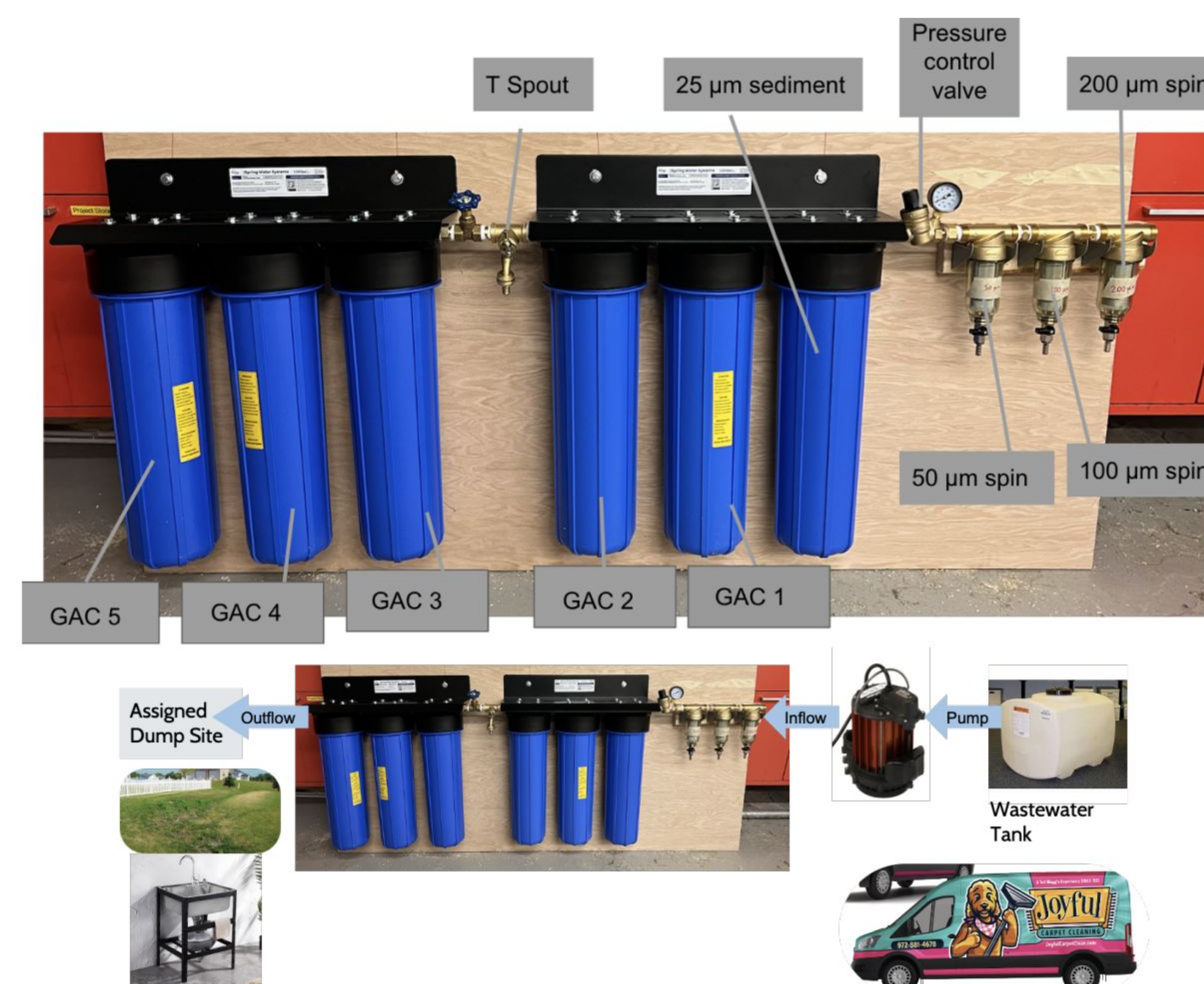


Low Cost, Open Source PFAS Filter Design for Small Cleaning Businesses and Beyond

INTRODUCTION AND CONTEXT

Perfluoroalkyl and polyfluoroalkyl substances (PFAS) are a family of toxic, carcinogenic, and bioaccumulating chemicals that are ubiquitous in consumer products, from cleaning chemicals to flame- and stain-retardant treatments of furniture fabrics and carpet. Thousands of small cleaning businesses in the USA create and release hundreds of gallons of PFAS- contaminated wastewater daily from their cleaning operations due to cleaning products that contain PFAS. They lack an awareness of PFAS presence in their wastewater as well as a way to remove or dispose of their contaminated wastewater. Our state's Department of Environmental Services sponsored a capstone project to address this need and remove PFAS from wastewater.



Our solution uses 5 granular activated carbon filters and a sediment filter to permanently remove PFAS from wastewater.

Forever chemicals, forever removed

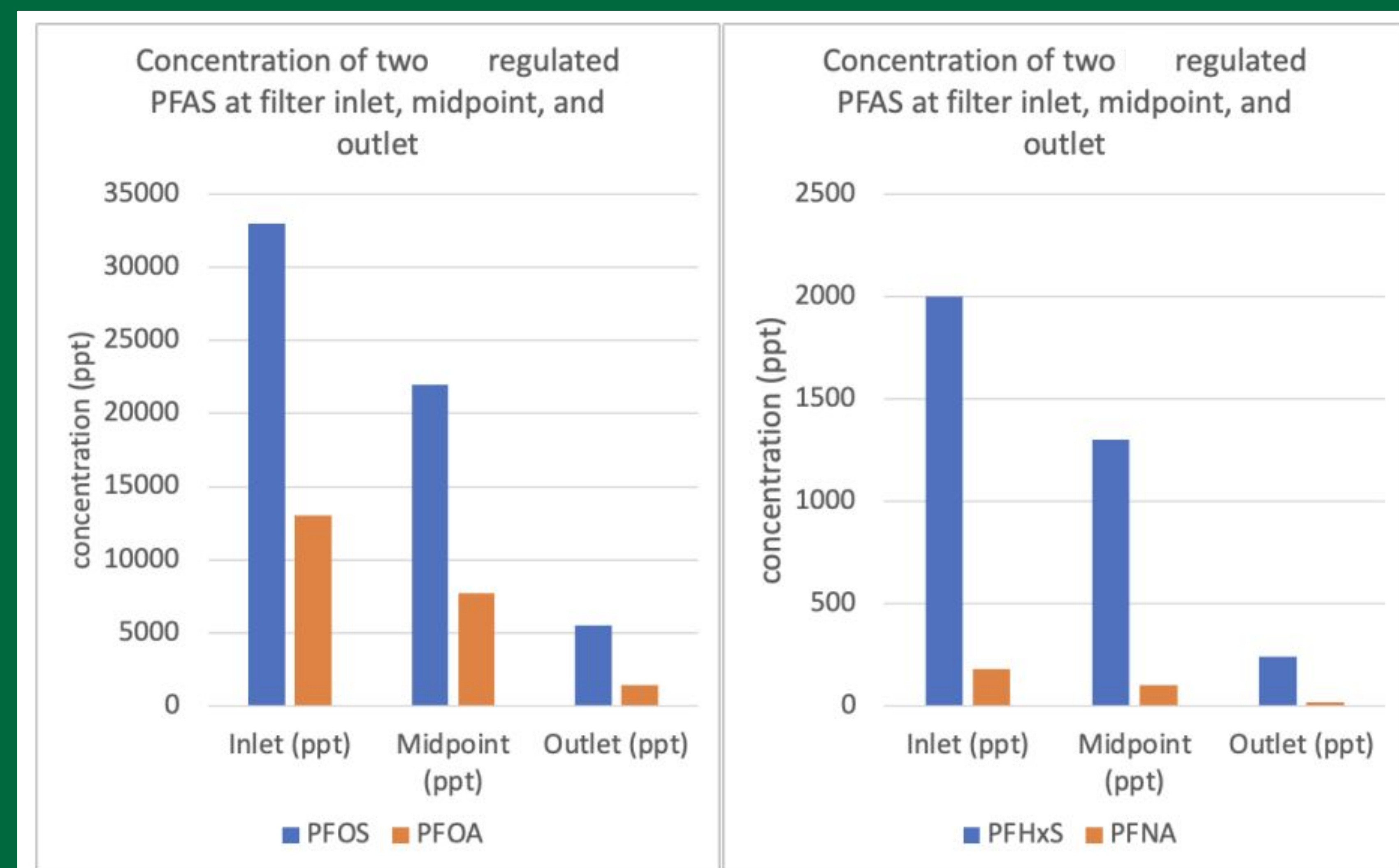


Table 1 Design Requirements for an open-source PFAS filtering system

Requirement	Quantification	Justification	Test
Gallons per day filtered	750 gallons/day minimum	Customer requirement, trade publication	Calculation of volume filtered over fixed time interval
PFAS removal efficacy	Within NH regulations for drinking water (reach goal of < 2 ppt, where 2 ppt is the detectable limit)	Existing SOA for AC filters	Test PFAS contaminated water before and after filtering
Cost	Capital cost < \$2500 Operation cost < \$2000 annually	Must be acceptable to small business to promote adoption	Acceptable environmental fee on customer bill as a cost recovery model
Floorspace required	< 50 sf	Must fit within existing workspace	User and sponsor feedback
Energy use	< 10 kWh per day	Energy costs must be minimal	Pump specs and time of operation calculation
User experience (time, space, ease of use)	Must fit within existing workflow	Must be easy to use and easy to construct from open-source documents provided.	User and sponsor feedback in response to video of use.
Initial PFAS concentration range	Up to 150,000 ppt	Sponsor measurement 118,000 ppt at one site	Obtain 118,000+ ppt wastewater and sample pre- and post-filtering. Send to Eurofins lab for testing.
Life of filter/ time between filter change	3-6 months	Typical for household applications. Needed to minimize cost. Need user feedback to confirm.	No physical test possible as large quantities (> 50,000 gallons of PFAS contaminated water needed). Rely on research to provide a conservative estimate of filter life
Safety	Must be safe to use and leak free, with no potential overflow. GAC absorbs oxygen when wet, so space needs adequate ventilation	Cannot cause more harm to the users or the environment	Calculate potential quantity of O2 absorbed by quantity of GAC used. Assure adequate air volume in space.
Ethical	Educate users. Accessible guides for do-it-yourself construction and use.	All Engineering products must remain consistent with ethical considerations	Users can identify importance of filtering based on educational materials and DIY instructions

METHOD

Our innovation lies in the design, prototyping, and testing of a low-cost system for removal of PFAS compounds from wastewater generated by cleaning companies. Our design is rooted in the scientific literature and scales designs from both lab-scale and municipal-scale PFAS filtering studies to provide a small-scale filter solution meeting the requirements of small businesses.



COLLABORATION

We worked closely with several advisors and members of the public impacted by PFAS:

- our engineering technical adviser who is a licensed PE and engineering faculty member
- our co-advisor who is a PFAS expert in the department of epidemiology at our college's medical school
- our project's sponsor who is a research scientist with an expertise in PFAS remediation who is employed by our state's Department of Environmental Services
- our customer: carpet cleaning businesses
- our state's Department of Environmental Services