UF Herbert Wertheim College of Engineering
UNIVERSITY of FLORIDA

HINKLEY CENTER FOR SOLID AND HAZARDOUS WASTE MANAGEMENT

Characterization and Management of Per- and Polyfluorinated Alkyl Substances (PFAS) Remediation Residuals

Technical Advisory Group Meeting

April 27th , 2021

PI Timothy Townsend, PhD
Co-PI, John Bowden, PhD
GRA, Jake Thompson
Collaborator, Helena Solo-Gabriele, PhD

POWERING THE NEW ENGINEER TO TRANSFORM THE FUTURE

THE HINKLEY CENTER FOR SOLID AND HAZARDOUS WASTE MANAGEMENT

HINKLEY CENTER FOR SOLID AND HAZARDOUS WASTE MANAGEMENT

https://www.hinkleycenter.org/

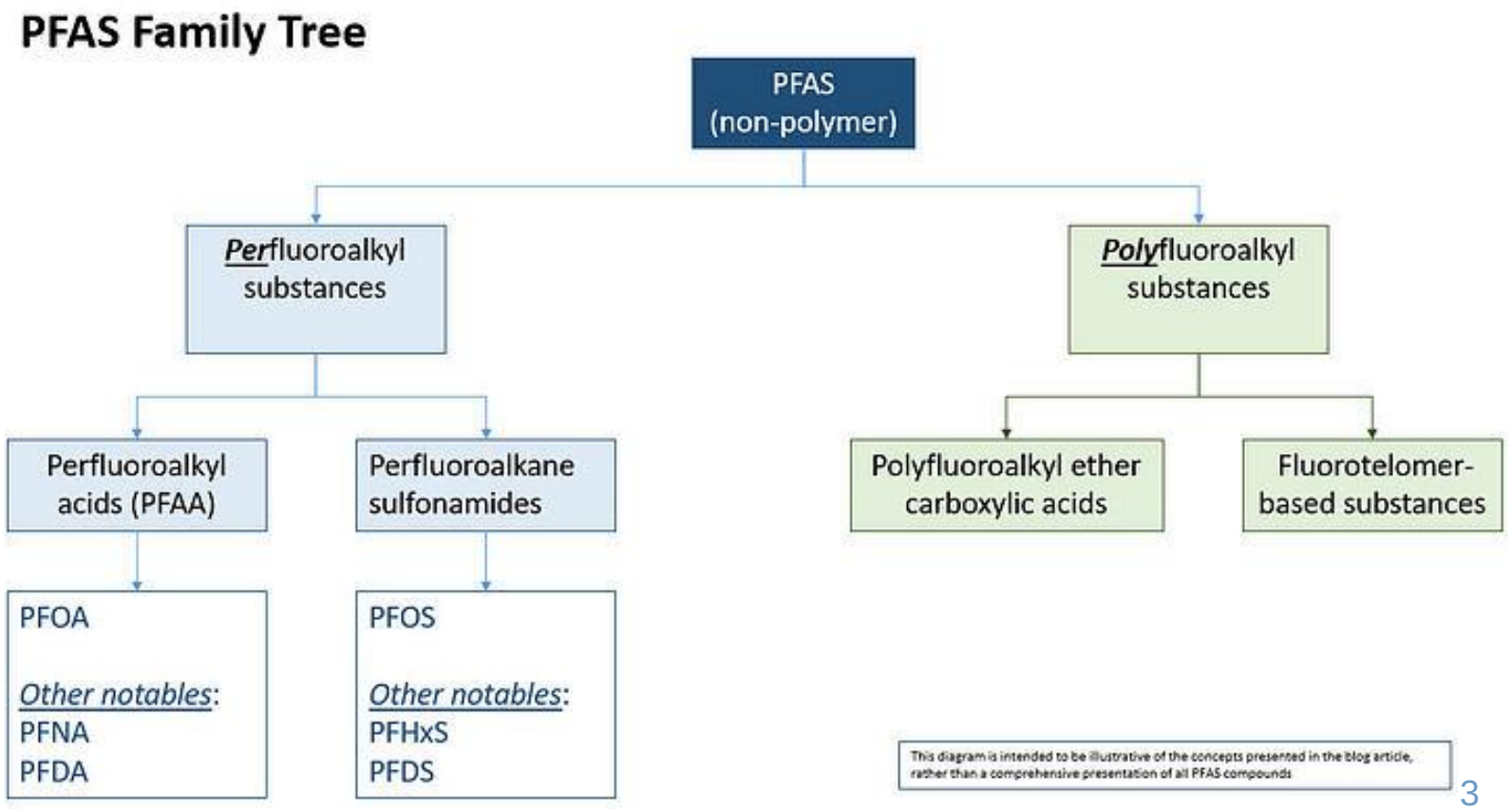
Meeting Overview and Agenda

- Introduction and meeting overview.
- Background information on sources of PFAS contaminated media and importance of this project.
- Explain the objectives of the project.
- Show current work of EPA LEAF methods conducted on PFAS contaminated soils.
- Open for discussion from technical advisors.
- Conclude meeting.

Key West firefighters applying AFFF during a training class

PFAS Overview

- More than 4,700 unique species of PFAS
- Carbon-Fluorine backbone
- Persistent in the environment – can last for hundreds of years



Previous Hinkley Center Projects

TITLE: "PFAS Releases from Landfills in Florida"

FUNDING SESSION - 2019

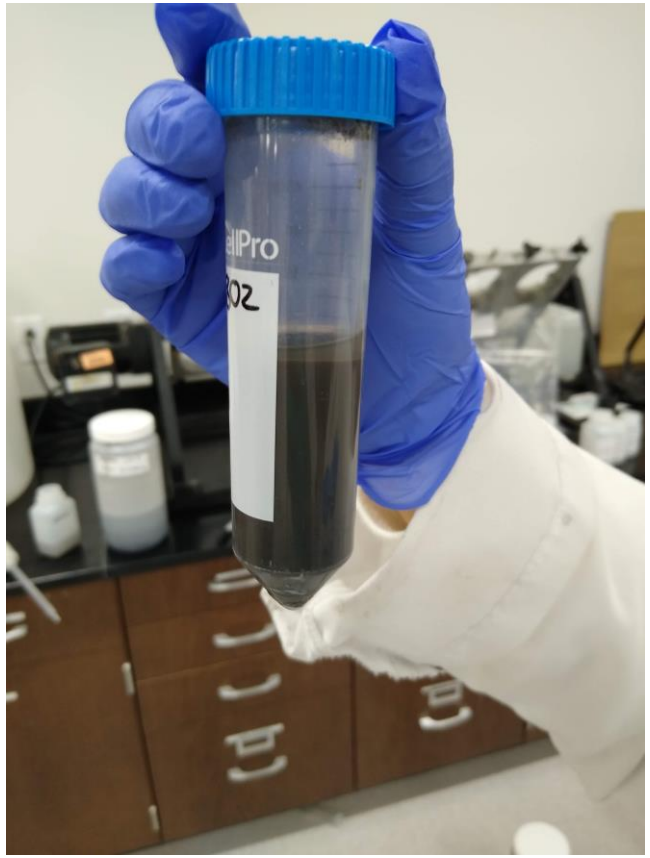
PRINCIPAL INVESTIGATOR - "Helena Solo-Gabriele"

Per- and poly-fluorinated alkyl substances (PFASs) are found in consumer products that are stick and stain resistant such as Teflon, sealants, textiles, and paper products. PFASs are also known to affect human health. They are linked to thyroid and liver diseases, diseases of the immune system, and cancer. Given their wide ranging usage in consumer products and their long-term environmental persistence, landfills represent a logical end-of-service-life reservoir where PFASs can be ultimately removed from the environment to minimize subsequent human health impacts. Recent prior research supported through the Hinkley Center with in-kind support through the U.S. EPA has shown that PFASs are released in the leachates from landfills in Florida. However, no work has yet been done to quantify the amount of PFAS found in landfill storm water and groundwater. In addition, a mass balance analysis is lacking to quantify how much PFAS (kilograms per unit time) is released at landfills, through leachate, storm water, and groundwater. The objectives of this proposal are to: a) expand the sampling program for PFAS to include additional PFAS species in leachates plus the inclusion of storm water and groundwater at landfills, and b) conduct a mass balance analysis of PFAS at landfills using a readily-available landfill modeling software combined with PFAS measurement data. The results will be used to focus efforts in terms of treatment of potential water sources at landfills that carry PFAS.

Concentrating Per- and Polyfluoroalkyl Substances (PFAS) in Municipal Solid Waste Landfill Leachate Using Foam Separation

Nicole M. Robey, Bianca F. da Silva, Michael D. Annable, Timothy G. Townsend, and John A. Bowden*

Previous PFAS Studies



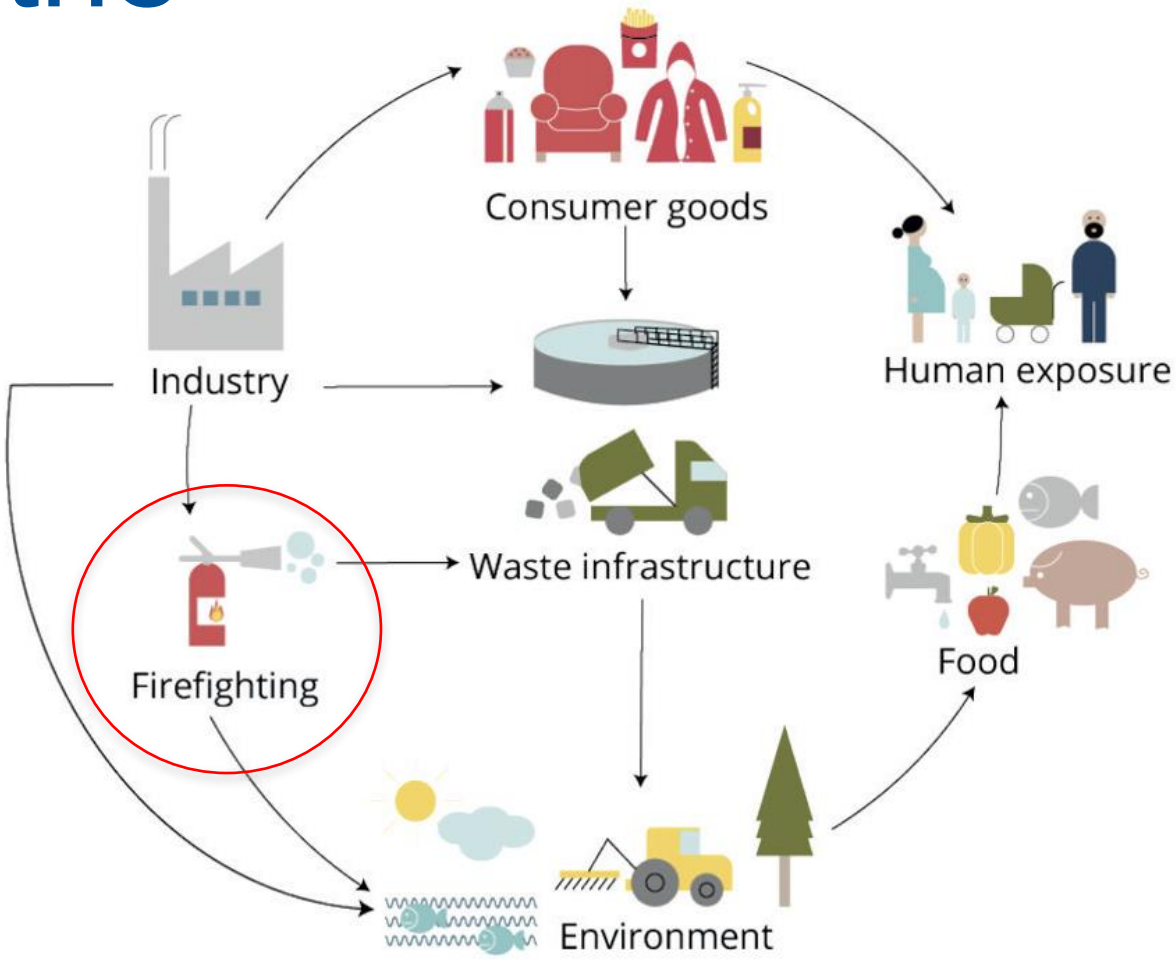
Street Sweepings

Waste to Energy Ash

MSW

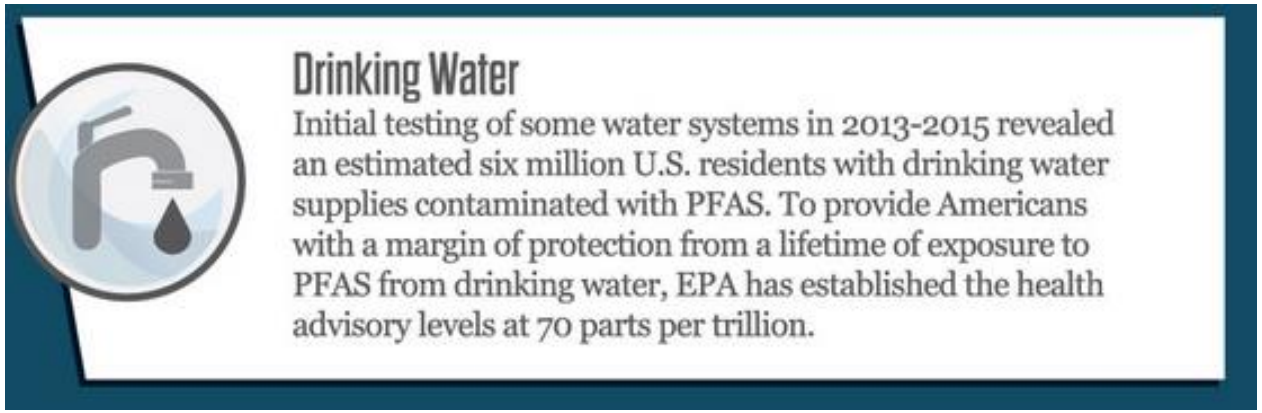
How Do PFAS Enter the Environment?

- PFAS are found in almost every waste residual (leachate, wastewater, MSW, street sweepings ect.)
- AFFF (Aqueous Film Forming Foam) is a major source of environmental contamination of ground water and soil.



PFAS Toxicity

- Exposure is linked to adverse health effects.
- EPA sets advisory level of 70 ppt in drinking water
- State regulatory agencies are beginning to develop and promulgate risk-based health levels and cleanup thresholds



Need for Research on Remediation Residuals

- Very little information on PFAS leaching has been published
- Long-term behavior and mobility of PFAS-laden residuals not well understood
- Individual PFAS chemicals are likely to exhibit different leaching behavior during disposal/containment

Objectives of this Project

Phase I

Task I: Organize preexisting information in the literature regarding management, behavior, and work to date on risk-based thresholds (e.g., SCTL,GCTL).

Task II: Environmental characterization of PFAS-laden remediation wastes/residuals using standardized tests (e.g., TCLP, SPLP, and EPA LEAF methods).

Phase II

Task III: Evaluate PFAS destruction or transformation during thermal treatment. (e.g., incineration, and thermal reactivation of activated carbon).

Phase I

Task I: Critical Review

- Currently working on organizing information available on leachability and management of PFAS remediation residuals .
- In Florida provisional SCTL's have already been created based on non-cancer SCTL equation

PFOA: 1.3 mg/kg residential; 25 mg/kg commercial/industrial; leachability 0.002 mg/kg

PFOS: 1.3 mg/kg residential, 25 mg/kg commercial/industrial; leachability 0.007 mg/kg.

Task II: Leachability of PFAS in Contaminated Soils

- Conduct TCLP/SPLP and EPA LEAF methods on PFAS contaminated residuals to evaluate leachability
- Quantify the leachability for multiple species of PFAS in waste residuals
- Explore different physical/chemical parameters that effect leachability

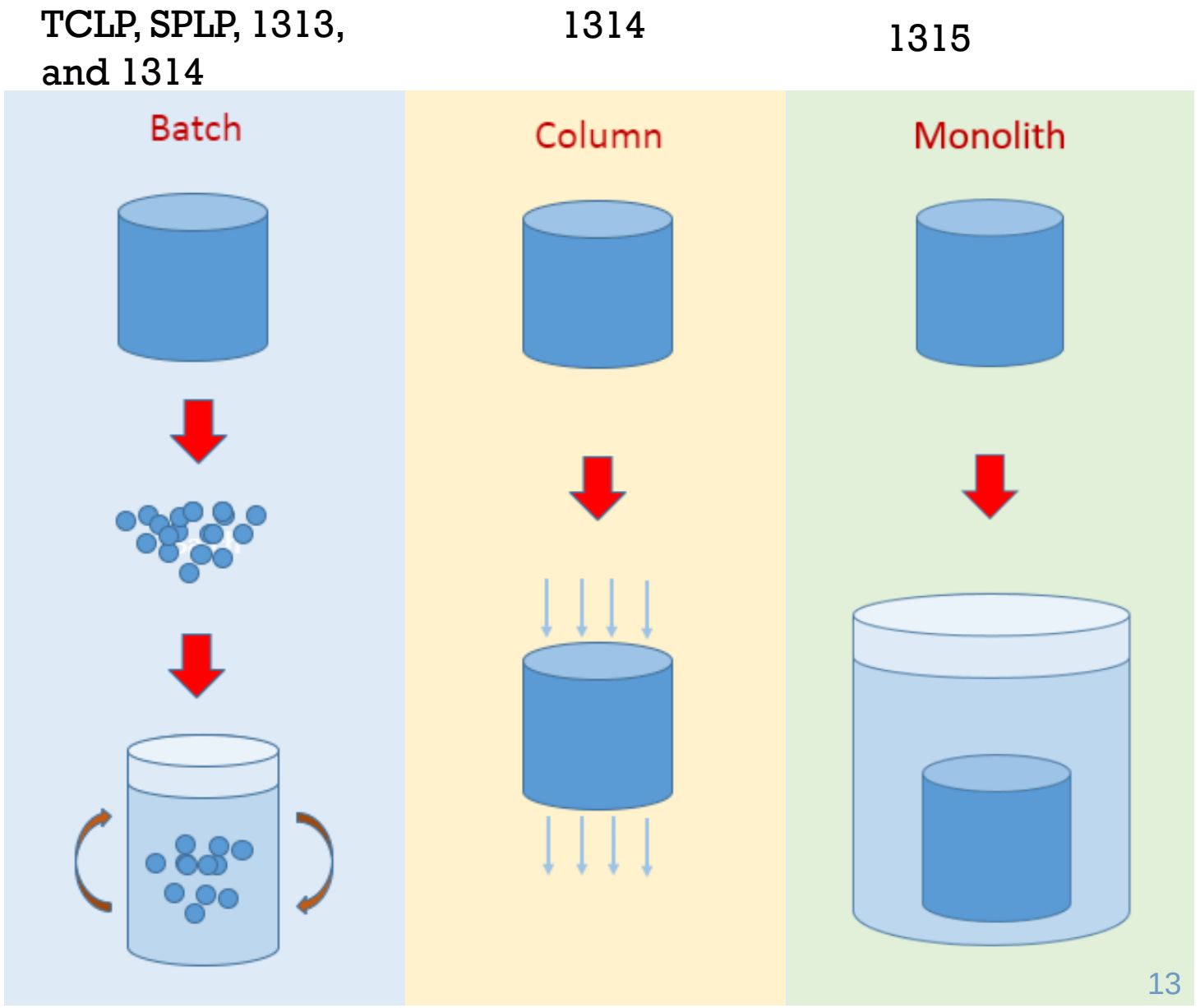
Leaching Procedure Types

Traditional EPA Methods

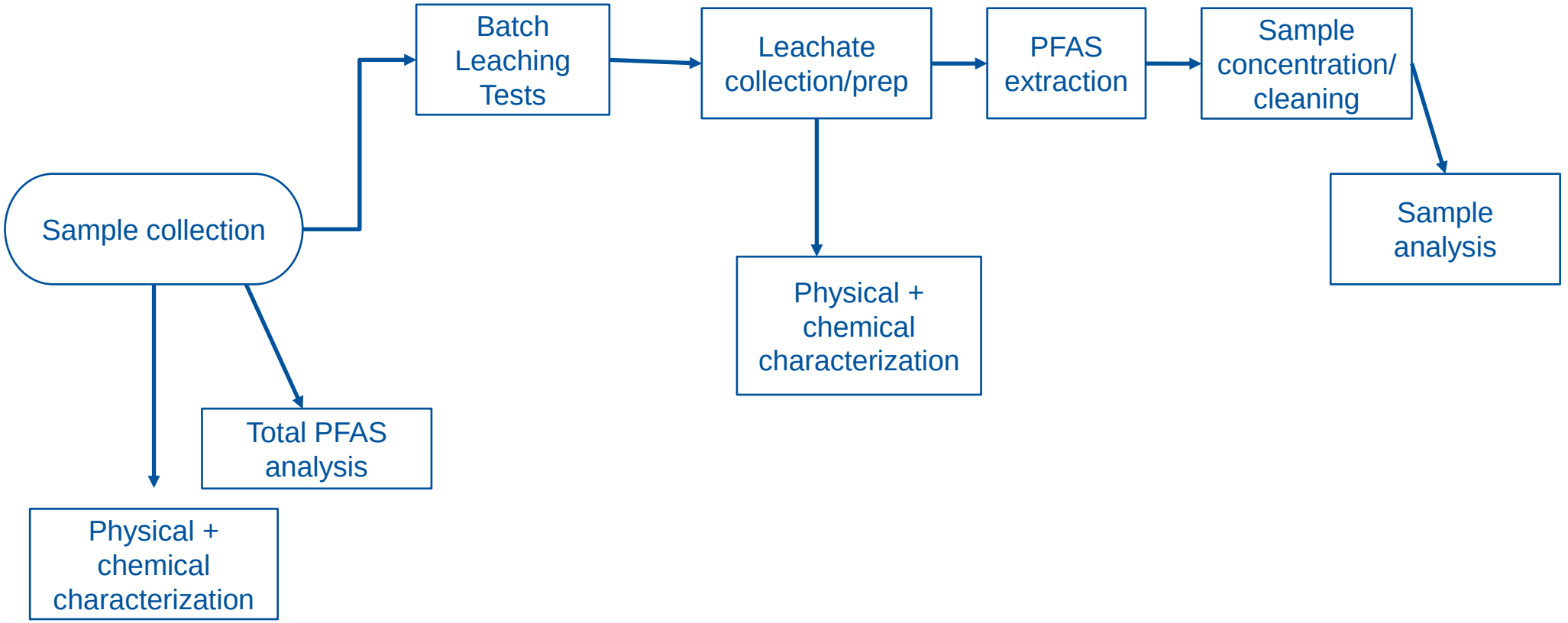
- 1311 Toxicity Characteristic Leaching Procedure (**TCLP**)
- 1312 Synthetic Precipitation Leaching Procedure (**SPLP**)

Leaching Environmental Assessment Framework (LEAF)

- 1313 Liquid Solid Partitioning as a Function of Extract pH
- 1314 Liquid Solid Partitioning using Up-Flow Percolation column
- 1315 Mass Transfer Rates of Constituents in Monolithic or Compacted Granular Materials
- 1316 Liquid Solid Partitioning as a Function of L/S

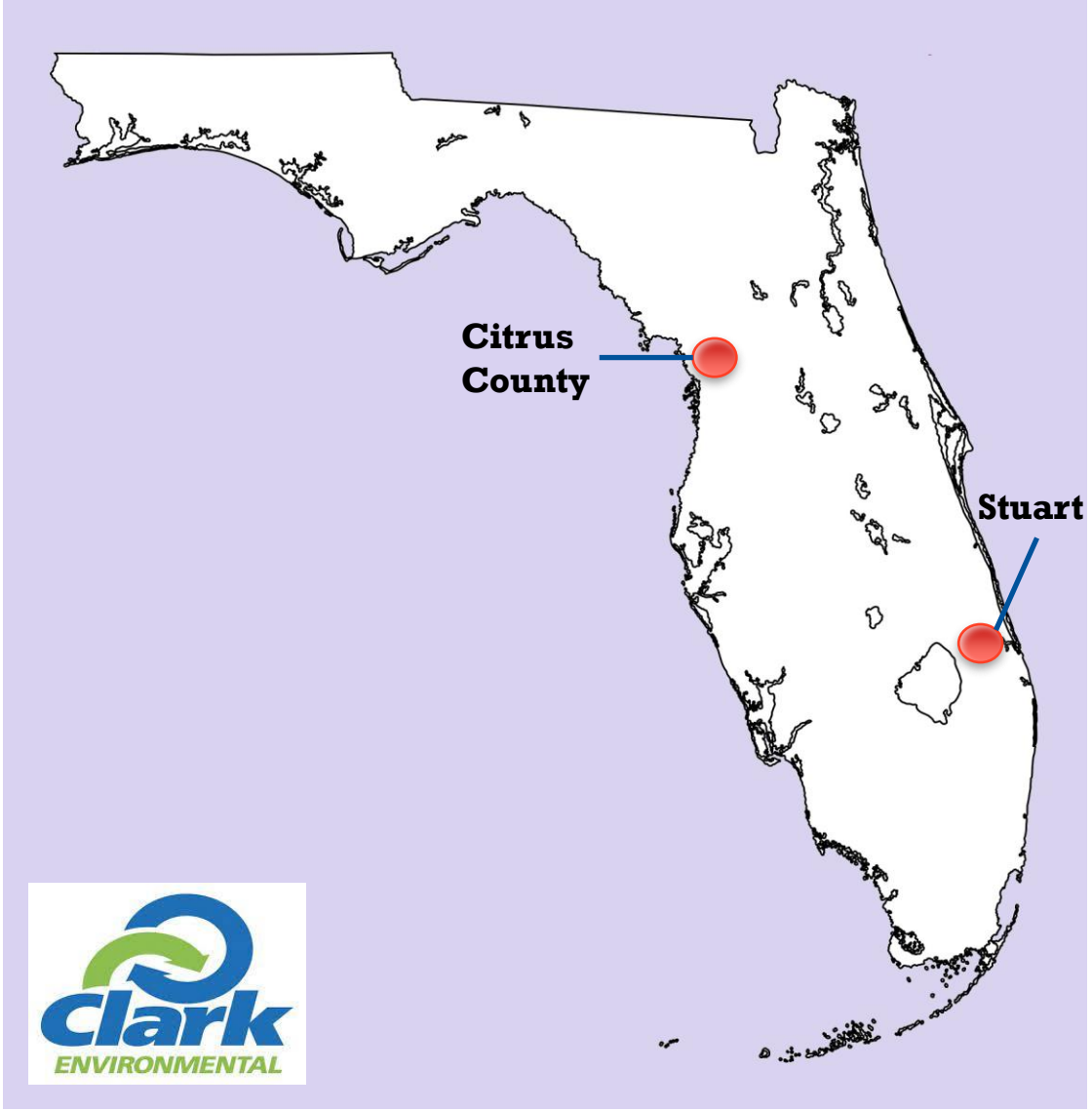


Workflow for Leaching Tests

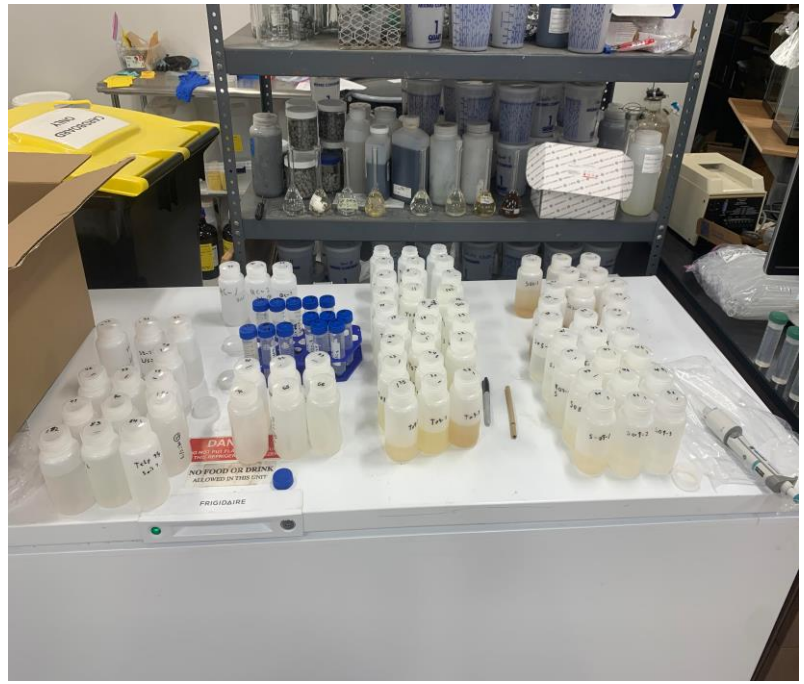


Sample Collection

- The number of samples is limited by availability of PFAS contaminated soils
- Two soils contaminated with AFFF
- Samples provided by Clark Environmental



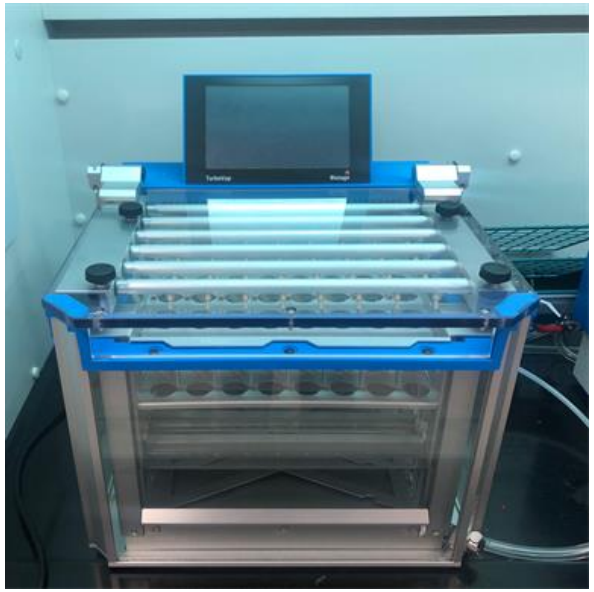
Batch Leaching Tests

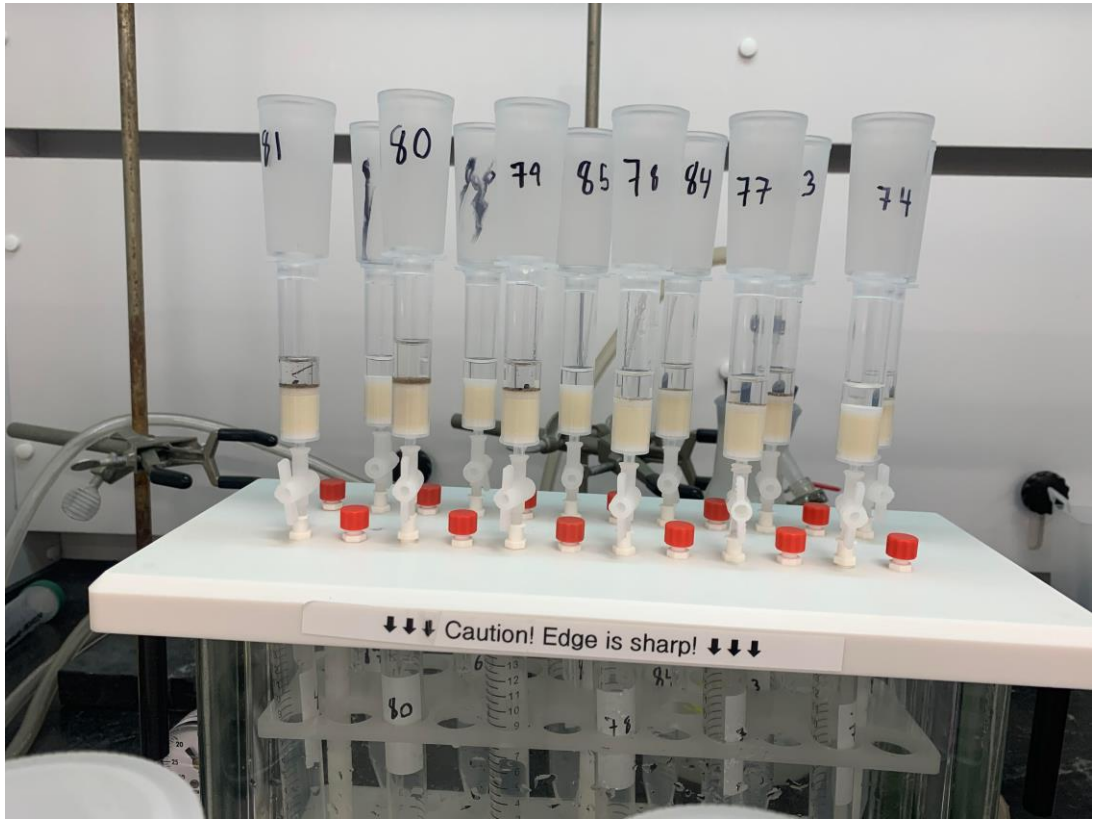


Sample Preparation → Rotation → Leachate Collection + Addition of Internal Standard

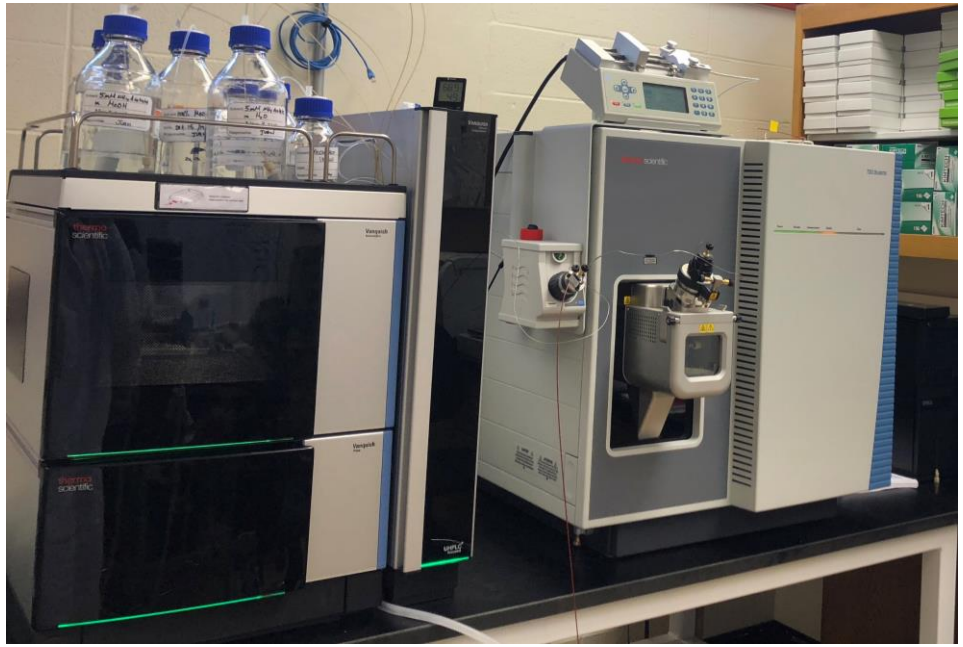
Sample Preparation

- Solid phase extraction of leachate
- Evaporation to concentrate the sample





Sample Analysis



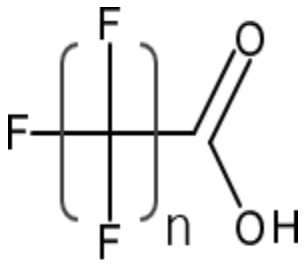
Triple Quadrupole Mass Spectrometer

Orbitrap High Resolution Mass Spectrometer

PFAS compounds

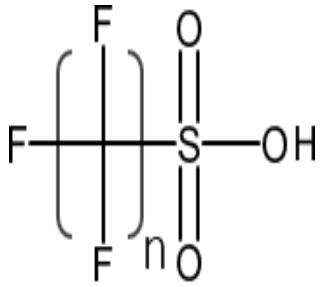
- 51 PFAS compounds

Perfluoroalkyl carboxylic acids



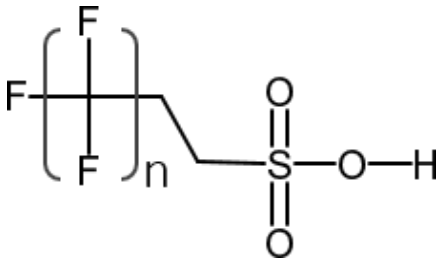
n =3 PFBA
n =4 PFPeA
n =5 PFHxA
n =6 PFHpA
n =7 PFOA
n =8 PFNA
n =9 PFDA
n =10 PFUnDA
n =11 PFDoDA
n =12 PFTrDA
n =13 PFTeDA
n =15 **PFHxDA**
n =17 **PFODA**

Perfluoroalkyl sulfonic acids



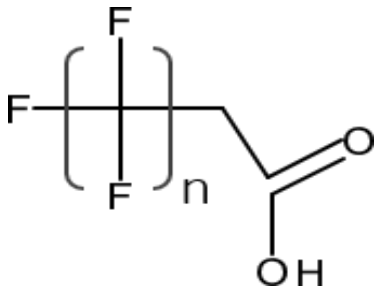
n =3 PFPrS
n =4 PFBA
n =5 PFPeS
n =6 PFHxS
n =7 PFHpS
n =8 PFOS
n =9 PFNS
n =10 PFDS
n =12 PFDoDS

Fluorotelomer sulfonic acids



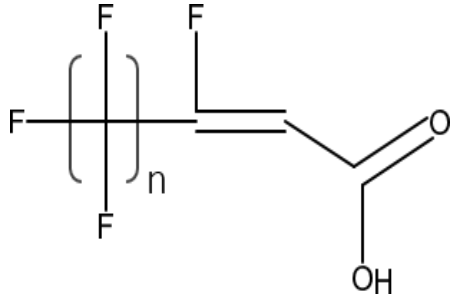
n =4, 4:2 FTS
n =6 6:2 FTS
n =8 8:2 FTS
n =10 10:2 FTS

Saturated fluorotelomer sulfonic acids



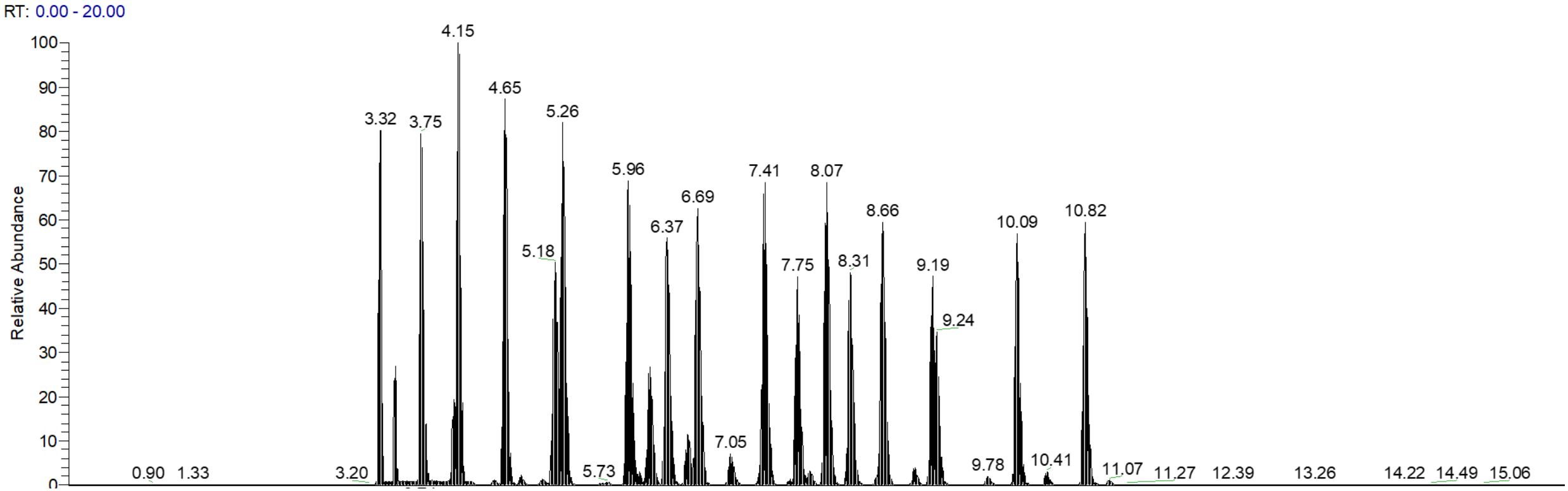
n =6 FHEA or 6:2 FTCA
n =8 FOEA or 8:2 FTCA
n =10 FDEA or 10:2 FTCA

Unsaturated fluorotelomer sulfonic acids



n =7 FOUEA or 8:2 FTUA
n =9 FDUEA or 10:2 FTCA

Data Analysis



Chromatograms of 51 PFAS spiked at 20 ng/L in solvent

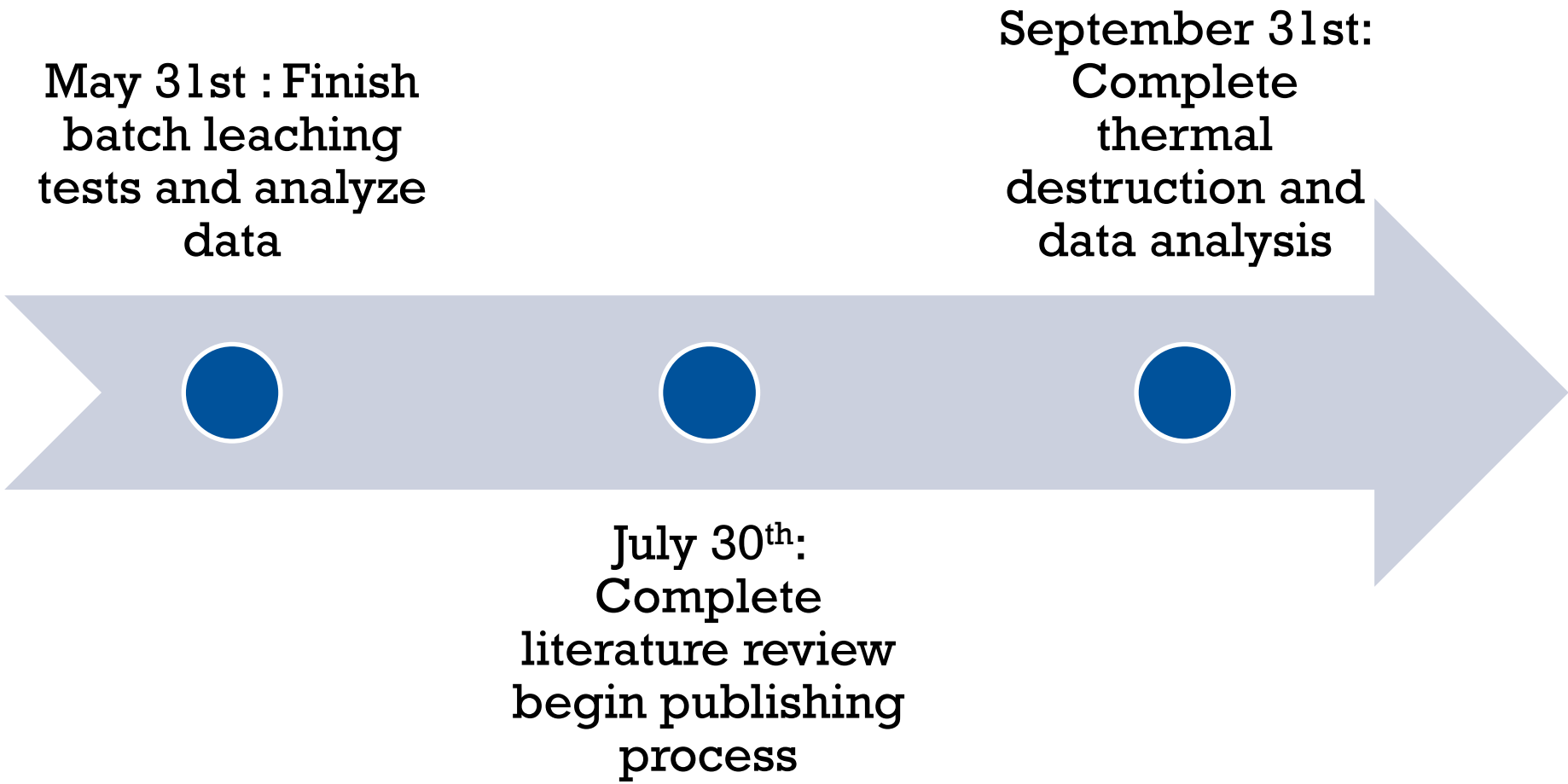
Phase II

Task III : Thermal Behavior

- Evaluate the thermal treatment of PFAS contaminated wastes testing for time, temperature and parent waste composition.
- Thermal treatment using laboratory furnaces, controlling time and temperature based on typical conditions.
- Targeted PFAS extraction of wastes before and after treatment.

Task III : Thermal Behavior

Current and Future Work Timeline



Questions?

UF Herbert Wertheim College of Engineering
UNIVERSITY of FLORIDA

Thank you for your time!

POWERING THE NEW ENGINEER TO TRANSFORM THE FUTURE