last visited Sept. 22, 2023).

4. Minn. Pollution Control Agency, PFAS Ban, https://www.pca.state.mn.us/get-engaged/pfas-ban (last visited Nov. 6, 2023).

5. Minn. Pollution Control Agency, PFAS in Products: Reporting, https://www.pca.state.mn.us/get-engaged/pfas-in-products-reporting (last visited Nov. 6, 2023).

6. Barr Eng'g Co., Hazen & Sawyer, Evaluation of Current Alternatives and Estimated Cost Curves for PFAS Removal and Destruction from Municipal Wastewater, Biosolids, Landfill Leachate, and Compost Contact Water (2023).

7. Waste 360, The Science of PFAS: Finding Strength in the Single Bond, https://www.waste360.com/pfas-pfoas/science-pfas-finding-strength-single-bond (last visited Nov. 6, 2023).

8. Abdallah Mshaty et al., Neurotoxic Effects of Lactational Exposure to Perfluorooctane Sulfonate on Learning and Memory in Adult Male Mouse, 145 Food & Chem. Toxicology 111710 (2020).

9. Ren Zhou et al., Combined Effects of BPA and PFOS on Fetal Cardiac Development: In Vitro and In Vivo Experiments, 80 Envtl. Toxicology & Pharmacology 103434 (2020).

10. Bevin E. Blake et al., Associations Between Longitudinal Serum Perfluoroalkyl Substance (PFAS) Levels and Measures of Thyroid Hormone, Kidney Function, and Body Mass Index in the Fernald Community Cohort, 242(A) Env't Pollution 894 (2018).

11. C8 Sci. Panel, Probable Link Evaluation for Chronic Kidney Disease (2012).

12. Minn. Att'y Gen., Probable Link Evaluation for Heart Disease (Including High Blood Pressure, High Cholesterol, Coronary Artery Disease) (2012).

13. U.S. Dep't of Health and Human Servs., Agency for Toxic Substances and Disease Registry, Toxicological Profile for Perfluoroalkyls 5–15, (2021).

14. Kelly L. Smalling et al., Per- and polyfluoroalkyl substances (PFAS) in United States tapwater: Comparison of underserved private-well and public-supply exposures and associated health implications, 178 Environment International 108033 (2023).

15. Nina Moini, Minnesota Plants to Spend $700 Million to Reduce 'Forever Chemical' Water Pollution in East Metro MPR NEWS, Aug. 18, 2021.

16. Jennifer Bjorhus, Investigation Targets Discharges of Next-Generation 'Forever Chemicals' from 3M's Cottage Grove Plant, STARTRIBUNE, Dec. 18, 2020.

17. Minn. Pollution Control Agency, PFAS and Closed Landfills, https://www.pca.state.mn.us/air-water-land-climate/pfas-and-closed-landfills (last visited Oct. 25, 2023).

18. Minn. Dep't of Health, State Updates Fish Consumption Guidance for Two Twin Cities Metro Water Bodies, https://www.health.state.mn.us/news/pressrel/2023/fish073123.html (last visited Nov. 6, 2023).

Sources (continued)

19. Sharon Kroening, Minn. Pollution Control Agency, Perfluorinated Chemicals in Minnesota's Ambient Groundwater (2017).

20. Minn. Dep't of Health, PFAS Testing of Minnesota Community Water Systems, https://mdh.maps.arcgis.com/apps/MapSeries/index.html?appid=63515695237f425ea7120d1aac1fd09a (last visited Nov. 6, 2023).

21. Deena Winter, Forever chemicals found in tribal school well on Leech Lake reservation, MINNESOTA REFORMER, Sept. 1, 2023.

22. U.S. Env't Pro. Agency, Per- and Polyfluoroalkyl Substances (PFAS): Proposed PFAS National Primary Drinking Water Regulation, https://www.epa.gov/sdwa/and-polyfluoroalkyl-substances-pfas (last visited Nov. 6, 2023).

23. Minn. Dep't of Health, Fish Consumption Guidance, https://www.health.state.mn.us/communities/environment/fish?msclkid=095ef2cebff011eca31eae0a272c6c43#statewide (last visited Nov. 6, 2023).

24. Minn. Dep't of Health, Human Health-Based Water Guidance Table, https://www.health.state.mn.us/communities/environment/risk/guidance/gw/table.html (last visited Nov. 6, 2023).

25. Id.

26. Minn. Pollution Control Agency, PFAS Monitoring Plan 3 (2022).

27. Allen Henry, Douglas Corp. to Pay $1.375M Settlement for Releasing "Forever Chemicals" in Several Metro Lakes, CBS NEWS MINNESOTA, May 17, 2023.

28. Mich. Dep't of Env't Quality, PFAS Cycle, https://www.michigan.gov/-/media/Project/Websites/PFAS-Response/MPART/PFAS-Cycle.pdf?rev=7a6d09ac9b0b48829b866f00f2a5f4fc (2020).

29. Nat'l Biosolids Data Project, Minnesota Biosolids Management 2018 State Summary, https://static1.squarespace.com/static/601837d1c67bcc4e1b11862f/t/608034046ace2f22d5d19d90/1619014665760/MN_BiosolidsNarrativeSummary_NBDP_20210412.pdf (2021).

30. Barr Eng'g Co., Hazen & Sawyer, supra, note 6 at 6.

31. Minn. Pollution Control Agency, Results from Testing for PFCs at Wastewater Treatment Plants in Minnesota (2023).

32. Barr Eng'g Co., Hazen & Sawyer, supra, note 6.

33. Cheryl Hogue, Incineration may Spread, not Break Down PFAS, CHEMICAL & ENG'G NEWS, Apr. 27, 2020.

34. U.S. Env't Prot. Agency, Land Application of Biosolids, https://www.epa.gov/biosolids/land-application-biosolids (Last visited Nov. 4, 2023).

35. U.S. Env'l Prot. Agency, Office of Inspector Gen., Report No. 19-P-0002, EPA Unable to Assess the Impact of Hundreds of Unregulated Pollutants in Land-Applied Biosolids on Human Health and the Environment (2018).

36. U.S. Env'l Prot. Agency, Biosolids Laws and Regulations, https://www.epa.gov/biosolids/biosolids-laws-and-regulations (last visited Oct. 10, 2023).

37. Sharon Anglin Treat, Institute for Agric. & Trade Pol'y, Forever Chemicals and Agriculture Case Study (2021).

38. Sharon Lerner, Toxic PFAS Chemicals Found in Maine Farms Fertilized with Sewage Sludge, THE INTERCEPT, Jun. 7, 2019.

39. Mich. Dep't of Env't, Great Lakes, & Energy, Initiatives to Evaluate the Presence of PFAS in Municipal Wastewater and Associated Residuals (Sludge/Biosolids) in Michigan 9 (2020).

40. Ian Pepper, Cass Kelly, & Mark Brusseau, Is PFAS from Land Applied Municipal Biosolids a Significant Source of Exposure via Groundwater?, 864 Sci. Total Env't 161154 (2023).

Sources (continued)

41. 40 C.F.R. § 403.2 (2023).

42. Jennifer A. Pozzebon & Lars Seifert, Emerging Environmental Health Risks Associated with the Land Application of Biosolids: A Scoping Review, 22 Env't Health 57 (2023).

43. Gwynn R. Johnson, PFAS in Soil and Groundwater Following Historical Land Application of Biosolids, 211 Water Rsch. 118035 (2022).

44. Marc Mills, U.S.Env't Prot. Agency Office of Rsch. & Dev., Session 6: PFAS Treatment in Biosolids–State of the Science (2020).

45. Minn. R. 7041.1100; Minn. R. 7041.0600.

46. Minn. R. 7041.0100, subp. 40.

47. U.S. Env'l Prot. Agency, Key EPA Actions to Address PFAS, https://www.epa.gov/pfas/key-epa-actions-address-pfas (last visited Nov. 6, 2023).

48. U.S. Env'l Prot. Agency, Addressing PFAS Discharges in NPDES Permits and Through the Pretreatment Program and Monitoring Programs (2022).

49. Mich. Dep't of Env't, Great Lakes, and Energy, supra note 39 at 9.

50. Minn. Pollution Control Agency, Municipal Wastewater PFAS Cover Letter Communication Memorandum of Understanding, https://www.pca.state.mn.us/sites/default/files/wq-wwprm1-38.pdf (last visited Nov. 6, 2023).

51. Danielle Kaeding, Wisconsin DNR Offers to Test Sewage Sludge for PFAS at Wastewater Facilities, WISC. PUBLIC RADIO, July 6, 2023.

52. S. Env't Law Ctr., Settlement Reached to Control Burlington's PFAS Pollution into the Haw River, https://www.southernenvironment.org/press-release/settlement-reached-to-control-burlingtons-pfas-pollution-into-the-haw-river/ (last visited Nov. 6, 2023).

53. Me. Stat. tit. 38, §1305-B, sub-§7.

54. Me. Dep't of Env't Prot., Per- and Polyfluoroalkyl Substances (PFAS), https://www.maine.gov/dep/spills/topics /pfas/ (last visited Sept. 15, 2023).

55. 20P-005 Vt. Code R. § 6-1303(g)(3) (2020).

56. 20P-005 Vt. Code R. § 6-1306(n)(2) (2020).

57. 20P-005 Vt. Code R. § § 6-1306(r) (2020).

58. 3M Co. v. Dep't of Env't Great Lakes & Energy, No. 364067, 2023 WL 5418164, at *2 (Mich. App. Aug. 22, 2023).

59. Mich. Dep't of Env't, Great Lakes, and Energy, supra note 39 at 5.

60. Barr Eng'g Co., Hazen & Sawyer, supra, note 6.

61. Id. at 80.

62. Id. at 157.

63. Minn. Pollution Control Agency, Groundbreaking study shows unaffordable costs of PFAS cleanup from wastewater, https://www.pca.state.mn.us/news-and-stories/groundbreaking-study-shows-unaffordable-costs-of-pfas-cleanup-from-wastewater (last visited Nov. 6, 2023).