Emerging Contaminants in the Lake James Watershed

Jesus Lovaton

(Dancy-Jones, 2010)

Introduction

My name is Jesus Lovaton, and I am a recent graduate from Appalachian State University.

I have been working with the LJEA as an emerging contaminants intern for over a year.

I am very passionate about conservation, and my ultimate goal is to have a career in conservation.

Emerging Contaminants

Emerging contaminants are chemical compounds, industrial pollutants, and human by-products that can seep into lakes, rivers, and oceans and cause ecological harm (USGS).

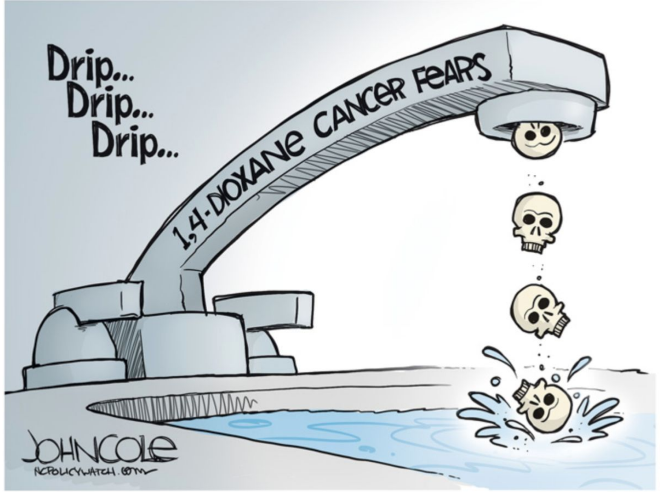
These compounds are understudied and their long-term environmental and adverse health effects are still unknown (Feng and Rosenfeld 2011).

1,4-Dioxane: Effects

1,4-Dioxane is a clear liquid that fully dissolves in water. (NCDEQ, 2023).

Tumors have been observed in animals exposed to 1,4-Dioxane orally (EPA, 2000). Dermal exposure can cause liver and kidney damage (NCBI, 2007).

1,4-Dioxane is reasonably anticipated to be a human carcinogen based on animal testing, though there is not enough data to evaluate the relationship between human cancer and 1,4-Dioxane exposure (NTP, 2014).



1,4-Dioxane: Potential Sources

- Possible sources of 1,4-Dioxane that can get into the Lake James Watershed (EPA, 2023):
  - Wastewater treatment plants
  - Soap and detergent manufacturers
  - PET (Polyethylene Terephthalate) manufacturing
  - Hydraulic Fracturing Operations
- Elevated levels of 1,4-Dioxane have been detected in areas of Greensboro, Reidsville, and Asheboro wastewater treatment plants. The N.C. Division of Water Resources has began requiring all cities to submit corrective action plans to reduce 1,4-Dioxane discharge, in addition to weekly sampling for the Greensboro and Reidsville WWTPs (NCDEQ, 2023).

1,4-Dioxane: Testing and Remediation

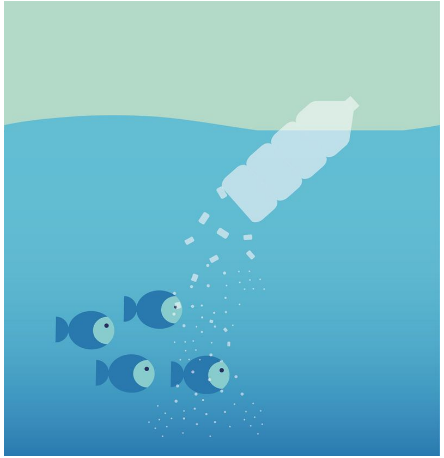
The most common testing method for 1,4-Dioxane is EPA 8270. This method is designed to detect 1,4-Dioxane even at low levels in water (CLU-IN, 2001).

1,4-Dioxane cannot be removed with conventional wastewater treatment processes (Zenker et al., 2003). Advanced oxidation processes (AOPs) can heavily reduce 1,4-Dioxane concentrations through the use of oxidative agents (94-99% reduction in some studies) (Zhang et al., 2017).

(Polimerek, 2005)

Microplastics: Effects

- Microplastics are defined as any type of plastic that is less than 5 mm in length (Ghosh et al., 2023).
    - Primary microplastics were made to be 5 mm before entering the environment, such as plastic glitter or very small beads.
    - Secondary microplastics are from the breakdown of larger plastic pieces through natural processes.
- The effects of microplastics on human health are still not well understood, but preliminary research points to negative health effects, such as inflammation, skin irritation, and the disruption of circadian rhythms (Ghosh et al., 2023).
- Effects on wildlife are a bit more understood. In a study performed at the Río de la Plata in South America, 87 fish belonging to 11 different species were captured and tested for microplastics, with a 100% occurrence of microplastics. (Pazos et al., 2017).



(EEA, 2022)

Microplastics: Potential Sources

In a study performed by Nava et al., 38 different lakes and reservoirs in 23 different countries were tested for microplastics (MPs), and MPs were detected in all 38. 9,425 plastic particles were identified and mostly consisted of secondary MPs.

Because secondary microplastics are so abundant and produced from the breakdown of larger plastics, preventing and extracting larger plastic items before the degradation occurs would be worthwhile to prevent the spread of microplastics in lakes (Nava et al., 2023).

During the MEFE cleanup, 148-600 million microplastic particles were prevented from entering the Lake James watershed in only 4 person-hours of effort.

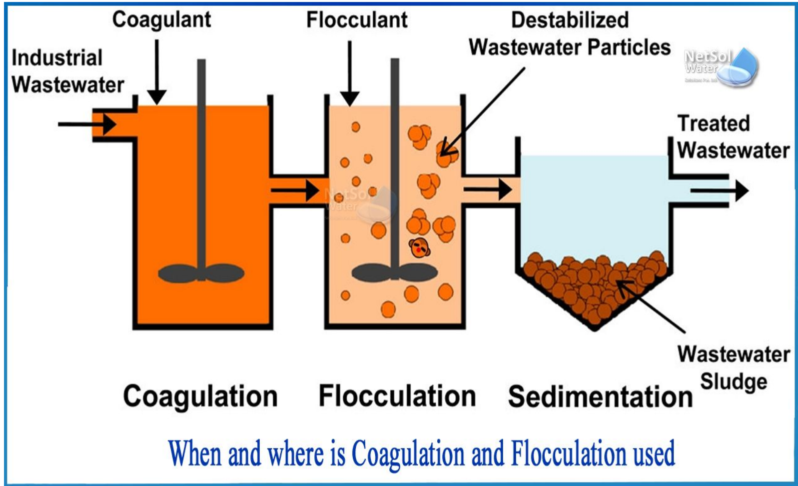
(Harris, 2023)

Microplastics: Remediation

Coagulation-flocculation-sedimentation (CFS) technology is commonly used for microplastic removal. Coagulants make microplastics coalesce into flocs and precipitate, then separated from the water phase using metallic salts, like iron and aluminium (Pan et al., 2023).

Degradation of microplastics research is still in the early stages, but research looks promising.

(NetSol Water)



Microplastics: Testing

When analyzing collected mps, it’s important to record color, shape, and size, as they can have different environmental impacts. Color can affect toxicity and different wildlife may selectively feed on certain color of plastics.

A standardized collection of microplastic samples includes using a boat and horizontal net trawls.

The samples should be wet-sieved on a 250-µm mesh for analysis, treated with 15% H2O2 to eliminate organic matter and organisms. Each sample should then be analyzed under a microscope and accepted (or rejected) as microplastics based on a catalogue of morphological criteria (Nava et al., 2023).

(Haverford, 2018)

(Sea Plastics)

PAH: Effects

(Gardner, 2010)

Polycyclic aromatic hydrocarbons (PAHs) are classes of naturally occurring chemicals, derived from the burning of coal, oil, gasoline, wood, some trash, tobacco, and the cooking of meat and other foods. PAHs are considered carcinogens. (Mallah, 2022).

Benzo A Pyrene is a well-know PAH that can cause cancer and naphthalene can cause skin inflammation with repeated contact to the skin (Mallah, 2022)((Alaekwe & Abba, 2022).

PAHs can also have health effects on aquatic wildlife as well. PAH can disturb the early development of fish, cause bone disruption, and negatively affect the liver and immune system (Honda & Suzuki, 2020).

PAH: Potential Sources

- Anthropogenic pollution of PAH is a result of incomplete combustion (Mallah, 2022).
    - Industrial Sources: waste incineration, production of metals, cement, dye, tires, and asphalt industries
    - Mobile pollution sources: exhaust from vehicles
    - Household practices:kerosene/wood stoves and cooking on oil/gas burners
- PAH concentration varies by season, but winter and autumn have the highest concentrations. This is due to higher amounts of house heating and incomplete combustion of fossil fuels (Mallah, 2022).

(Piwnicki, 2021)

PAH in Water

PAHs are not typically found in water at high concentrations, due to them having low solubility and high affinity for particulate matter (Nkansah et al., 2012). However, PAH can still get into water through contamination (like oil spills) and leachate from coal tar and asphalt linings (Alaekwe & Abba, 2022).

Rainwater can have higher than normal levels of PAH, due to the adsorption of air particles, which diffuses into the water during rains (Alaekwe & Abba, 2022)

(Major, 2021)

PAH: Testing and Remediation

- Adsorption is an effective remediation technique for PAH due to its hydrophobic nature and high affinity to particulate matter. By using lightweight expanded clay aggregate (LECA) as a sorbet, PAHs such as phenanthrene, fluoranthene and pyrene can be removed from water.

- LECA is a type of clay that becomes pelletized at high temps. These ceramic pellets are lightweight and porous. They contain no harmful substances, and will not break down in water.

- Testing for PAH is done through liquid/solid extraction and a high performance liquid chromatography (HPLC) system (NEMI).

(Tribe, 2022)

PFAS: Effects

- Per- and polyfluoroalkyl substances (PFAS) are a class of chemicals that are often referred to as ‘forever chemicals’, due to the length of time they take to break down (Sprout).
- Research shows that high levels of PFAS exposure can cause these health effects (NCDHHS, 2022):
  - Negatively affected growth, learning, and behavior of infants and children
  - Increased risk of high blood pressure for pregnant women
  - Increased cholesterol levels
  - Reduced immune response
  - Increased risk of kidney or testicular cancer
- Effects on wildlife include an impact on the immune systems in fish, alligators, and other marine life. PFAS has also been shown to impact the hatching and emergence success of birds and turtles (Andrews et al., 2023).

(Valosin, 2013)

PFAS: Potential Sources

PFAS can be found in all kinds of places globally, including water, soil, air, and living organisms (Andrews et al., 2023).

Major sources of PFAS contamination in water are fire training/fire response sites, industrial sites, landfills, WWTPs, and biosolids.

Industrial sites include manufacturing facilities where PFAS-containing products are made or facilities where PFAS-containing products are used, such as applying non-stick coating (Dyaniwood, 2023).

Industries that may manufacture or use PFAS are textile and leather processors, paper mills, metal finishers, and wire manufacturers (Dyaniwood, 2023).

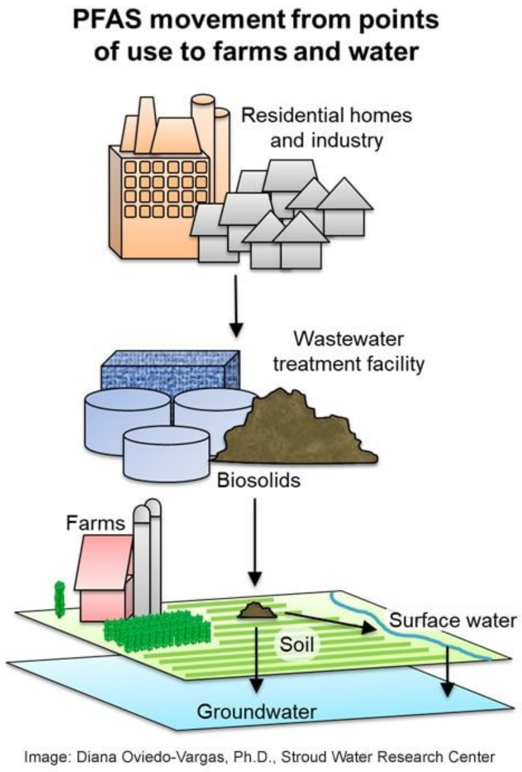
(RPU, 2022)

PFAS: Biosolids

WWTPs produce solid waste products called biosolids when treating wastewater (Thompson et al., 2023). Biosolids are known to contain PFAS. The fate of biosolids varies, with 54% being used for agriculture, 21% being incinerated, 16% being distributed, and 9% being relegated to landfills in North Carolina (Dhanasekar et al., 2022).

PFAS can leach out of biosolids and into groundwater. This leaching happens over time due to weathering like sunlight and rain, and can occur in landfills and land application in agriculture.

Biosolids are important for agriculture, as they add important nutrients and reduce the need for fertilizer. Many PFAS-removing technologies are being investigated in order to allow biosolids to still be applied without the risk of PFAS leaching (Dhanasekar et al., 2022).



(Oviedo-Vargas, 2021)

PFAS: Fire-fighting Foam

Aqueous film-forming foams (AFFF) are used to put out flammable liquid fires such as gasoline or jet fuel by the U.S. military, civilian airports, and other fire fighting organizations (Dyaniwood, 2023). These foams are known to contain PFAS used to suppress the fire (Clean Water Action).

(May, 2020)

Furthermore, areas where AFFF was used can release PFAS into the environment through rainfall events years after AFFF was used in that location, due to its long lasting nature (Thai et al., 2022).

PFAS: Biosolids Remediation

Many technologies are currently being developed in order to remove or destroy PFAS in biosolids. One of these technologies involves the design and construction of the first AirSCWO-6 system, which will be able to eliminate pharmaceuticals, PFAS, microplastics and antibiotic resistant bacteria in biosolids, and recover resources in the form of energy, mineral nutrients, heat and reusable water (Dhanasekar et al., 2022).

(374Water, 2023)

PFAS: AFFF Remediation

The easiest way to remedy this issue is to use foam that does not use PFAS. Some states have set restrictions or completely outlawed the use of PFAS-containing AFFFs, like California and Washington (Clean Water Action).

A much better alternative to AFFs are protein-based foams, which while they spread more slowly, are more heat resistant, durable, and biodegradable (Clean Water Action).

PFAS regulation is an effective way to prevent increased environmental damage. One significant event is that the EPA recently proposed to designate PFAS as a hazardous substance under CERCLA. This would hold polluters responsible for cleaning up PFAS contamination (Dhanasekar et al., 2022).

(National Transportation Safety Board, 1987)

PFAS: Testing

Testing for PFAS in the Lake James watershed could be done by using the draft EPA Method 1633, which can test for 40 PFAS compounds in wastewater, surface water, groundwater, soil, biosolids, sediment, landfill leachate, and fish tissue (EPA, 2021).

It is an isotope dilution liquid chromatography tandem mass spectrometry (LC-MS/MS) method (Eurofins, 2022).

According to studies by the EPA using these methods, almost every freshwater fish in the U.S. are contaminated with PFAS in the parts-per-billion range – even greater than parts per trillion (Amarelo, 2023).

PFAS: A Look into the Lake James Watershed

Landfill Sites within the Lake James watershed

Open in Map Viewer Classic

Jesus Lovaton
lovatonj_app22

Layers

- Sketch
- Pre-Regulatory Landfill Sites
- Lakest
- Streams
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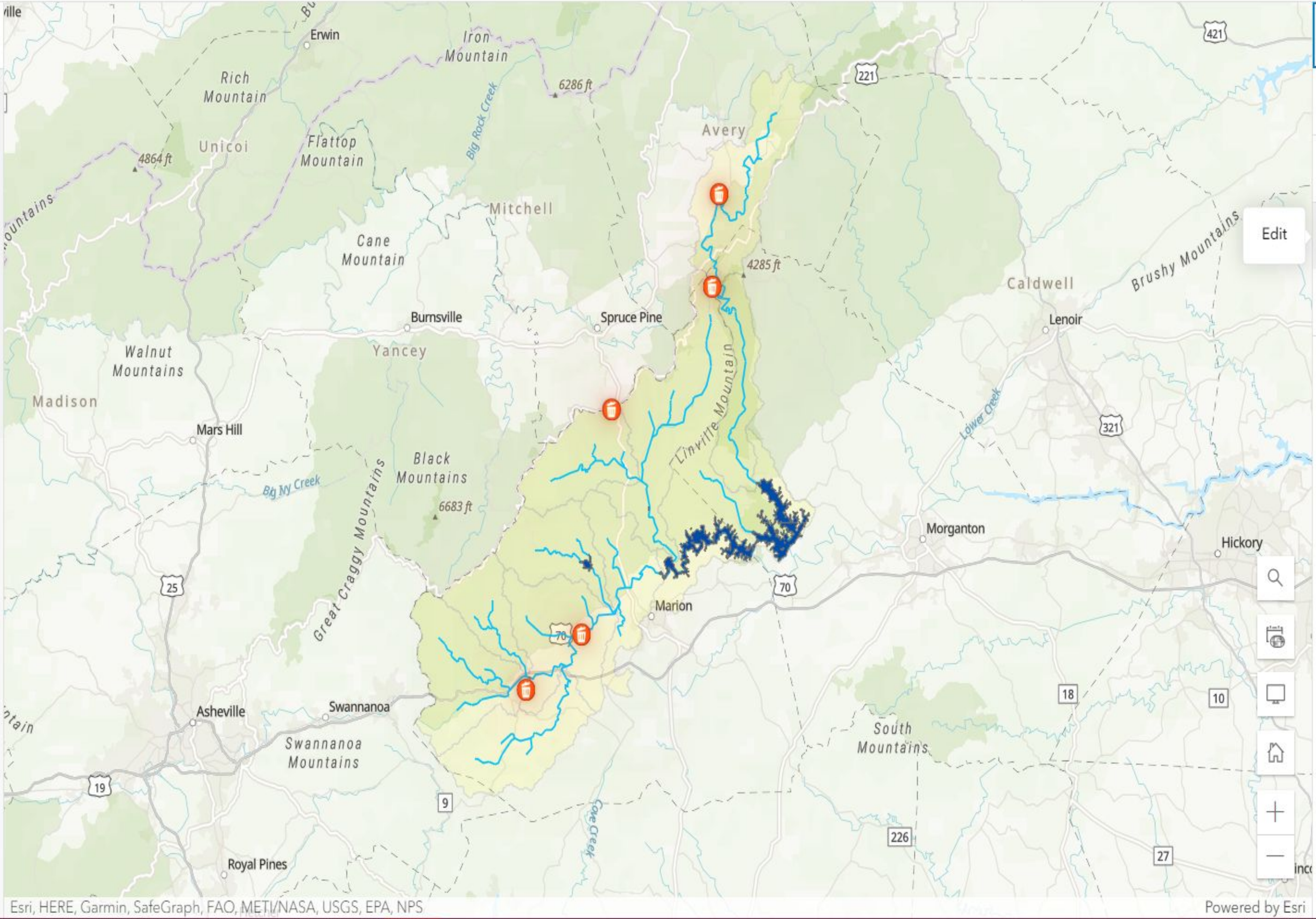
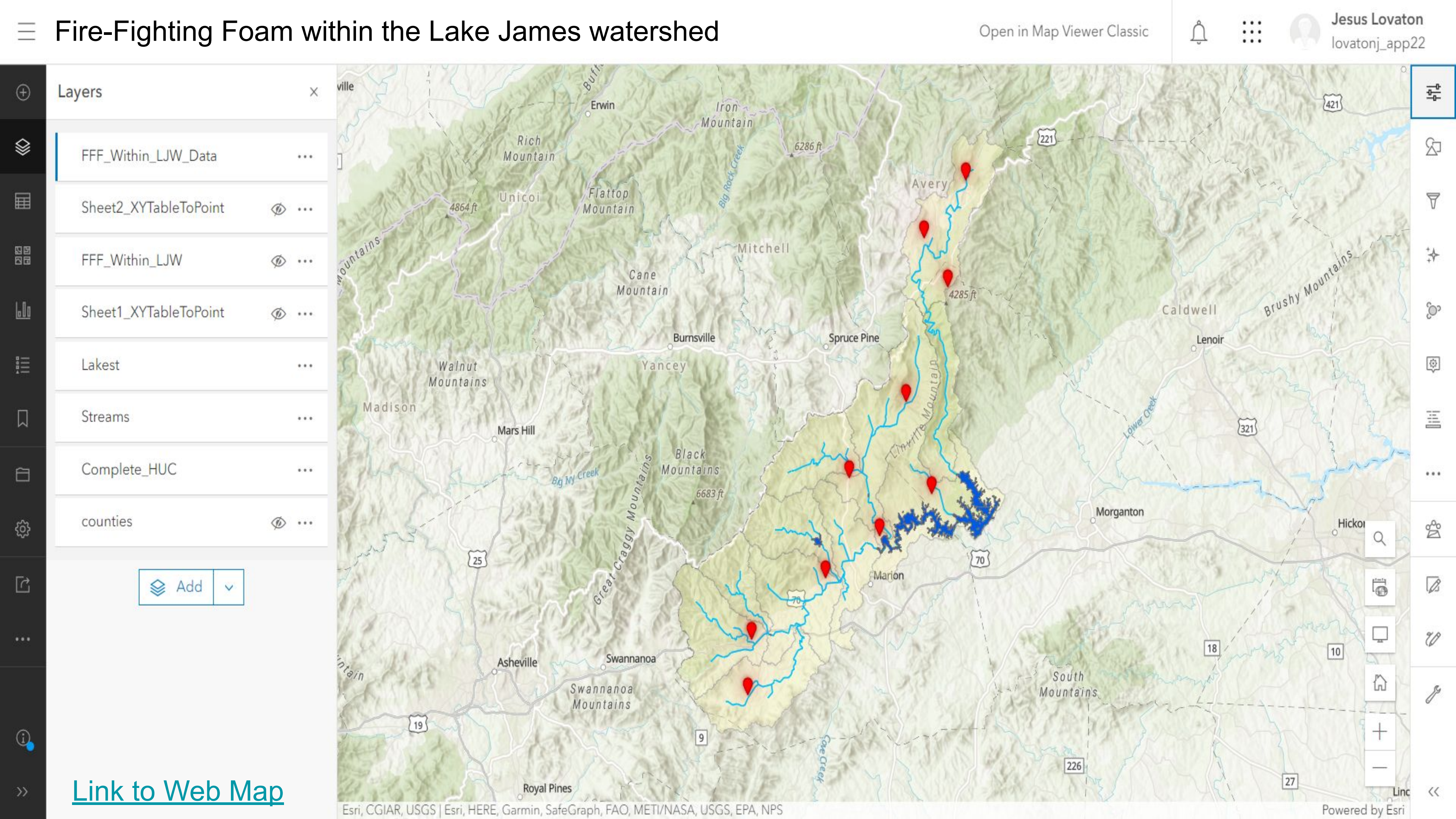


[Link to Web Map]

Fire-Fighting Foam within the Lake James watershed



[Link to Web Map]

Conclusion

All four of these contaminants of emerging concern could pose a threat to the health and natural beauty of the Lake James watershed. However, some of them are more of a threat to the watershed than others.

There does not seem to be an industrial source to contaminate the watershed with 1,4-Dioxane, though WWTPs in the Lake James area should still test for it.

Additionally, PAHs low solubility and high affinity for particulate matter makes its presence in water less likely.

PFAS and microplastics are much more likely to pose a threat to the watershed, due to the long lasting nature of PFAS and the widespread appearance of microplastics.

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