

A close-up photograph of clear water being poured into a glass, with splashes and ripples visible. The background is a solid blue color.

EPA Tools & Resources Training Webinar: PFAS Removal in Drinking Water Treatment Systems

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US EPA Office of Research and Development*

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- Background of EPA PFAS (per- and polyfluoroalkyl substances) Treatment Research
- EPA Models
 - Treatability database
 - Performance models
 - Cost models
- Demonstration of Performance Models
 - How to download
 - Example runs





EPA's PFAS Drinking Water Research

Problem: Utilities lack treatment technology cost data for PFAS removal

Actions:

- Gather performance and cost data from available sources (DOD, utilities, industry, etc.)
- Conduct EPA research on performance of treatment technologies including home treatment systems
- Update EPA's Treatability Database, Treatment Models and Unit Cost Models
- Connect EPA's Treatability Database to EPA's Unit Cost Models for ease of operation
- Model performance and cost, and then extrapolate to other scenarios
- Address treatment impact on corrosion
- Evaluate reactivation of granular activated carbon

Impact: *Enable utilities to make informed decisions about cost-effective treatment strategies for removing PFAS from drinking water*

Model Scenarios

- Variable source waters
- Variable PFAS concentrations in source water
- Alternate treatment goals
- Changing production rates
- Different reactivation/disposal options
- Document secondary benefits



Suite of Tools

To provide tools to accurately predict the performance and cost of treating PFAS in drinking waters

Treatability Database

United States Environmental Protection Agency

Environmental Topics Laws & Regulations About EPA Search EPA.gov

Related Topics: [Water Research](#) CONTACT US SHARE

Drinking Water Treatability Database (TDB)

Provides information on the control of contaminants

EPA's [Drinking Water Treatability Database \(TDB\)](#) is an easy to use tool that provides referenced information on the control of contaminants in drinking water. It was designed for use by utilities, first responders to spills or emergencies, consultants and technical assistance providers, treatment process designers, and researchers.

Information in the TDB is gathered from thousands of literature sources and assembled on one site. Information is available for over 70 regulated and unregulated contaminants and more than 30 treatment processes.

[Navigating the TDB](#) [Capabilities](#) [Future Updates](#) [Support](#)

Quick Start

- [Find a Contaminant](#)
- [Find a Treatment Process](#)

Cost Models

United States Environmental Protection Agency

Environmental Topics Laws & Regulations About EPA Search EPA.gov

Related Topics: [Safe Drinking Water Act](#) CONTACT US SHARE

Drinking Water Treatment Technology Unit Cost Models and Overview of Technologies

Drinking Water Treatment Technology Unit Cost Models

...and executive orders require EPA to estimate compliance costs for new drinking water standards. The three major components of these costs are:

...nt

...ng

...rative costs

...chnologies remove or destroy pollutants (such as arsenic, disinfection byproducts, and waterborne pathogens).

...treatment costs, EPA developed several engineering models using a bottom-up approach known as work breakdown structure (WBS) models:

Performance Models

United States Environmental Protection Agency

Environmental Topics Laws & Regulations About EPA Search EPA.gov

Related Topics: [Water Research](#) CONTACT US SHARE

Environmental Technologies Design Option Tool (ETDOT)

Adsorption treatment modeling for contaminant removal from drinking water and wastewater

The Environmental Technologies Design Option Tool (ETDOT) is a suite of software models that provides engineers with the capability to evaluate and design systems that use granular activated carbon or ion exchange resins for the removal of contaminants, including PFAS, from drinking water and wastewater.

Access ETDOT

Access the ETDOT software, manuals, and more at [ETDOT GitHub site](#). [EXIT](#)

[Suite of Models](#) [Compatibility](#) [Applications](#) [Related EPA Resources](#)

Suite of Models

ETDOT was developed by National Center for Clean Industrial and Treatment Technologies at Michigan Technological University (MTU). In 2019, EPA signed an agreement with MTU to make this suite of adsorption models available to the public at no cost.



Treatment Information

Publicly Available Drinking Water Treatability Database

Interactive literature review database that contains 123 regulated and unregulated contaminants and covers 35 treatment processes commonly employed or known to be effective (thousands of sources assembled on one site)

Currently available:

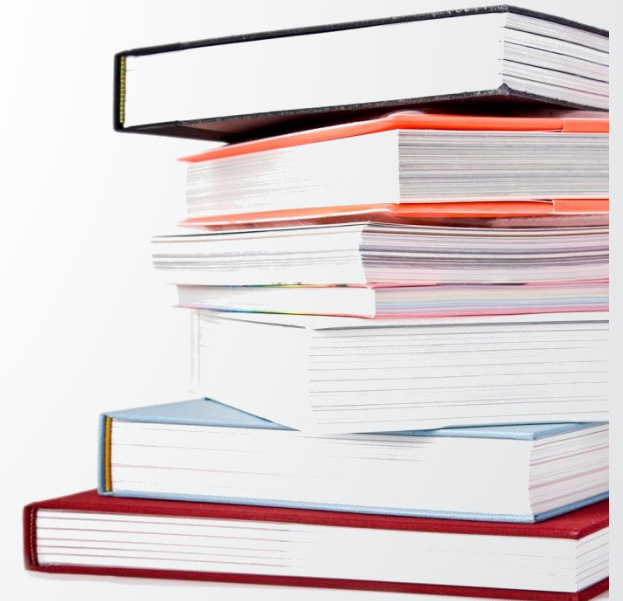
PFOA, PFOS, PFTriA, PFDoA, PFUnA, PFDA, PFNA, PFHpA, PFHxA, PFPeA, PFBA, PFDS, PFHpS, PFHxS, PFBA, PFBS, PFOSA, FtS 8:2, FtS 6:2, N-EtFOSAA, N-MeFOSAA and GenX

epa.gov/water-research/drinking-water-treatability-database-tdb

Search: EPA TDB

Recently updated!

Contains treatment information to be used in performance or cost models





Treatability Database

Agency Landing Page

The screenshot shows the EPA website header with the logo and navigation menu. The main content area features the title "Drinking Water Treatability Database (TDB)" and a sub-header "Information on treatment processes for controlling contaminants". A "NEW" badge indicates that information is now available for 35 treatment processes and 123 regulated and unregulated contaminants, including 26 PFAS chemicals. A sidebar titled "On this Page" contains a list of links: "Overview and Search Capabilities", "Applications", "Platform and Compatibility", and "Future Updates and Support". A blue button labeled "Access the TDB" is circled in black, with an orange arrow pointing from it to the "Find Contaminant" link in the Database Homepage screenshot.

Database Homepage

The screenshot shows the EPA website header with the logo and navigation menu. The main content area features the title "Welcome to the Drinking Water Treatability Database" and a large image of water splashing. The navigation menu includes "Home", "About the TDB", "Contact Us", "Find Contaminant", "Find Treatment Process", "Help", and "Quick Links". The "Find Contaminant" and "Find Treatment Process" links are circled in black.

epa.gov/water-research/drinking-water-treatability-database-tdb

Search: EPA TDB



PFAS Treatment

Per- and Polyfluoroalkyl Substances

Informational Links

Contaminant Navigation

Overview

Treatment Processes

Properties

Fate and Transport

References

Overview

CAS Number:

Synonyms:

Heptafluoropropyl 1,2,2,2-tetrafluoroethyl ether (E1),2,3,3,3-tetrafluoro-2-(heptafluoropropoxy)propanoate (FRD-902),2,3,3,3-tetrafluoro-2-(heptafluoropropoxy)propanoic acid (FRD-903),Ammonium perfluoro-2-methyl-3-oxahexanoate (GenX),Heptadecafluorononanoic acid,Heptafluorobutyric acid,Nonadecafluorocapric acid,Nonadecafluorodecanoic acid,Pefluorobutane sulfonate,Perfluorobutyric acid,Perfluorocapric acid,Perfluorohexanesulfonic acid potassium salt,Potassium tridecafluoro-1-hexanesulfonate,Tridecafluorohexane-1-sulfonic acid potassium salt

Contaminant Type: Chemical

Description:

Per- and polyfluoroalkyl substances (PFASs) are fluorinated aliphatic substances with unique properties, such as being both hydrophobic, lipophobic, and extremely stable due to the strength of the C-F bond [2539]. Their properties have led to their extensive use as surface active agents in products like stain repellants and fire-fighting foams [2527, 2539]. The two most frequently studied PFASs, perfluorooctane sulphonate (PFOS) and perfluorooctanoic acid (PFOA), have their own, separate entries in this treatability database. Both PFOS and PFOA are compounds with eight carbon atoms. This group entry covers

Per- and Polyfluoroalkyl Substances

Informational Links

Contaminant Navigation

Overview

Treatment Processes

Properties

Fate and Transport

References

Treatment Processes

The following processes were found to be effective for the removal of PFASs: granular activated carbon (GAC) (up to > 98 percent), membrane separation (up to > 99 percent), and ion exchange (up to > 99 percent). These results cover the removal of specific PFASs including PFTriA, PFDoA, PFUnA, PFDA, PFNA, PFHpA, PFHxA, PFPeA, PFPeS, PFDS, PFHpS, PFHxS, PFBA, PFBS, PFPrS, PFOSA, PFMOAA, PFO3OA, PFO2HxA, FtS 8:2, FtS 6:2, N-EtFOSAA, N-MeFOSAA, and GenX. For results on the removal of PFOS and PFOA, see the separate treatability database entries for those specific contaminants.

Studies were identified evaluating the following treatment technologies for the removal of PFASs:

Adsorptive Media

A bench-scale study conducted batch tests of adsorption using magnetic nanoparticles with different polymer coatings. In ultrapure water, the best performing of these achieved high removals of long chain and sulfonated PFASs (e.g., >90 percent ...

[See more](#)

Aeration and Air Stripping

At a full-scale site, packed tower aeration was not effective for removing PFASs [2441].



PFAS Treatment: Activated Carbon

Matrix of conditions and results from treatment references that can be downloaded into a spreadsheet

Ref #	Author	Year	Log or Percent Removal	Removal Type	Contaminant Influent	Contaminant Effluent	Contaminant Units	Contaminant	Scale	Design Flow	Water	Location Studied	GAC Type	Manufacturer	Product Name
2441	Dickenson,	2016	-10.5 to 13.7#	Percent	4.4 to 5.1#	5.7 to 6.3#	ng/L	PFHpA	F	5	SW	New Jersey	B	Calgon	F300
2441	Dickenson,	2016	-11 to 5#	Percent	3.6 to 5.8#	4.0 to 5.5#	ng/L	PFHxS	F	5	SW	New Jersey	B	Calgon	F300
2441	Dickenson,	2016	-13 to 6#	Percent	1.8 to 2.4#	1.7 to 2.7#	ng/L	PFNA	F	5	SW	New Jersey	B	Calgon	F300
2441	Dickenson,	2016	-19 to 10#	Percent	6.8 to 7.3#	6.1 to 8.7#	ng/L	PFHxA	F	5	SW	New Jersey	B	Calgon	F300
2441	Dickenson,	2016	-26#	Percent	<5.0#	6.3#	ng/L	PFBA	F	5	SW	New Jersey	B	Calgon	F300
2441	Dickenson,	2016	-34 to 8#	Percent	0.59 to 0.97#	0.54 to 1.3#	ng/L	PFDA	F	5	SW	New Jersey	B	Calgon	F300
2441	Dickenson,	2016	-66 to 70#	Percent	1.23 to 1.81#	0.537 to 2.48#	ng/L	PFBA	F	0.5472 to	GW	Minnesota	B	Calgon	F600
2441	Dickenson,	2016	0 to 19#	Percent	<0.05 to 0.085	<0.05 to 0.069#	ng/L	PFPeA	F	0.5472 to	GW	Minnesota	B	Calgon	F600
2441	Dickenson,	2016	0 to 76#	Percent	<0.05 to 0.210	<0.05#	ng/L	PFHxS	F	0.5472 to	GW	Minnesota	B	Calgon	F600
2441	Dickenson,	2016	33#	Percent	15#	10#	ng/L	PFBA	F	5#	SW	Colorado	B	Norit	GAC 300
2441	Dickenson,	2016	46 to 60#	Percent	0.127 to 0.192	<0.05 to 0.1023	ng/L	PFHxA	F	0.5472 to	GW	Minnesota	B	Calgon	F600
2441	Dickenson,	2016	5 to 6#	Percent	2.1 to 3.6#	2.0 to 3.4#	ng/L	PFBS	F	5	SW	New Jersey	B	Calgon	F300
2441	Dickenson,	2016	7.2 to 12.7#	Percent	4.8 to 5.5#	6.4 to 6.9#	ng/L	PFPeA	F	5	SW	New Jersey	B	Calgon	F300
2441	Dickenson,	2016	74#	Percent	17#	4.4#	ng/L	PFPeA	F	5#	SW	Colorado	B	Norit	GAC 300
2441	Dickenson,	2016	91#	Percent	11#	0.97#	ng/L	PFNA	F	5#	SW	Colorado	B	Norit	GAC 300
2441	Dickenson,	2016	>89#	Percent	4.5#	<0.50#	ng/L	PFHpA	F	5#	SW	Colorado	B	Norit	GAC 300
2441	Dickenson,	2016	>96#	Percent	5.8#	<0.25#	ng/L	PFHxS	F	5#	SW	Colorado	B	Norit	GAC 300
2441	Dickenson,	2016	>96#	Percent	6.4#	<0.25#	ng/L	PFBS	F	5#	SW	Colorado	B	Norit	GAC 300
2505	Cummings,	2015	>72 to >93#	Percent	18 to 72	<5	ng/L	PFNA	F		SW	Logan System Birch	B	Calgon	F-400



Drinking Water Treatment for PFOS

Ineffective Treatments

- Conventional Treatment
- Low Pressure Membranes
- Biological Treatment (including slow sand filtration)
- Disinfection
- Oxidation
- Advanced oxidation

PAC Dose to Achieve

50% Removal	16 mg/l
90% Removal	>50 mg/L

Dudley et al., 2015

Effective Treatments

	Percent Removal	
Anion Exchange Resin (IEX)	90 to 99	- Effective
High Pressure Membranes	93 to 99	- Effective
Powdered Activated Carbon (PAC)	10 to 97	- Effective for only select applications
Granular Activated Carbon (GAC)		
Extended Run Time	0 to 26	- Ineffective
Designed for PFAS Removal	> 89 to > 98	- Effective



Suite of Tools

To provide tools to accurately predict the performance and cost of treating PFAS in drinking waters

Treatability Database

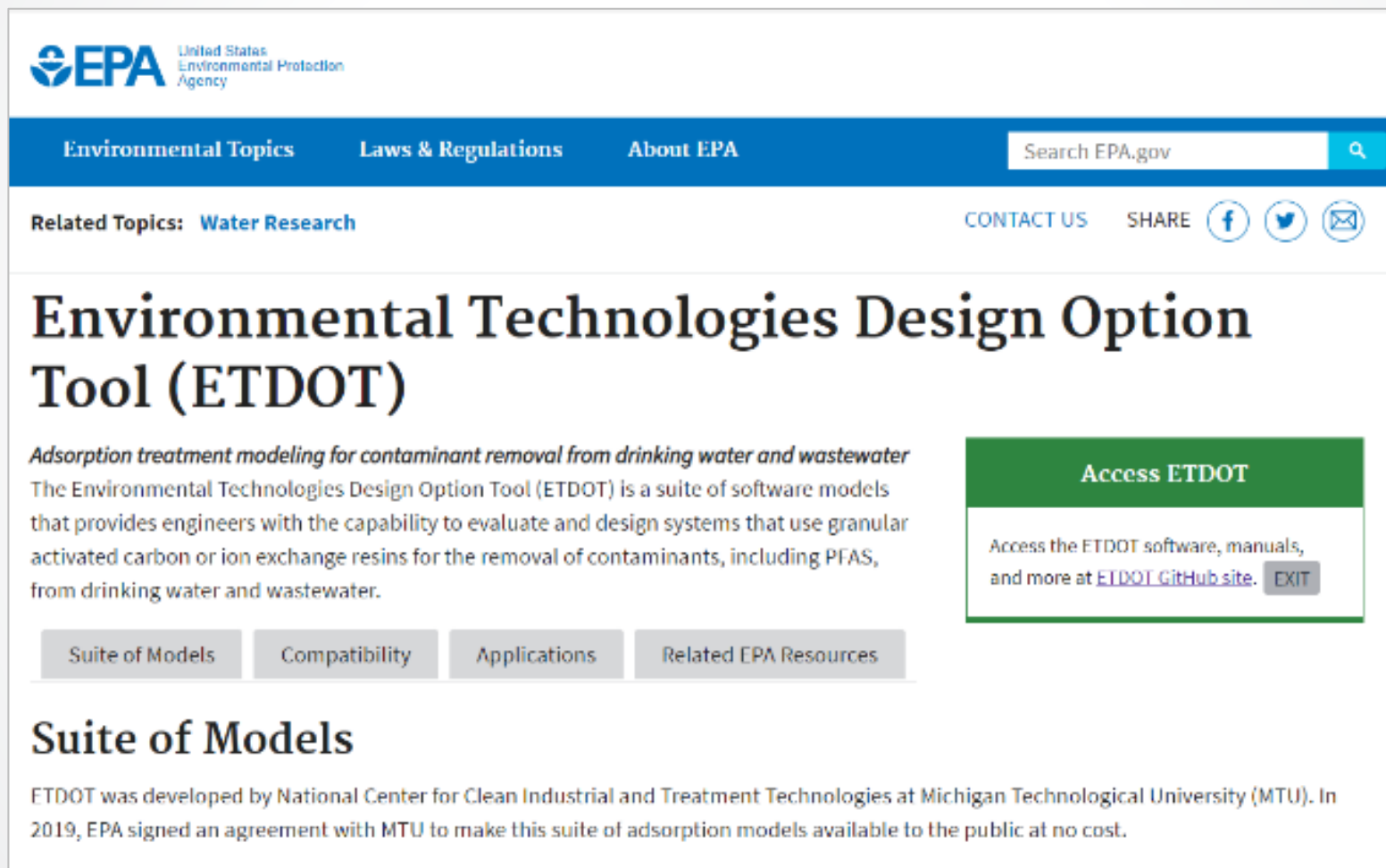
The screenshot shows the EPA website's navigation bar with 'Environmental Topics', 'Laws & Regulations', and 'About EPA'. Below the search bar, 'Related Topics: Water Research' is displayed. The main heading is 'Drinking Water Treatability Database (TDB)'. A sub-heading reads 'Provides information on the control of contaminants'. A 'Quick Start' section lists 'Find a Contaminant' and 'Find a Treatment Process'. A paragraph explains that the TDB is an easy-to-use tool for finding information on contaminant control. A bottom navigation bar includes 'Navigating the TDB', 'Capabilities', 'Future Updates', and 'Support'.

Cost Models

The screenshot shows the EPA website's navigation bar. Below the search bar, 'Related Topics: Safe Drinking Water Act' is displayed. The main heading is 'Drinking Water Treatment Technology Unit Cost Models and Overview of Technologies'. A sub-heading reads 'Drinking Water Treatment Technology Unit Cost Models'. A paragraph mentions that EPA estimates compliance costs for new drinking water standards. A bottom navigation bar includes 'Suite of Models', 'Compatibility', 'Applications', and 'Related EPA Resources'.

Performance Models

The screenshot shows the EPA website's navigation bar. Below the search bar, 'Related Topics: Water Research' is displayed. The main heading is 'Environmental Technologies Design Option Tool (ETDOT)'. A sub-heading reads 'Adsorption treatment modeling for contaminant removal from drinking water and wastewater'. A paragraph explains that ETDOT is a suite of software models for evaluating and designing systems for PFAS removal. A green 'Access ETDOT' button is prominent. A bottom navigation bar includes 'Suite of Models', 'Compatibility', 'Applications', and 'Related EPA Resources'. A footer note states that ETDOT was developed by National Center for Clean Industrial and Treatment Technologies at Michigan Technological University (MTU) and is available to the public at no cost.



The screenshot shows the EPA website's page for the Environmental Technologies Design Option Tool (ETDOT). At the top left is the EPA logo with the text "United States Environmental Protection Agency". A navigation bar contains "Environmental Topics", "Laws & Regulations", and "About EPA", along with a search box for "EPA.gov". Below the navigation bar, it says "Related Topics: Water Research" and includes "CONTACT US" and "SHARE" buttons with social media icons. The main heading is "Environmental Technologies Design Option Tool (ETDOT)". Below this is a sub-heading "Adsorption treatment modeling for contaminant removal from drinking water and wastewater" and a paragraph describing the tool as a suite of software models for evaluating and designing systems that use granular activated carbon or ion exchange resins for contaminant removal, including PFAS. To the right of the text is a green button labeled "Access ETDOT" and a box containing the text "Access the ETDOT software, manuals, and more at [ETDOT GitHub site](#)." with an "EXIT" button. Below the text are four buttons: "Suite of Models", "Compatibility", "Applications", and "Related EPA Resources". The section "Suite of Models" is expanded, showing a paragraph: "ETDOT was developed by National Center for Clean Industrial and Treatment Technologies at Michigan Technological University (MTU). In 2019, EPA signed an agreement with MTU to make this suite of adsorption models available to the public at no cost."

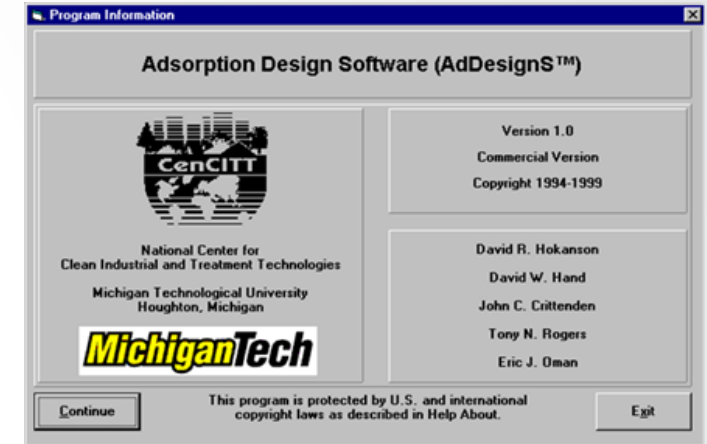
<https://www.epa.gov/water-research/environmental-technologies-design-option-tool-etdot>

Search: EPA ETDOT

Models available at the GitHub site:

- Adsorption Design Software for Windows (AdDesignS) *Version 1.0*
- Advanced Oxidation Process Software (AdOx) *Version 1.0.2*
- Aeration System Analysis Program (ASAP) *Version 1.0*
- Biofilter Design Software *Version 1.0.27*
- Continuous Flow Pore Surface Diffusion Model for Modeling Powdered Activated Carbon Adsorption *Version 1.0*
- Dye Study Program (DyeStudy) *Version 1.0.0*
- Predictive Software for the Fate of Volatile Organics in Municipal Wastewater Treatment Plants (FaVOr) *Version 1.0.11*
- Ion Exchange Design Software (IonExDesign) *Version 1.0.0*
- Software to Estimate Physical Properties (StEPP) *Version 1.0*

epa.gov/water-research/environmental-technologies-design-option-tool-etdot



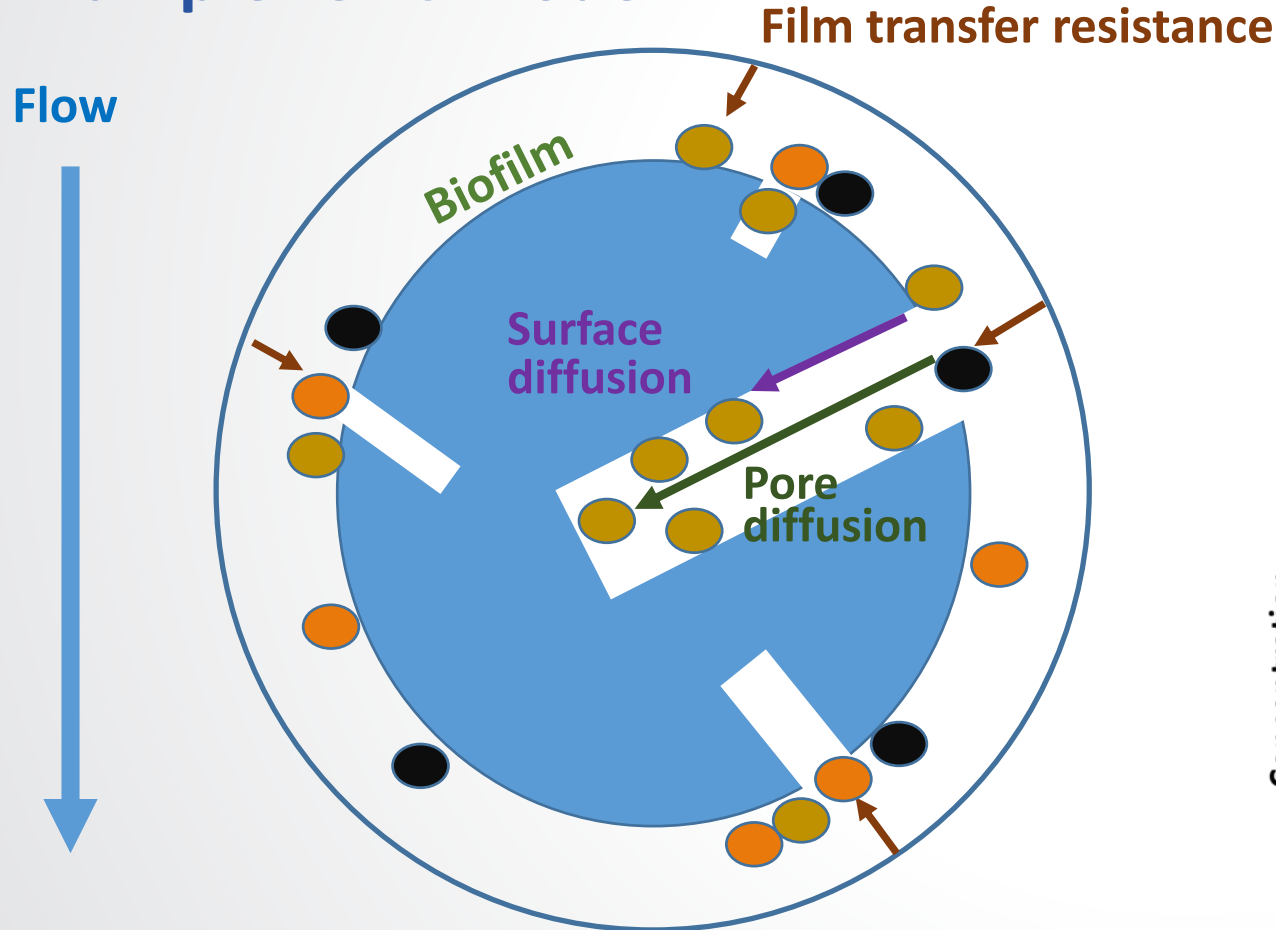
*The engines are written in
FORTRAN with a Visual
Basic front end*

ETDOT Modeling Tool

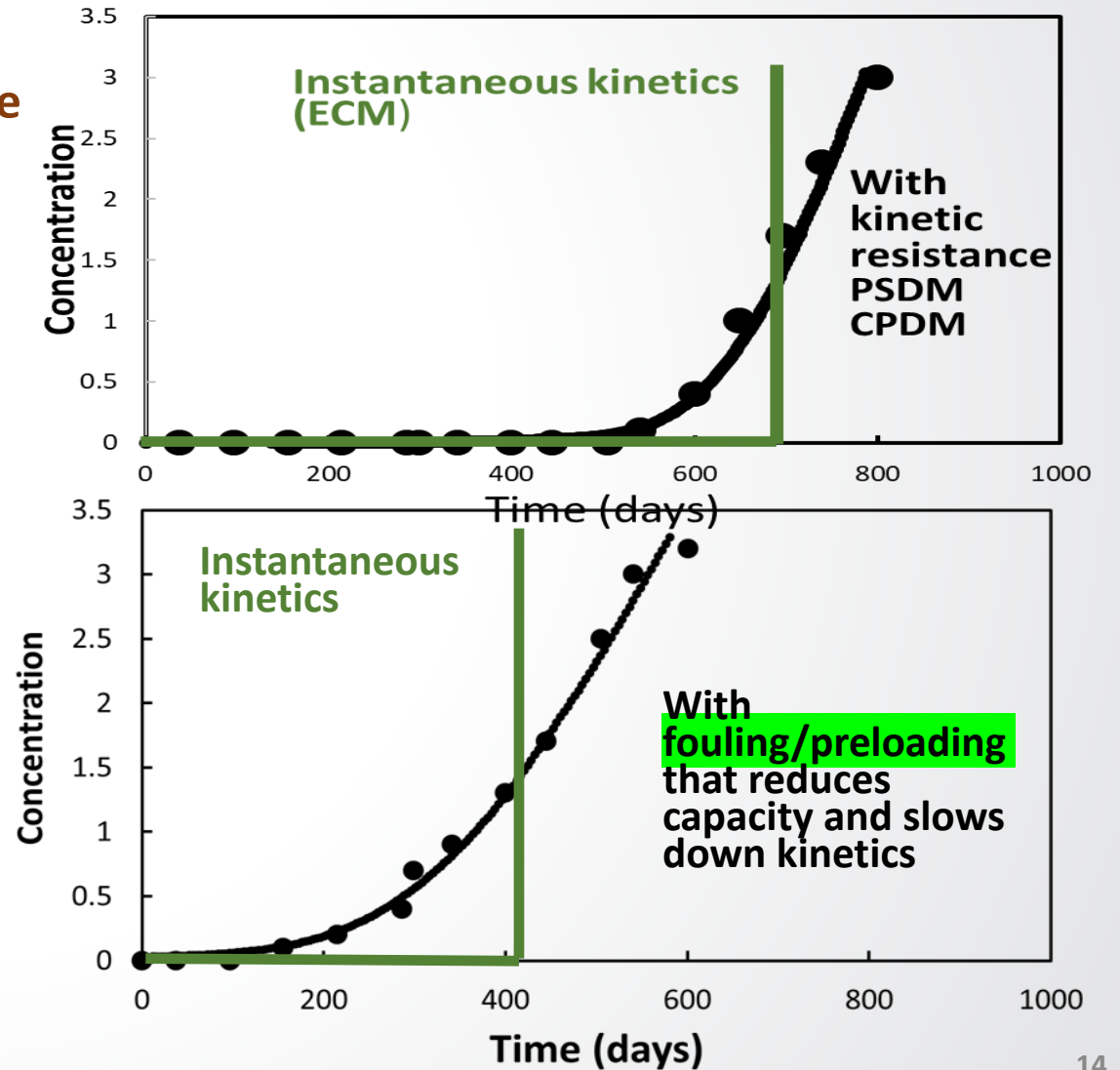
It is expected that these established and new models will be useful to the following:

- State primacy personnel interested in evaluating data sets
- Water utilities with experience in running models
- Consulting engineers
- University academicians

Example: GAC Model



The models range from simple to complex



EPA's Drinking Water Cost Models

Adsorptive media

Anion exchange

Biological treatment

Cation exchange

GAC

Greensand filtration

Microfiltration / ultrafiltration

Multi-stage bubble aeration



Non-treatment

Packed tower aeration

Point of Use (POU)/

Point of Entry (POE)*

Reverse Osmosis / Nanofiltration

UV disinfection

UV Advanced Oxidation

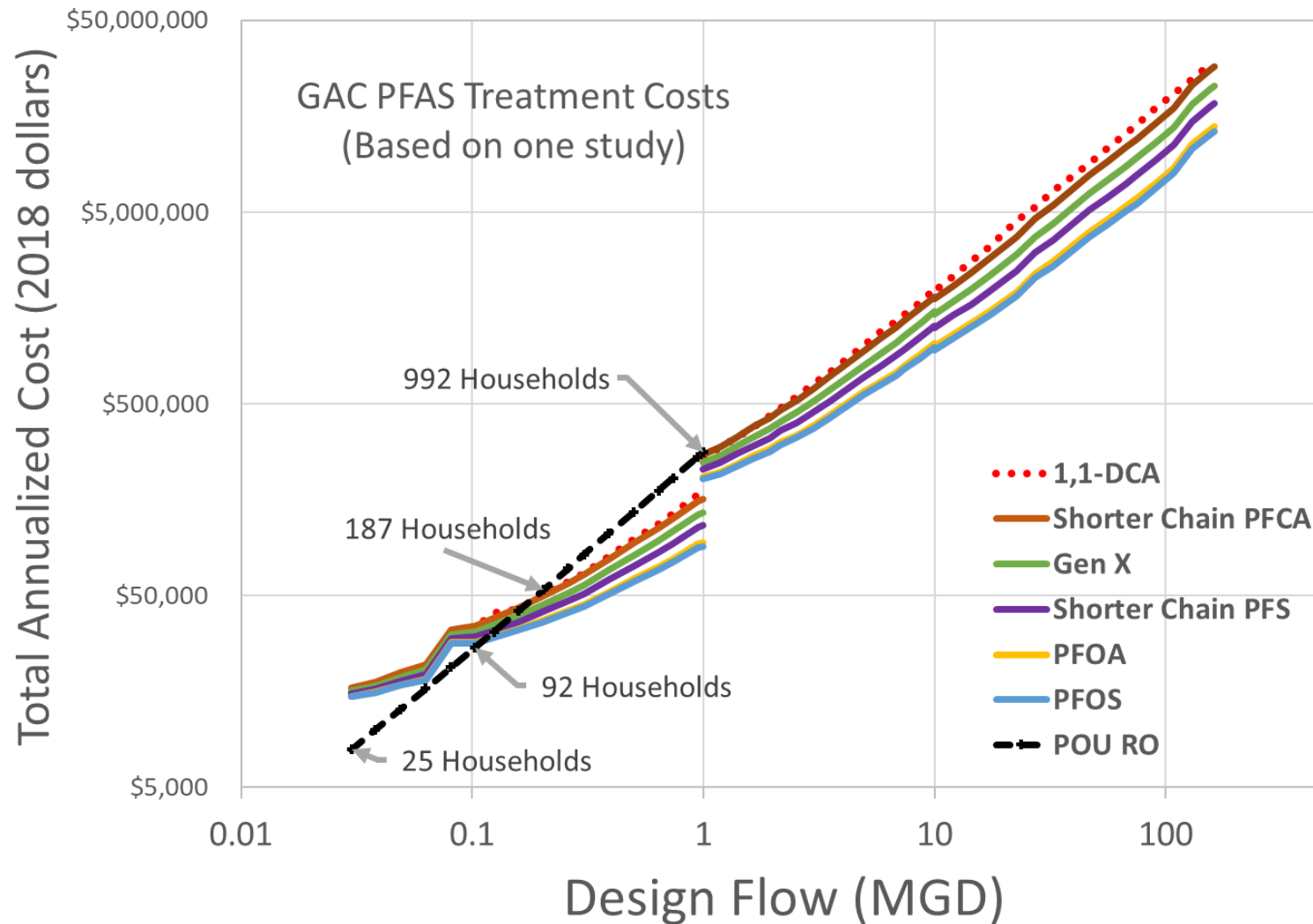
epa.gov/dwregdev/drinking-water-treatment-technology-unit-cost-models-and-overview-technologies

Search: EPA WBS

*POU/POE temporarily taken off web. Please contact [Rajiv Khera](#)



Costs for PFAS Treatment: One GAC Example



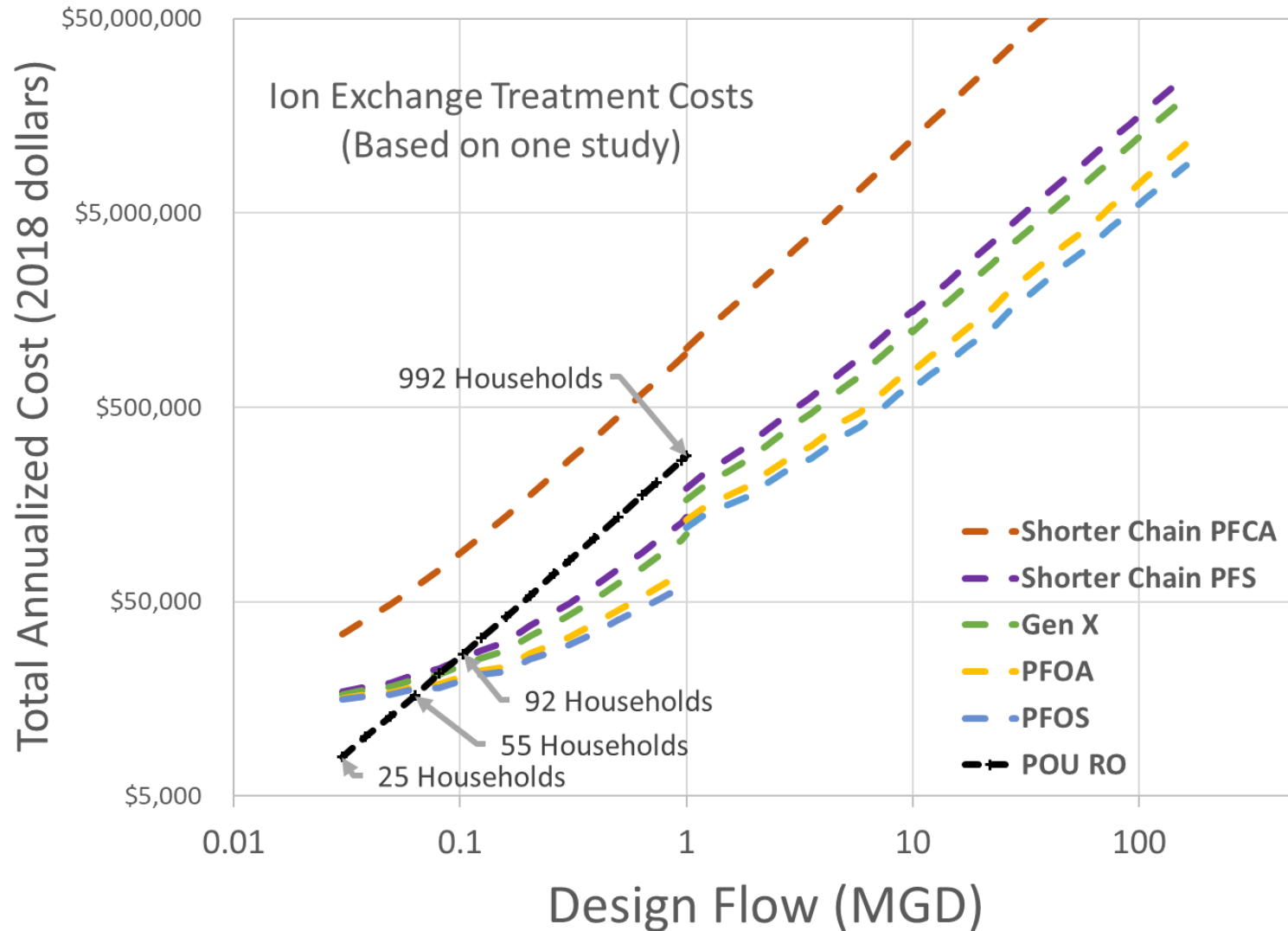
Costs can be generated for various sizes, contaminants, and even POU scenarios

Primary Assumptions:

- Two vessels in series
- 20 min Empty Bed Contact Time (EBCT) Total
- Bed Volumes Fed
 - 1,1-DCA = 5,560 (7.5 min EBCT)
 - Shorter Chain PFCA = 4,700
 - Gen-X = 7,100
 - Shorter Chain PFS = 11,400
 - PFOA = 31,000
 - PFOS = 45,000
- 7% Discount rate
- Mid Level Cost



Costs for PFAS Treatment: One IEX Example



Costs can be generated for various sizes, contaminants, and even POU scenarios

Primary Assumptions:

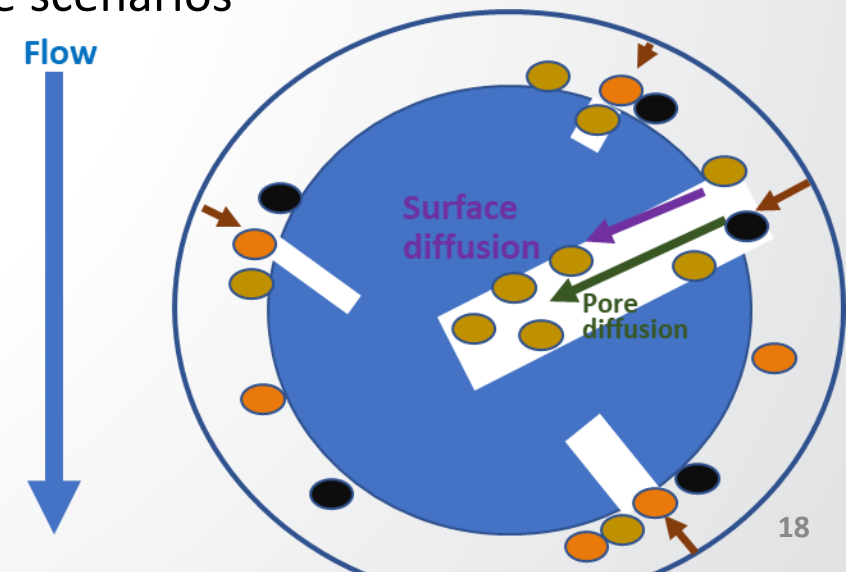
- Two vessels in series
- 3 min EBCT Total
- Bed Volumes Fed:
 - Shorter Chain PFCA = 3,300
 - Gen-X = 47,600
 - Shorter Chain PFS = 34,125
 - PFOA = 112,500
 - PFOS = 191,100
- 7% Discount rate
- Mid Level Cost

Treatability Database

- Further update treatability database with new references

Performance Models

- Update Graphical User Interface to work with Windows 10
- Provide Python code for pore surface diffusion model (PSDM GAC) to automate the optimization routines for:
 - Specific throughput and carbon use rate calculations for multiple scenarios
 - Automated fitting of parameters
 - Automated optimal bed configuration
 - Automated optimal Empty Bed Contact Time (EBCT) selection
 - Automated evaluation of bed replacement frequency
 - Evaluation of multiple feed conditions
 - Evaluation of multiple flow conditions
 - Automated fitting and predicting lead/lag operations



Performance Models *(continued)*

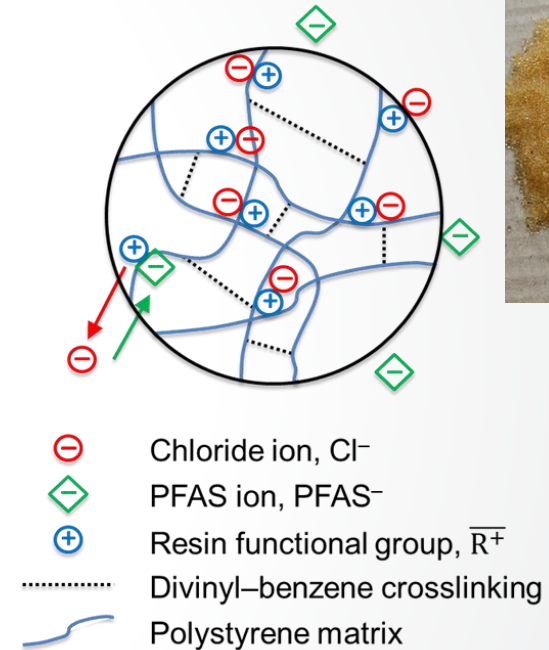
- Provide code for ion exchange models for
 - Include competition (e.g., inorganic ions and PFAS)
 - Continuous flow (columns) and batch (isotherm and kinetics)
 - Gel (HSDM) and macro porous (PSDM) resins
 - with automation features

Cost Models

- Further updates to the cost models

Combined Models

- Further merge Treatability Database, performance models, and cost models
- Further merge the Treatability Database with [EPA's CompTox Chemicals Dashboard](#)





Performance Model Demonstration

To provide tools to accurately predict the performance and cost of treating PFAS in drinking waters

Treatability Database

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Cost Models

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Performance Models

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Environmental Technologies Design Option Tool (ETDOT)

Adsorption treatment modeling for contaminant removal from drinking water and wastewater

The Environmental Technologies Design Option Tool (ETDOT) is a suite of software models that provides engineers with the capability to evaluate and design systems that use granular activated carbon or ion exchange resins for the removal of contaminants, including PFAS, from drinking water and wastewater.

Suite of Models Compatibility Applications Related EPA Resources

Suite of Models

ETDOT was developed by National Center for Clean Industrial and Treatment Technologies at Michigan Technological University (MTU). In 2019, EPA signed an agreement with MTU to make this suite of adsorption models available to the public at no cost.

Software included in ETDOT:

- Adsorption Design Software for Windows (AdDesignS) Version 1.0
- Advanced Oxidation Process Software (AdOx) Version 1.0.2
- Aeration System Analysis Program (ASAP) Version 1.0

Access ETDOT

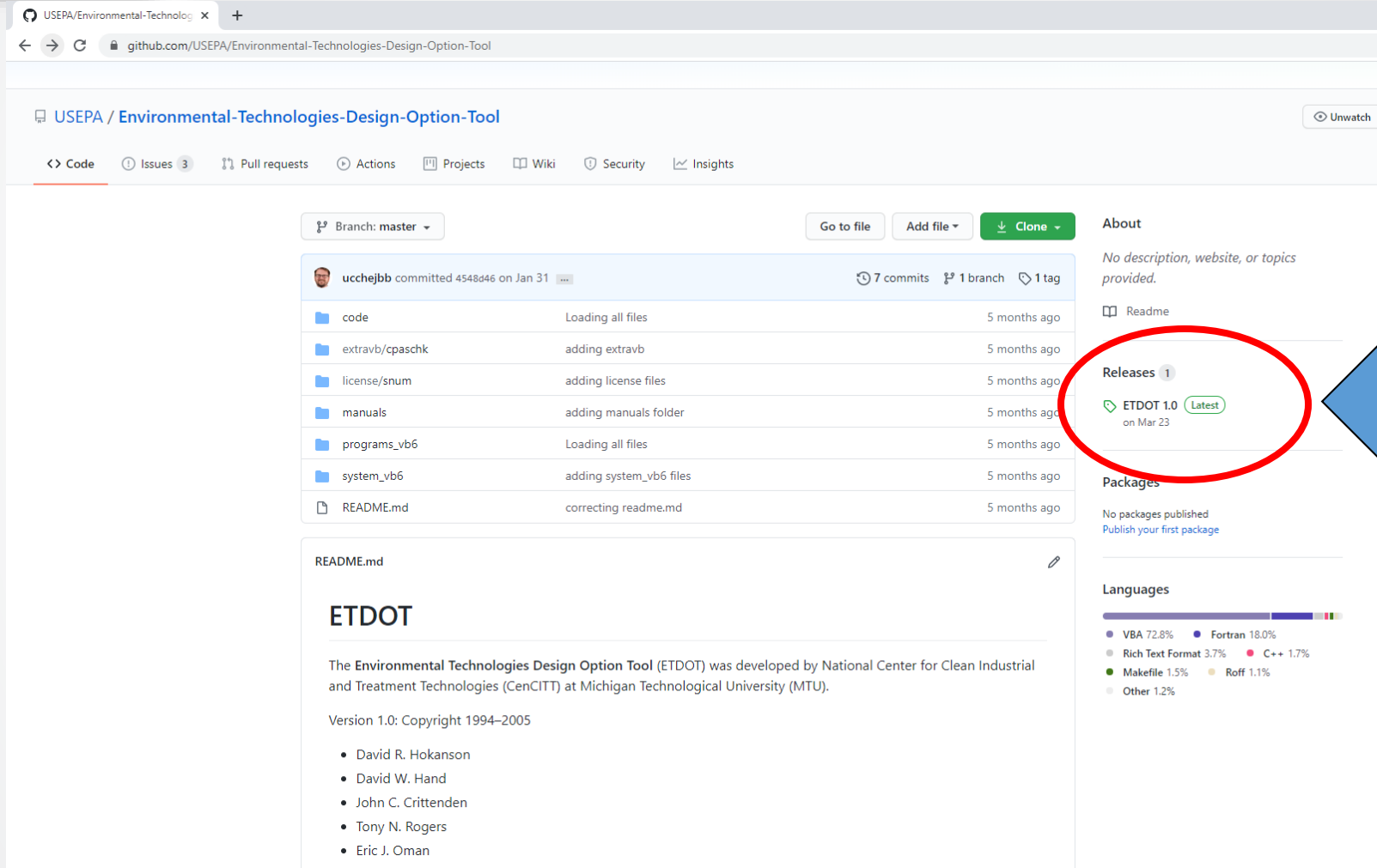
Access the ETDOT software, manuals, and more at [ETDOT GitHub site](#). **EXIT**

GitHub Site

<https://www.epa.gov/water-research/environmental-technologies-design-option-tool-etdot>

Search: EPA ETDOT

GitHub: ETDOT Software



The screenshot shows the GitHub repository page for 'USEPA / Environmental-Technologies-Design-Option-Tool'. The repository is on the 'master' branch. The file list includes folders for 'code', 'extravb/cpaschk', 'license/snum', 'manuals', 'programs_vb6', 'system_vb6', and a 'README.md' file. The 'Releases' section on the right is circled in red and contains one release: 'ETDOT 1.0' on Mar 23, marked as 'Latest'. A blue arrow points from the text 'Current Release' to this release. The 'About' section is empty, and the 'Languages' section shows a bar chart with VBA (72.8%), Fortran (18.0%), Rich Text Format (3.7%), C++ (1.7%), Makefile (1.5%), Roff (1.1%), and Other (1.2%).

<https://github.com/USEPA/Environmental-Technologies-Design-Option-Tool>

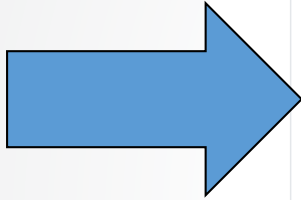


Releases on GitHub: ETDOT Software

The screenshot shows the GitHub release page for the repository 'USEPA / Environmental-Technologies-Design-Option-Tool'. The 'Releases' tab is selected. The latest release is 'ETDOT 1.0', released by user 'ucchjbb' on March 23. The release description states: 'ETDOT suite of software version 1.0. Supplied by MTU.' Under the 'Assets' section, three files are listed: 'etdot_1-0.zip' (70.8 MB), 'Source code (zip)', and 'Source code (tar.gz)'. A blue arrow points from the text 'Download 'etdot_1-0.zip'' to the 'etdot_1-0.zip' asset.

Download 'etdot_1-0.zip'

<https://github.com/USEPA/Environmental-Technologies-Design-Option-Tool/releases/tag/1.0>



Disclaimer:

The United States Environmental Protection Agency (EPA) GitHub project code is provided on an "as is" basis and the user assumes responsibility for its use. EPA has relinquished control of the information and no longer has responsibility to protect the integrity, confidentiality, or availability of the information. Any reference to specific commercial products, processes, or services by service mark, trademark, manufacturer, or otherwise, does not constitute or imply their endorsement, recommendation or favoring by EPA. The EPA seal and logo shall not be used in any manner to imply endorsement of any commercial product or activity by EPA or the United States Government.

Installation Instructions

This software requires *Administrator Rights* to a computer to install and to run. Files are installed directly to a folder X:\ETDOT10... where X is the system main drive.

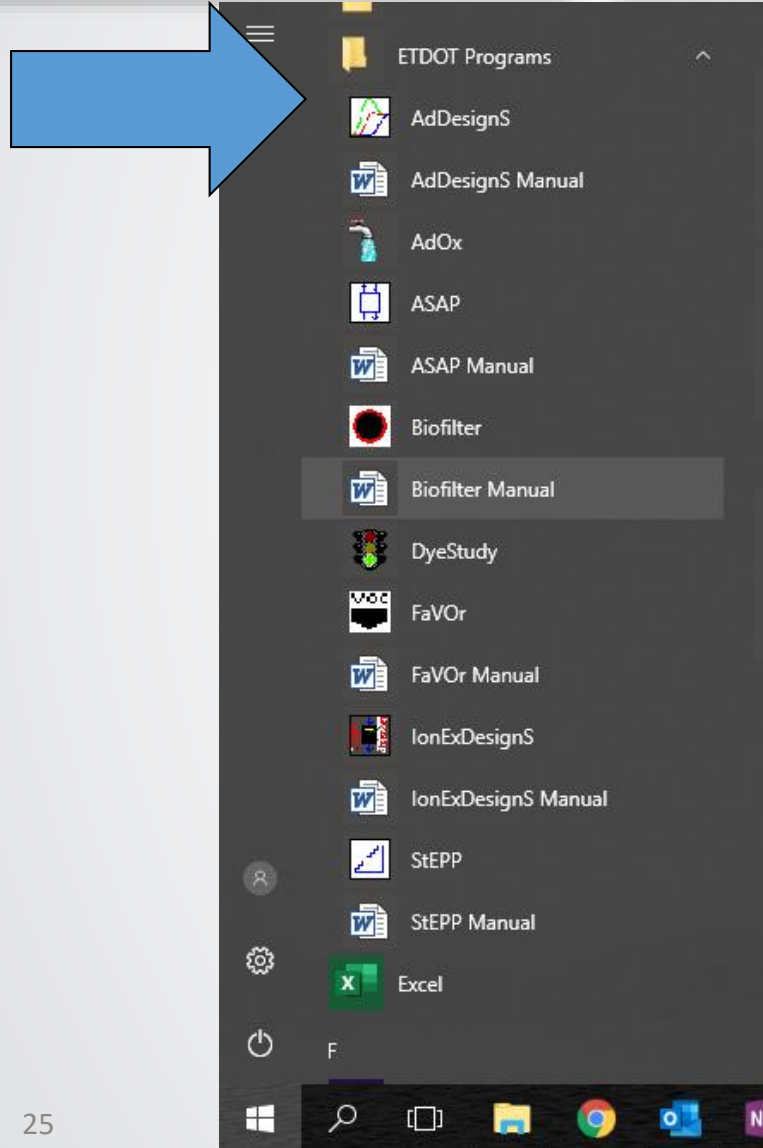
1. Download zip file in the release tab.
2. Unzip/Unpack zip file
3. Run *setup.exe* and follow prompts
4. When prompted enter license key: CAADV0-R74JM-QXCNP-7EER9-1AT72
5. To run each module in Windows 7 or newer: Edit *properties* of the program to be run and select Compatibility Tab and "run in compatibility mode". Select Windows 98/Me from the Compatibility Mode dropdown menu.

Available Users manuals will be located in the modules subfolder within the help folder.

Notes on current software

The ETDOT suite of software packages consists of a FORTRAN engine with a Visual Basic (version 6) graphical user interface. The VB6 portion of the code relies on ActiveX control files which are located in the repository, however, these are an older coding standard and no longer supported with current versions of Visual Studio 20##. Precompiled engine files are included.

Accessing ETDOT Software



Start Menu:
'ETDOT Programs'

Software & Instruction Manuals are listed





AdDesignS™ Software

AdDesignS - (Untitled)

File Phase Run Results Options Databases Help

Water Properties:
Pressure: 1.00 atm
Temperature: 15.0 C
Correlations

Component Properties:
New Component

Fixed Bed Properties:
Adsorbent Database
Bed Length: 2.77 m
Bed Diameter: 3.05 m
Bed Mass: 9072 kg
Flowrate: 0.0358 m³/s
EBCT: 564 s
Bed Density: 0.4497 (g/mL)
Bed Porosity: 0.440
Superficial Velocity: 17.648 (m/hr)
Interstitial Velocity: 40.108 (m/hr)

Adsorbent Properties:
Adsorbent Database
Name: Calgon F 400
Apparent Density: 0.803 g/mL
Particle Radius: 5.13E-04 m
Porosity: 0.641
Particle Shape Factor: 1.00
Dimensionless Groups Polanyi Parameters

Simulation Parameters for PSDM Only:
Total Run Time: 174 d
First Point Displayed: 13.2 d
Time Step: 0.417 d
Number of Axial Elements: 1
Number of Collocation Points:
Axial Direction: 8
Radial Direction: 3

Print Screen

Data Changed

Results for the PSDM (No Reactions Present)

Results for:
New Component Length of the MTZ (cm): 53.773

	Time (days)	BVT(m³/m³)	VTM(m³/kg)	C (mg/L)
5% of influent conc.	28.64	4.39E+03	9.76	2.50
50% of influent conc.	30.59	4.69E+03	10.42	25.00
95% of influent conc.	34.59	5.30E+03	11.78	47.50
Treatment Objective	28.64	4.39E+03	9.76	2.50

Close

Grid Style:
Both

Excel...
Save Curves
Select Printer
Print
Print to File

Print Screen

C, µg/L

Time(days)

X Axis Type:
 Time BVT Volume Treated by Mass

Y Axis Type:
µg/L



Water Treatment Models

Python Tools:
Ion Exchange Models
PSDM – GAC Modeling

USEPA / Water_Treatment_Models

Code Issues Pull requests Actions Projects Wiki Security Insights

Branch: master Go to file Add file Clone About

File	Commit Message	Time Ago
IonExchangeModel	Clarify Br definition	5 days ago
PSDM	Adding file save to PSDM.run_all_smart	2 days ago
.gitignore	Create .gitignore	26 days ago
LICENSE.md	Adding License.md	27 days ago
Readme.md	Update Readme.md	2 days ago

ucchejbb committed 4f4f380 2 days ago 48 commits 1 branch 0 tags

README for Water Treatment Models

Tools in this repository:

1. Adsorption Model for Granular Activated Carbon (PSDM Folder)
2. Ion Exchange Model (IonExchangeModel Folder)

Both tools are programmed in Python. Additional resources and information associated with either can be found in their respective folders. These tools focus on predicting water treatment unit operation effectiveness, specifically how well treatment technologies (Granular Activated Carbon and Ion Exchange Resin) will work for removing contaminants.

Status

All code in this repository is being provided in a "draft" state and has not been reviewed or cleared by US EPA. This status will be updated as models are reviewed.

Additional Information

Releases: No releases published. Create a new release.

Packages: No packages published. Publish your first package.

Contributors: 3

- LeviHauptert LeviHauptert
- ucchejbb ucchejbb
- datsovb datsovb

Languages: Python 100.0%



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Readme.md

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https://github.com/USEPA/Water_Treatment_Models



Pore and Surface Diffusion Model (PSDM)

Water_Treatment_Models/PSDM x +

github.com/USEPA/Water_Treatment_Models/tree/master/PSDM

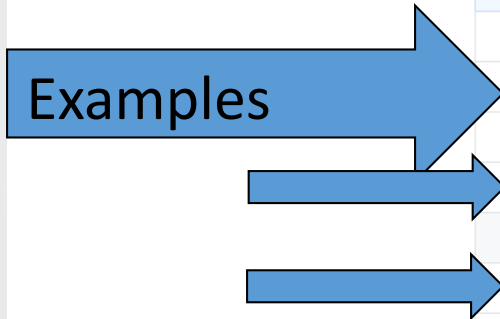
USEPA / Water_Treatment_Models Unwatch

<> Code Issues Pull requests Actions Projects Wiki Security Insights

Branch: master Water_Treatment_Models / PSDM / Go to file Add file

ucchejbb committed 4f4f380 2 days ago History

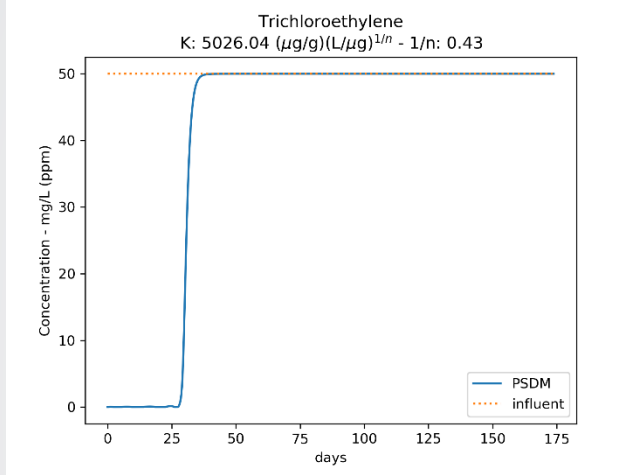
..		
Example_Multi.py	Uploading PSDM code	6 days ago
Example_Multi.xlsx	Uploading PSDM code	6 days ago
Example_TCE.py	Uploading PSDM code	6 days ago
Example_TCE.xlsx	Uploading PSDM code	6 days ago
Example_isotherm.py	Uploading PSDM code	6 days ago
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PSDM_tools.py	Uploading PSDM code	6 days ago
Readme.md	Uploading PSDM code	6 days ago
test.xlsx	Uploading PSDM code	6 days ago
test_PSDM.py	Uploading PSDM code	6 days ago



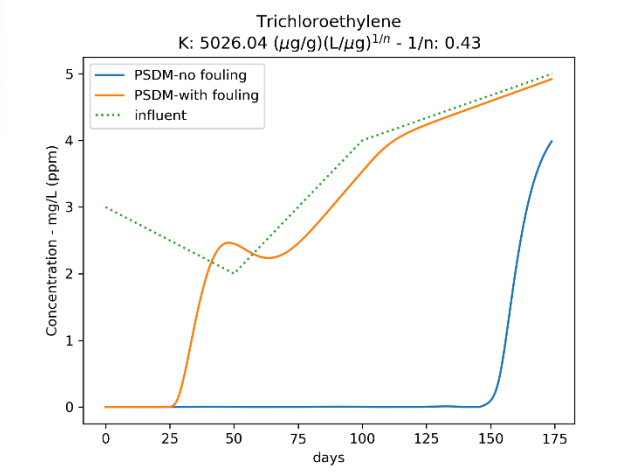
Examples

https://github.com/USEPA/Water_Treatment_Models

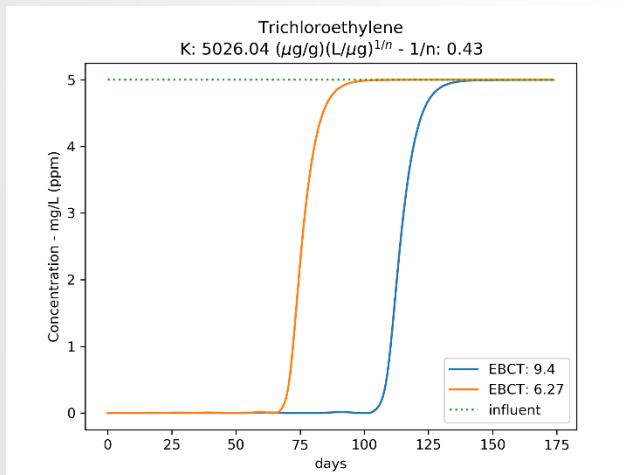
PSDM Model Examples



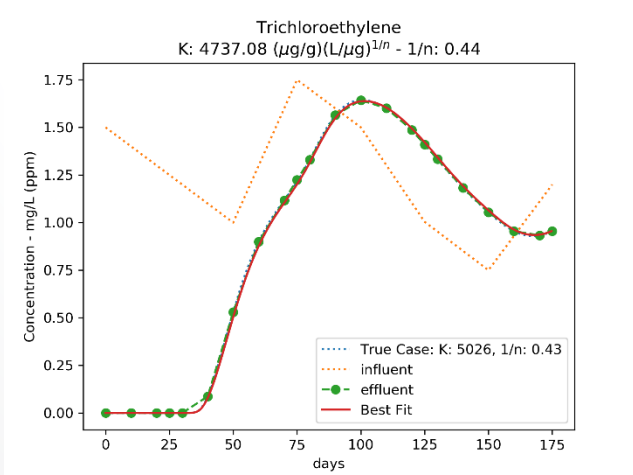
Single Compound



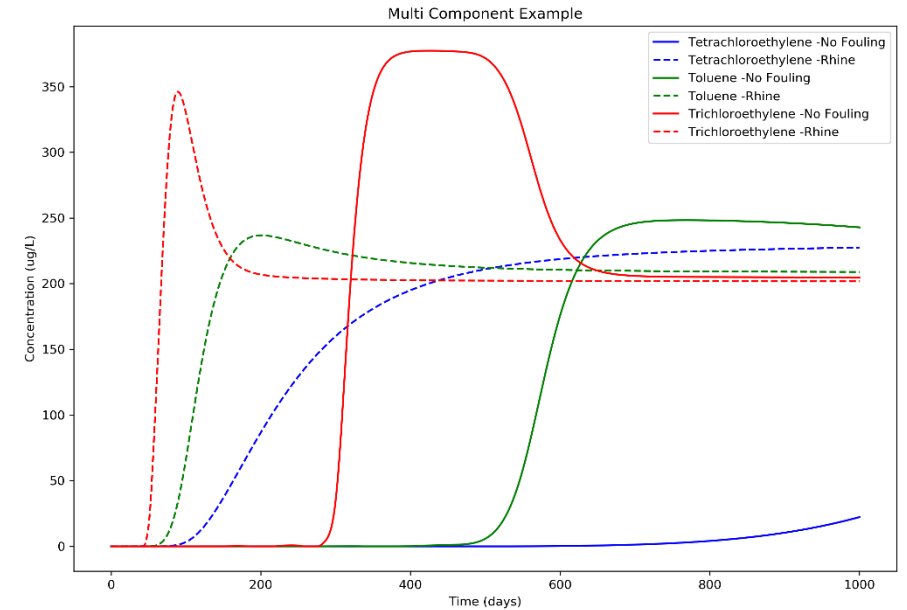
Modeling Fouling



Comparing EBCT



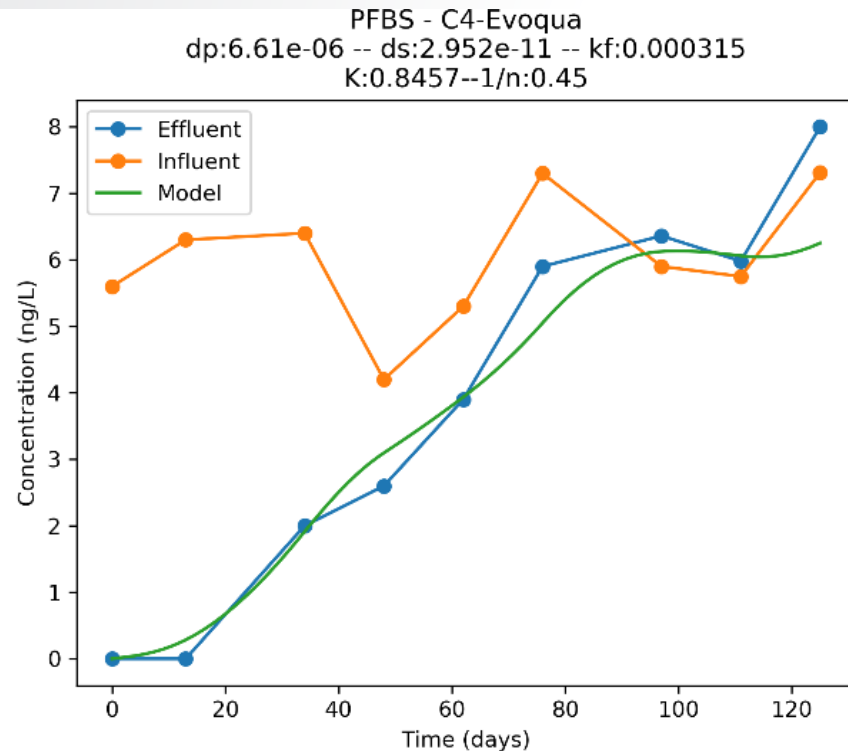
Fitting Pilot Data



Multicomponent competitive modeling

Models can be used to perform a variety of different analyses or applications

Fitting Pilot / Full-scale Data



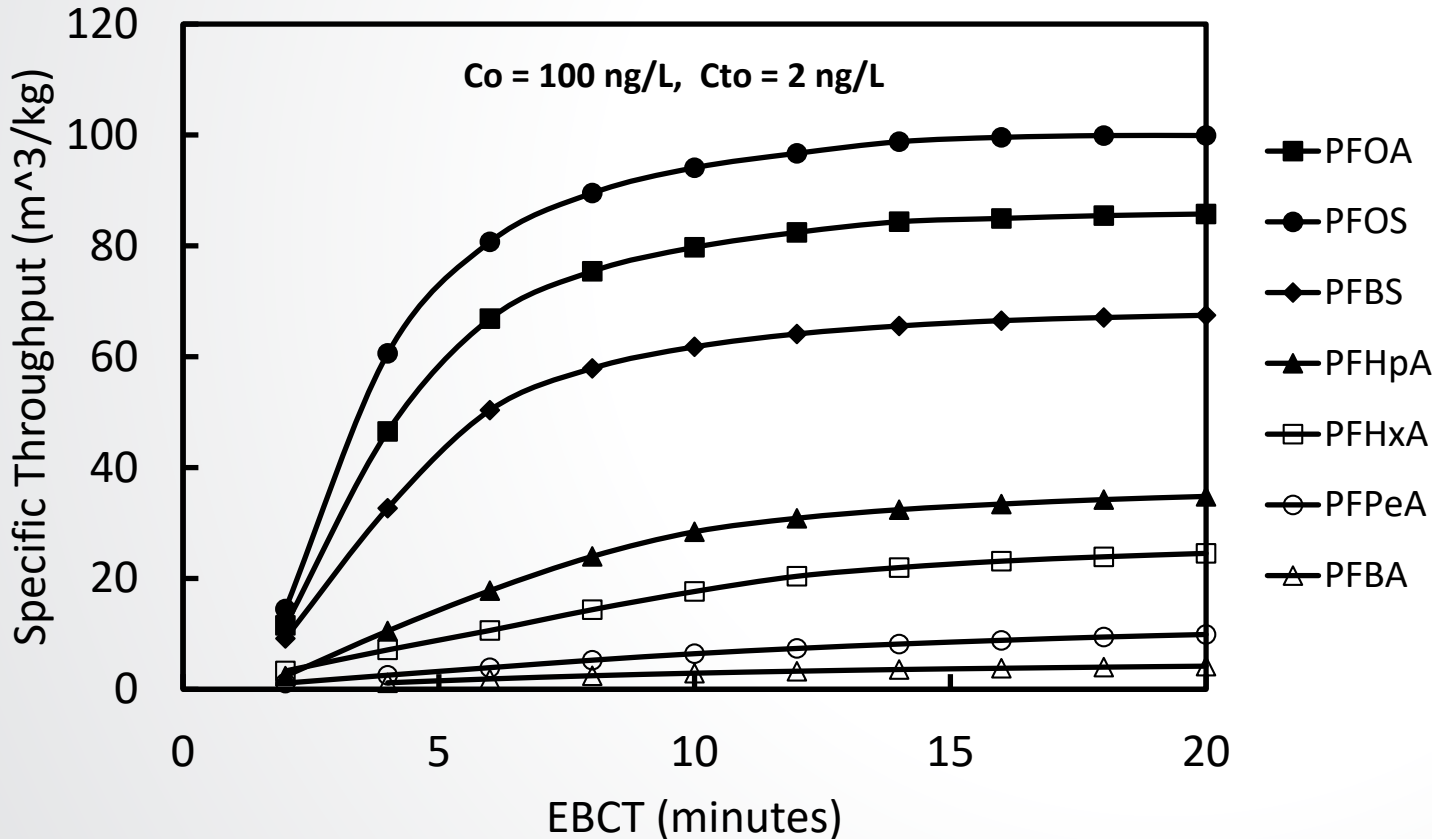
Predicting Results for Consistent Design

- Allows for comparison across technologies by cost

Allows for Predicting other Scenarios

- Other designs: number of contactors, contactor Empty Bed Contact Times (EBCTs), different treatment goals, etc.
- Other influent conditions: Changing concentrations of PFAS or background constituents, changing demand, etc.

Relationship Between Specific Throughput and EBCT



Example: What is the optimal Empty Bed Contact Time (EBCT) choice in the future?

- The models can evaluate EBCT for various PFAS for different PFAS at different influent concentrations, effluent goals, etc.

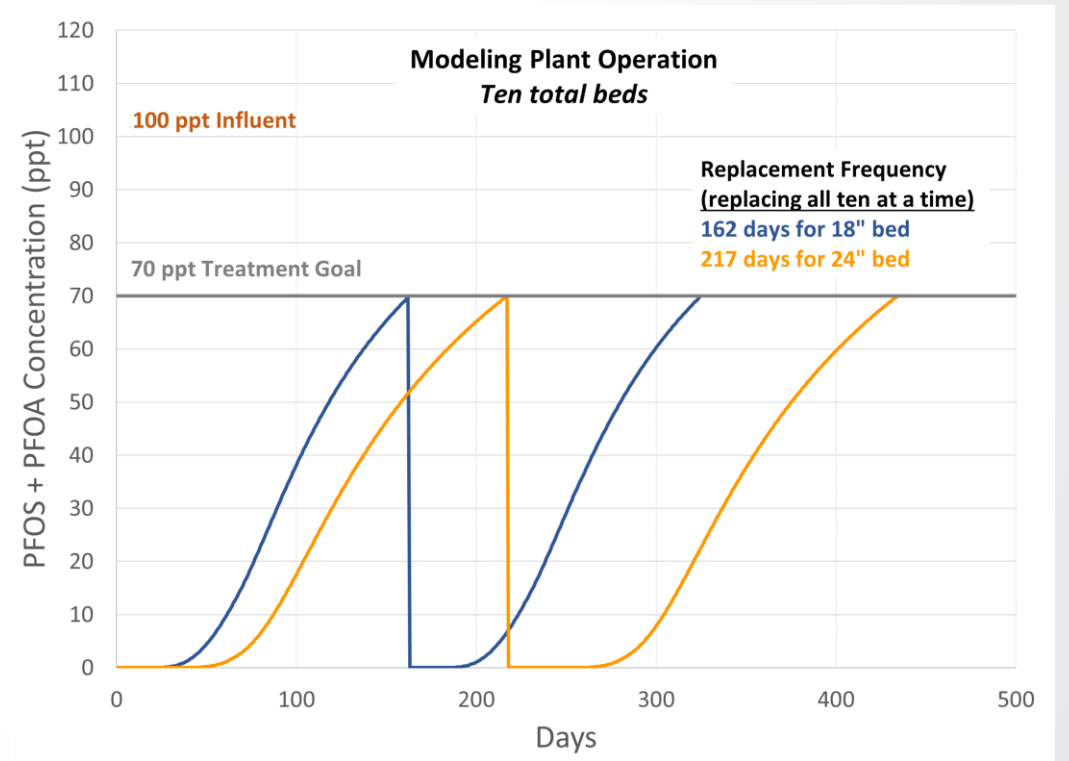
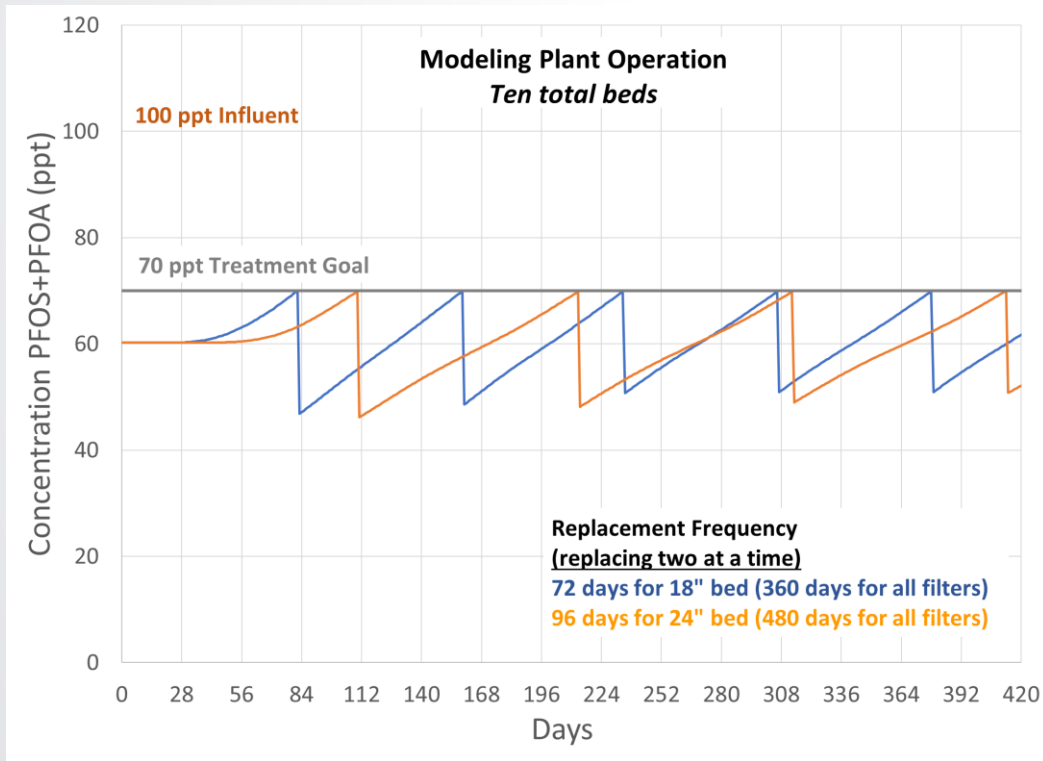
Modeled Specific Throughput can help determine EBCT or expected treatment volumes for single component treatment objectives



Design/Operation Evaluations

Example: How should the beds be deployed and replaced?

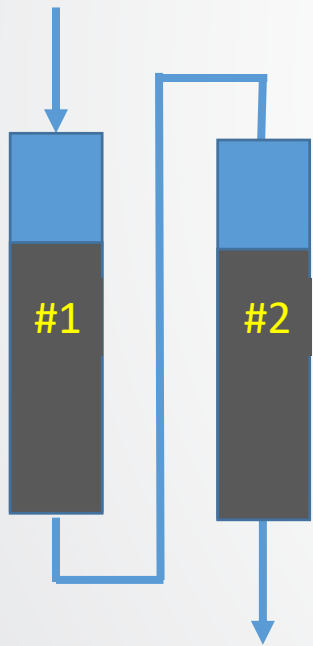
➤ The models can evaluate how many and how often beds need to be brought online or replaced



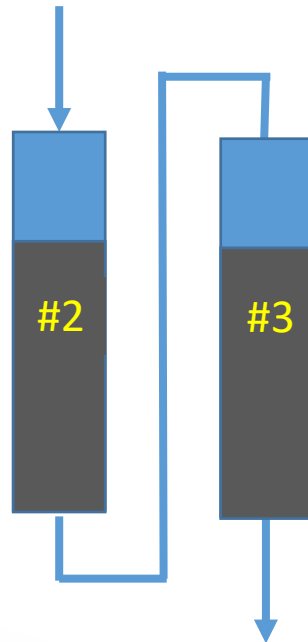
Lead/Lag Operation Evaluations

Example: What advantage can be gained with a lead/lag configuration?

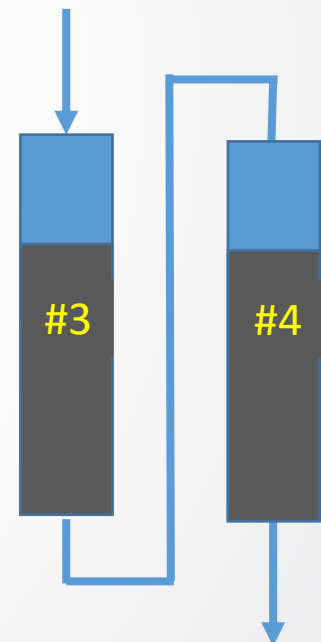
- The models can predict this increased carbon use rate.
- Note: Lead/lag operations can complicate modeling efforts, especially for those that take Natural Organic Matter (NOM) fouling/preloading into effect.



After a certain breakthrough (1st or 2nd column), a fresh column is added to the back of the train.



After a similar breakthrough point, a fresh column is added to the back of the train again.



In an ideal situation, the first column would be completely saturated to maximize the use of the carbon.

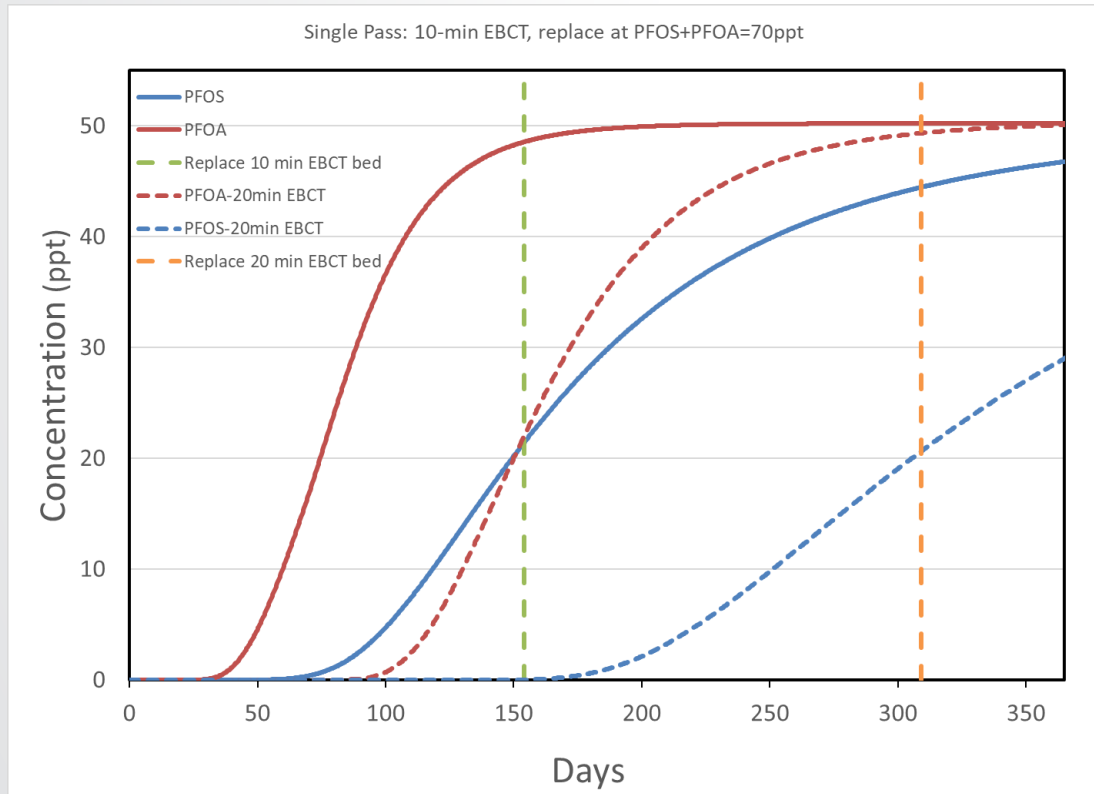


Example: Lead/Lag Operation Evaluations

Single use:

Time to 70 ppt breakthrough (PFOA & PFOS)

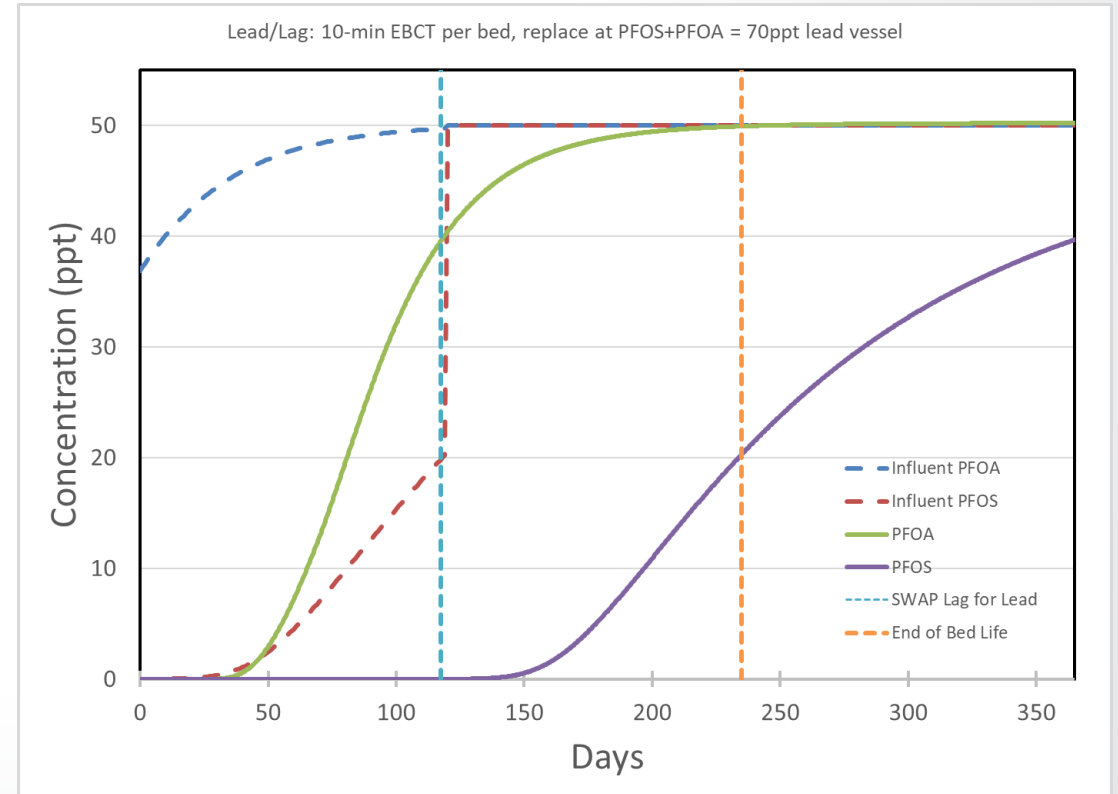
- 154 days (based on 1st column)



Lead/Lag:

Time to 70 ppt breakthrough (PFOA & PFOS)

- 236 days (based on 1st column)





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