



Water Treatment for PFOA and PFOS

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Topics

- PFOA/PFOS Physiochemical Properties-Treatment Challenges
- DuPont Laboratory Scale and Pilot Studies
- Granular Activated Carbon (GAC) Applications
- Typical GAC Filter Configurations
- Examples of DuPont GAC Water Treatment Applications
- GAC Operational Data, Effectiveness Monitoring & Performance
- Cost Summary
- GAC Change-Out & Spent Carbon Management
- Summary

PFOA/PFOS Physiochemical Properties-Treatment Challenges

- The strong fluorine-carbon bond and low vapor pressure makes PFOA/PFOS resistant to a number of conventional water treatment technologies, including:
 - Direct Oxidation
 - Biodegradation
 - Air Stripping & Vapor Extraction
 - Direct Photolysis (UV)

➤ Applies to other environmental media (soil, sludge, etc.)
- Recent publications have discussed some bench scale success with degradation or destruction using advanced oxidation and enhanced photochemical methods
- Water treatment methods ultimately must be practical and achieve treatment goals
- Thermal treatment remains the primary choice for solids

DuPont Laboratory Scale and Pilot Studies (PFOA)

- Initial remedial focus on PFOA in on-site soil, groundwater and landfill leachate
- Mid-1990's soil remediation study confirmed feasibility of in-situ thermal destruction ("electro-osmosis) for soils within solid waste management unit (SWMU) but is not cost effective
- Bench scale water filtration studies (2003) included:
 - Man-made materials (e.g., ZVI, steel slag, steel process millscale)
 - Natural materials (e.g., peat moss, bauxite ore, iron-copper catalyst)
 - Granular activated carbon (multiple grades)
 - Silicate Zeolites

→ **Only GAC proved successful**

DuPont Laboratory Scale and Pilot Studies (cont.)

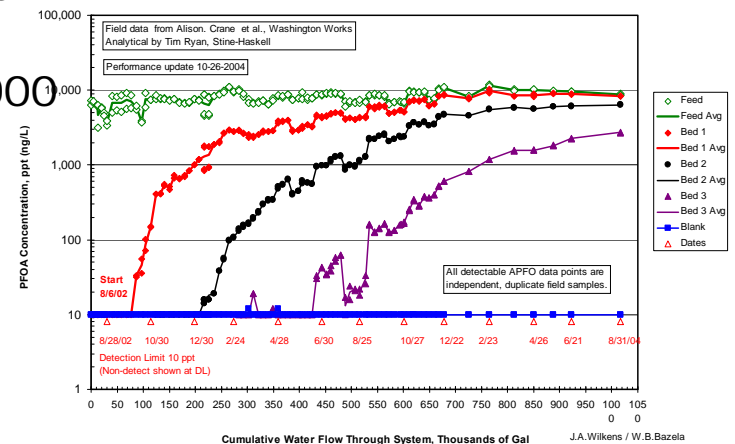
- Pilot scale study using potable water (“trace contaminant”) grade GAC(2004-2005)
 - 18 month study using 1gpm/10 ppb PFOA slip stream
 - Excellent results allowed scale-up for design of larger GAC treatment systems
- Note: Reverse osmosis is used by DuPont for process treatment and recycling, but is not typically a good candidate for a potable water treatment application due to the low concentration treatment goals

DuPont GAC Pilot Study

- GAC System
 - 10 ppb PFOA feed groundwater
 - Calgon "Filtrisorb 600" GAC column
 - Three sections, for intermediate analyses
 - 11 in. diam., 24 in. deep, 55 lbs GAC
- Operation
 - Two years, ending August 2004
 - Processed > 1,000,000 gallons
 - Analytical: HPLC / tandem mass spec.
 - Graph: log concentration vs. time
 - Output < 10 ppt DL (blue) thru 430,000 gal.
 - Run to develop performance data
 - Bed #1 (red) to near saturation
 - Beds #2 (black), #3 (purple) breakthrough
 - Design-quality data developed



Washington Works GAC Pilot Facility
PFOA Concentrations

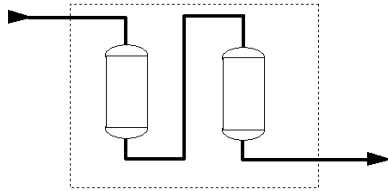




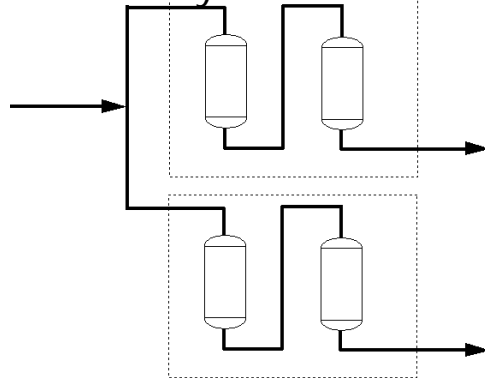
Typical GAC Filter Configurations

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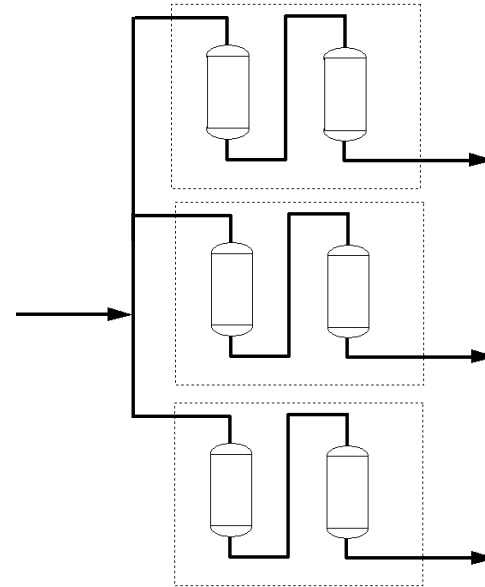
- Flow rate to 800 gpm (1.15 MGD)
 - 6,000 - 20,000 pounds GAC per vessel
 - Total System GAC = 12K to 40K pounds



- Flow Rate to 1,600 gpm (2.30 MGD)
 - 20,000 pounds GAC per vessel
 - Total System GAC = 80K pounds



- Flow Rate to 2,400 gpm (3.45 MGD)
 - 20,000 pounds GAC per vessel
 - Total System GAC = 120K pounds





Examples of DuPont GAC Water Treatment Applications

Private Well/Residential Application

- 2-4 gpm
- particulate pre-filter
- 100 lbs GAC/unit
- 1-3 year lifespan



Landfill Water Treatment Applications



< 10 gpm w/pre-metals
treatment

➤ 150 gpm w/pre-
cartridge solids
filtration



Ohio-1.5 MGD GAC Facility



Ohio-1.5 MGD GAC Facility Under Construction



06/13/2007

Ohio-1.0 MGD GAC Facility w/Equalization Tank



Ohio-.5 MGD GAC Facility Under Construction



WV-1.2 MGD GAC Facility



06/21/2007



GAC Operational Data, Effectiveness Monitoring and Performance

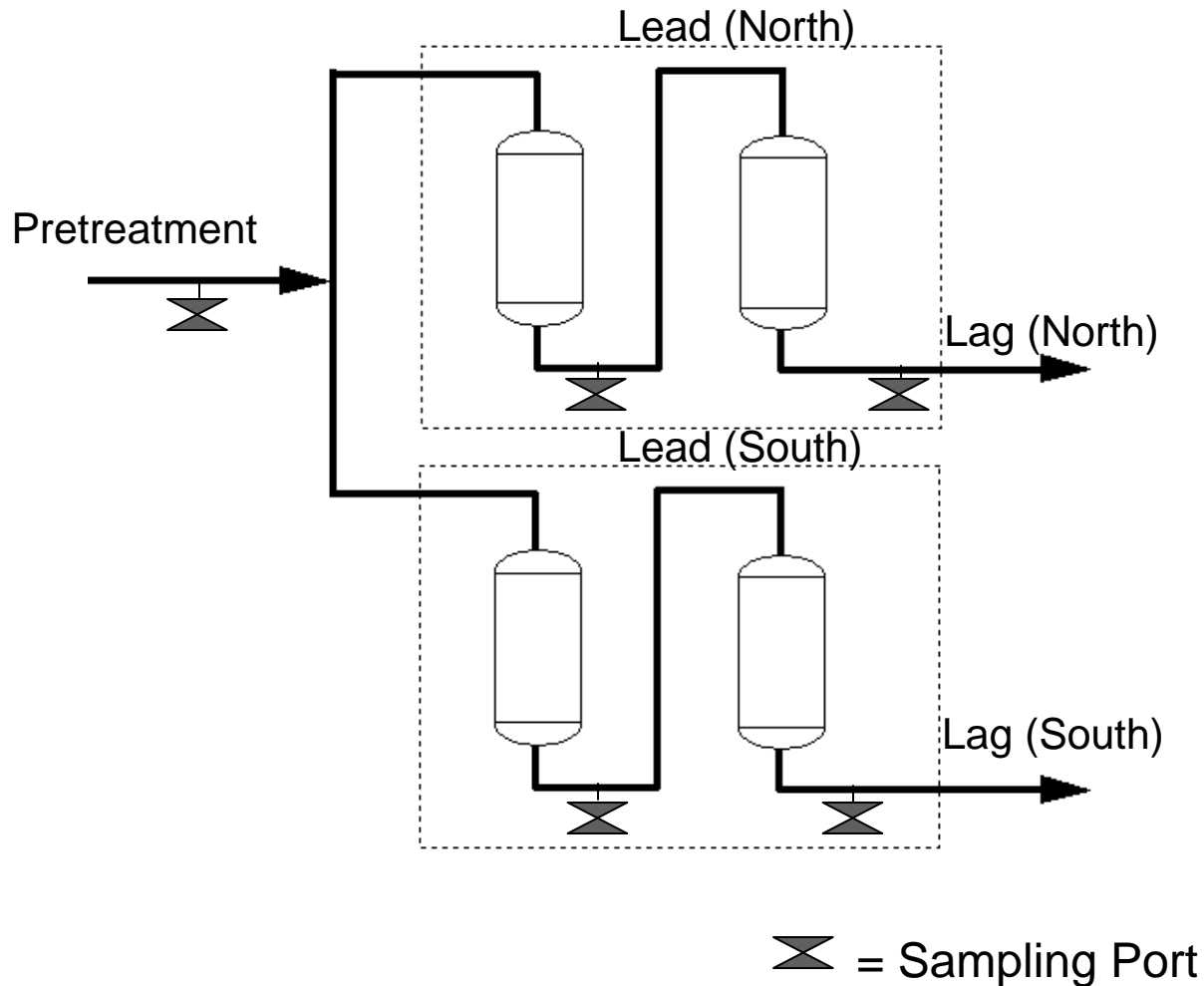
Operational Data

Site Designation	Flow Rate (gpm)		GAC Filter X-Sectional Area per Vessel (SF)	Carbon Volume per Vessel (gallons)	Hydraulic Loading per Vessel (gpm/SF)		EBCT per Vessel (min)		Flow to Change-out (million gallons)		Carbon Loading at Change-out (pounds/1,000 gal)		Days to Change-out	
	Low	High			Low	High	Low	High	Low	High	Low	High	Low	High
A	682	898	78.5	3774	4.3	5.7	8.4	11.1	98	288	0.14	0.41	104	286
B	778	824	78.5	3774	5.0	5.2	9.2	9.7	163	288	0.14	0.25	148	190
C	579	635	78.5	3774	3.7	4.0	11.9	13.0	76	200	0.20	0.53	87	162
D	528	592	78.5	3774	3.4	3.8	12.7	14.3	45	66	0.61	0.89	54	94
E	212	308	50.3	1887	4.2	6.1	6.1	8.9	74	100	0.10	0.14	274	429

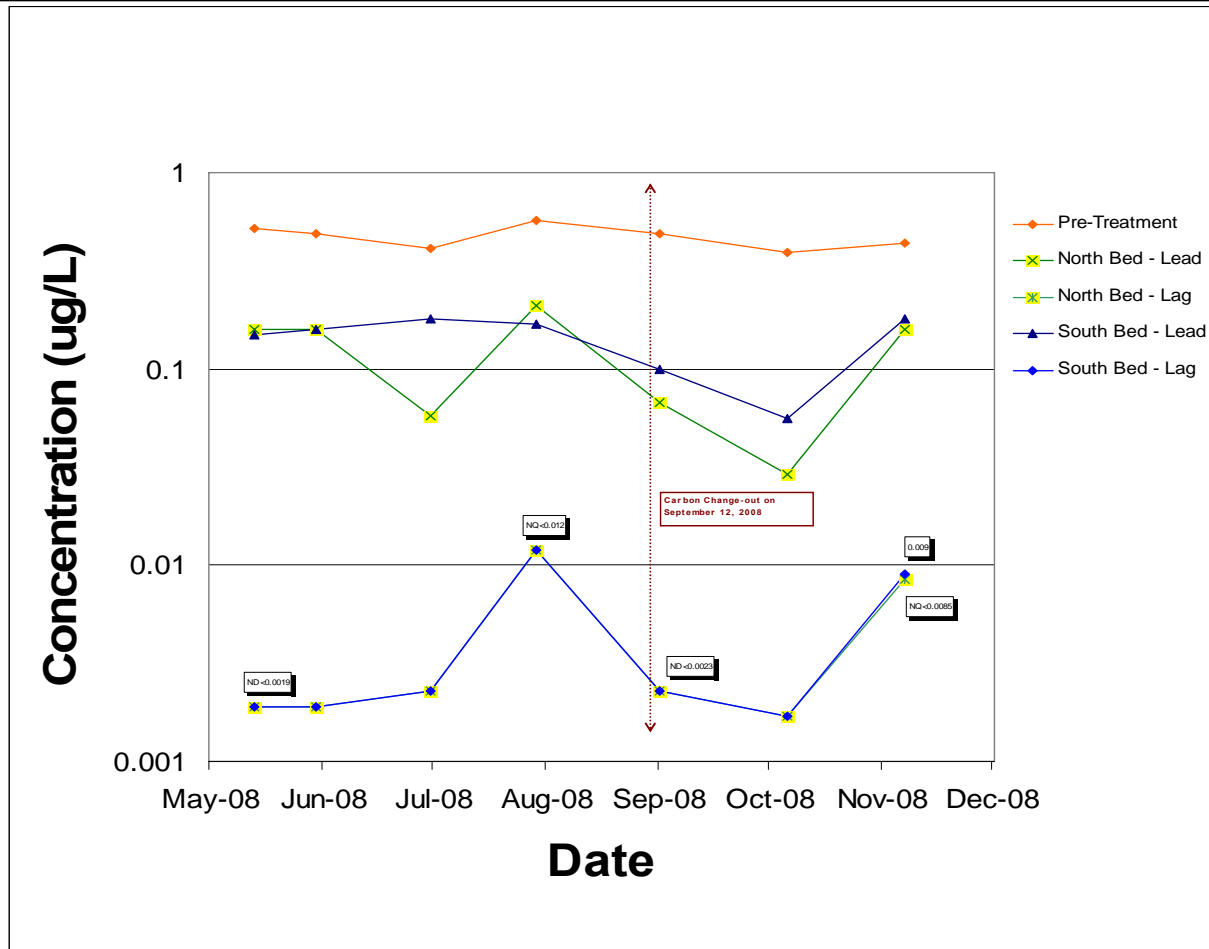
Notes:

1. Site E has two (2) vessels with 10,000 pounds GAC in each vessel. All other sites have four (4) vessels with 20,000 pounds GAC in each vessel.
2. Hydraulic loading is a measure of the flow rate of water through the cross-sectional area of the vessel.
3. Empty Bed Contact Time (EBCT) is the water contact time with the volume of carbon.

Effectiveness Monitoring Typically Monthly or Quarterly



Carbon Adsorption Data



Results of Not Detected (ND) are graphed as the Limit of Detection (LOD) value
Results of Not Quantified (NQ) are graphed as the Limit of Quantification (LOQ) value
ND < LOD < NQ < LOQ



Example Costs

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- 1 (mgd) million gallons per day potable water facility w/2 sets 20,000 GAC units, split parallel flow
 - Engineering design, permitting, construction (\$2.5-\$3.5 million)
 - Annual operations and monitoring (\$100K-\$300K)
- Residential system (lead/lag as shown)
 - \$5K including install. by certified plumber
 - Annual operations and monitoring (\$1-\$2K)



GAC Change-Outs and Spent Carbon Management

Carbon Change-Outs & Spent Carbon Management

- Typically exchange GAC in lead bed(s) based on monitoring program results
 - Example: 40,000 pounds GAC exchanged for 1,600 gpm system
 - Valve and pipe configurations allow the lead vessel to be placed in lag (polish) position after exchange
- Large multi-compartment trailer(s) used to transfer spent carbon and fresh carbon
- Backwashing
 - Conducted at carbon exchange after GAC is wetted/deaerated
 - Management of backwash water presents challenges in rural settings
 - Typically subject to NPDES permit
- Spent carbon regenerated at vendor facility for re-use in other non-potable applications * Re-gen. temperature fully destroys PFOA
- Example Cost
 - Virgin carbon \$1.10/pound to \$1.30/pound
 - Delivery and technical support extra



Summary

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- Limited technologies available for water treatment of PFOA and PFOS
- Thermal treatment of solids is very effective
- Granular activated carbon (GAC) most effective water treatment method
- GAC type will dictate level of removal. Special “trace” contaminant formulations best for lowest (i.e., part per trillion) treatment goals
- Reverse osmosis better for higher concentration industrial treatment
- Overall, there is a high level of current research on treatment of/for perfluorinated compounds