



By Ivey International Inc.



**ONLY PFAS REMEDIATION TECHNOLOGY CAPABLE OF PFAS MASS-REMOVAL FROM SOIL AND GROUNDWATER, AND 99.99998% DECONTAMINATION OF AFFF FIRE SUPPRESSION SYSTEMS.**

**PARIS 7<sup>th</sup> International Congress PFAS (June 16-19, 2026)**

**SURFACTANT ENHANCED PFAS AQUIFER +  
DECONTAMINATION OF AFFF FIRE SUPPRESSION SYSTEMS**

# IVEY GLOBAL DISTRIBUTION NETWORK



IVEY INTERNATIONAL INC. (Est. 1993) Is An Award-Winning Remediation Technology Company That Has Developed Innovative Patented and Proprietary Remediation Products and Processes Including:

Ivey-sol®, PFAS-SOL®, DECON-IT® and more.

**Powering Remediation For >30 Years!**





## **BIOGRAPHY**

**George (Bud) Ivey, B.Sc, CES, CESA, P.Chem, EP  
President, Senior Remediation Specialist  
Ivey International Inc.**



- **President and Senior Remediation Specialist with Ivey International Inc.**
- **Environmental Professional With >35 years of international Remediation Experience.**
- **Education: Organic Chemistry, Geological Engineering, and Master's In Project Management**
- **Worked on >3500 environmental Projects Globally**
- **Holds >30 international Patents and Trademarks**
- **Has been to >70 countries (Every Continent Except Antarctica)**
- **Recipient of 14 International Environmental Awards, and**
- **Loves the outdoors, hiking, kayaking, and has completed marathons to Ironman**





# PER AND POLYFLUOROALKYL SUBSTANCES (PFAS) A.K.A. C8 - **PFAS = PFOA + PFOS** **FOREVER CHEMICALS**

- Per- and Polyfluoroalkyl Substances (PFAS) are a group of **manufactured chemicals** that have been used in industry and consumer products since the **1940s**.
- Many **organizations worldwide mandated the use of fire fighting foam that contains PFAS**, known as Aqueous Film Forming Foam (AFFF). Plus, in many **commercial products**.
- However, per the Environmental Protection Agency (EPA), certain **PFAS can cause serious health problems, including cancer**, if people are exposed to them over a long period of time, and they can also be harmful to aquatic and terrestrial organisms.
- There are **>15,000 PFAS chemicals** (USEPA CompTox Database).
- **3M + DuPont + Chemours + Corteva Sued >200 Billion** For PFAS Groundwater & Health Impacts In USA alone.





# ITRC PFAS GUIDANCE DOCUMENT (CA.2023)

- ITRC PFAS Guidance Document Is A Good Industry Reference When Managing PFAS Impacted Sites
- **The New PFAS Guidance Document Will Be Released Late 2026 To Early 2027.**
- ITRC Web Site: <https://itrcweb.org>





# DARK WATER MOVIE (2019)



The story dramatizes lawyer Robert Bilott's case against the chemical manufacturing corporation DuPont after they contaminated a town with unregulated fluorinated chemicals known as PFOA and PFOS (PFAS).

Provides the disturbing story and truth behind Dupont manufacturing and selling of a product they knew caused harm to human health and the environment.

It stars Mark Ruffalo as Bilott, along with Anne Hathaway, Tim Robbins, Bill Camp, Victor Garber, Mare Winningham, William Jackson Harper, and Bill Pullman.

DuPont, 3M, Chemours/Corteva Have Been Sued For 100's of Billions USD Globally.





PFAS-SOL® Sub CMC  
Selective Surfactant  
Desorption Technology

**Improves physical, biological  
and chemical availability  
of PFOA and PFAS  
for remediation**

Biodegradable  
pH Neutral  
Non-Corrosive  
Non-Caustic  
Non-Ionic  
Impurity Free



Environmentally Responsible Solutions

**PFAS-SOL®**

Is a patent-pending, award winning  
non-ionic surfactant technology  
developed by Ivey International Inc.  
for the selective removal of PFOA and  
PFOS (PFAS) from contaminated  
soil, bedrock, and groundwater,  
and the decontamination of  
anthropogenic (manmade)  
material surfaces.

[www.iveyinternational.com](http://www.iveyinternational.com)







### Key Features of PFAS-SOL®:

- **Selective Desorption:** Specifically engineered to desorb PFAS from various surfaces (i.e. metal, plastic, glass, ceramics, soil, etc.) to make them available for Physical, Chemical and/or Biological treatment.
- **Environmentally Friendly:** Formulated to be biodegradable, pH neutral, non-corrosive, non-toxic, and non-caustic (ships as non-hazardous).
- **Versatile Application:** Used for both in-situ (on-site) and ex-situ (off-site) remediation, including decontaminating AFFF (Aqueous Film-Forming Foam) fire suppression systems, Fire-Trucks, to Soil Washing, and to field decontamination of environmental monitoring equipment.
- **Enhanced Efficiency:** Uses sub-Critical Micelle Concentration (sub-CMC) technology to aid desorption and lower surface tension of water (reduce water-cluster size) improving irregular surface cleaning.
- Presence in wastewater does not impact PFAS wastewater treatment system operations.

### Primary Uses of PFAS-SOL®:

- **Soil Remediation:** Washing – Flushing polluted soil to remove high concentrations of PFAS "*forever chemicals*".
- **Equipment Decontamination:** Cleaning firefighting equipment to prevent residual PFAS from re-contaminating new, fluorine-free foam replacements (*Reduce Risk of Cross Contamination*).
- **Groundwater Treatment:** Increasing the concentration of PFAS in the aqueous phase for easier mass recovery during pump-and-treat (P&T), multi-phase-extraction (MPE) and/or 'push-pull' or 'sweep' applications
- **Cross Contamination Risk Reduction:** Reduce risk to better comply with ASTM D5088 at sites.





# DECONTAMINATION OF PFAS IMPACTED SURFACES



**To Comply With ASTM D5088 Decontamination Standards**

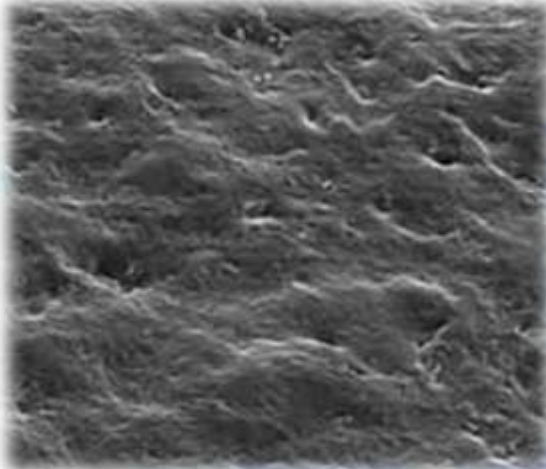




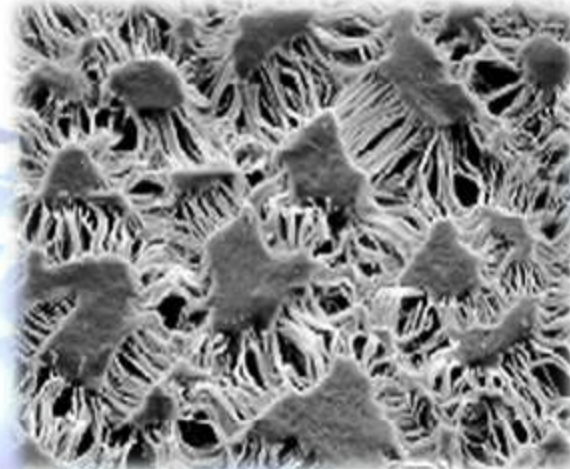
# Magnified Surfaces → For Contaminant (**PFAS**) Sorption



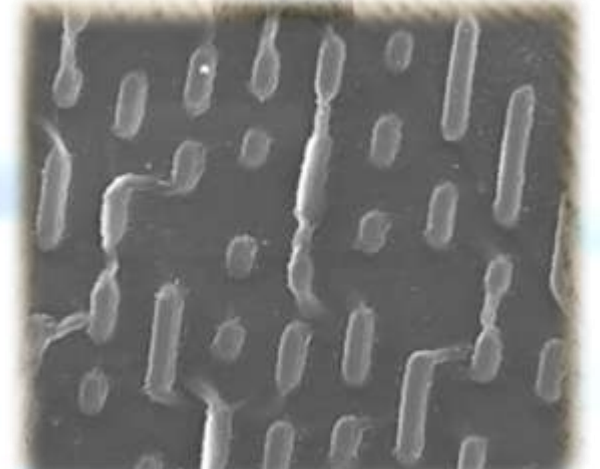
Glass Surface



Buber Flooring Surface



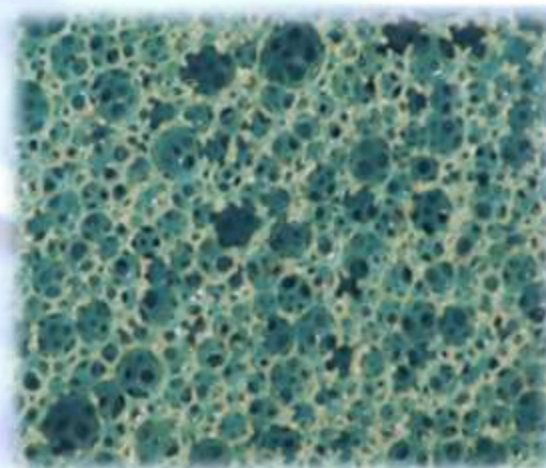
Gore-tex Surface



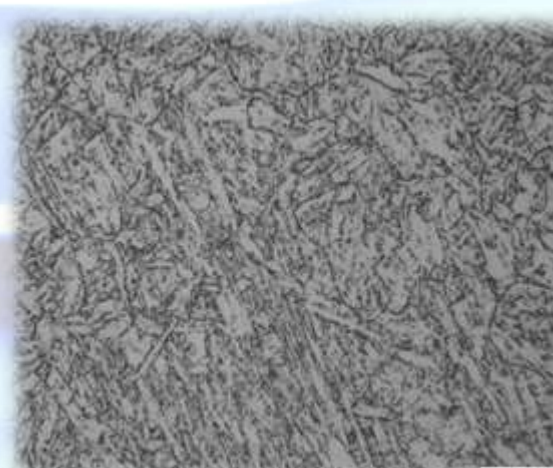
LP Record – CD Rom



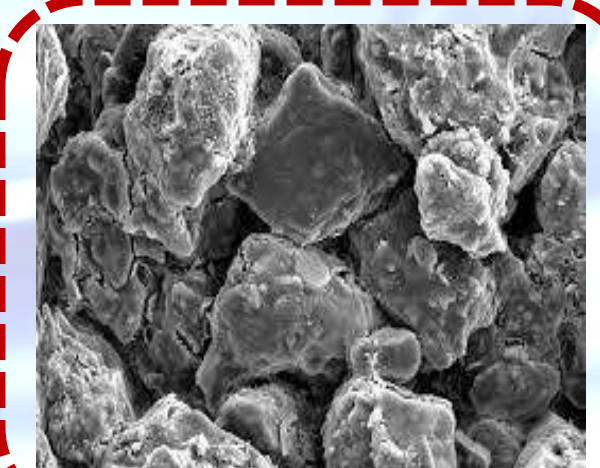
Concrete Surface



Foamed Plastic Surface



Stainless Steel Surface



Soil Surfaces



# PFAS-SOL<sup>®</sup> Increases '**Availability**' of PFOA and PFAS Sorbed, Globular and NAPL Phases Below The CMC (Critical Micelle Concentration) For Improved Remediation + Decontamination

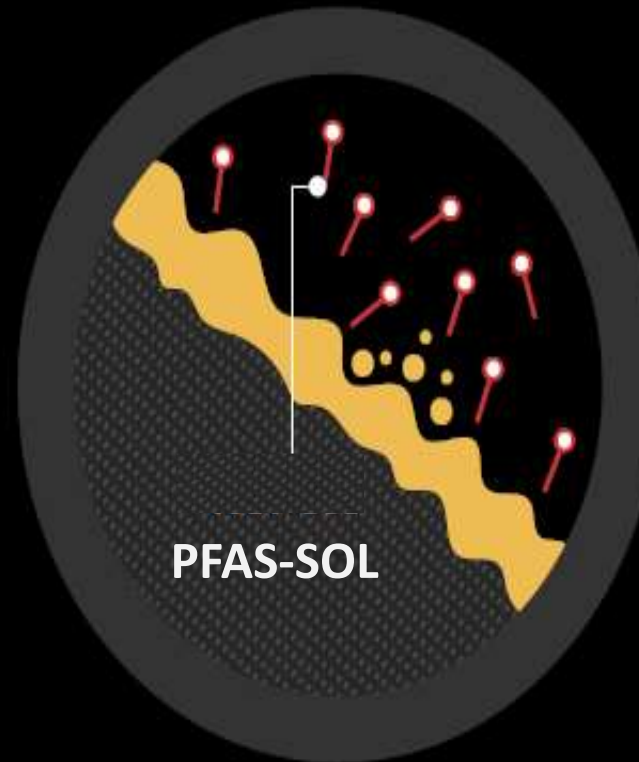
Solubility:  
PFOS = 680 mg/L\*  
PFOA = 9600 mg/L\*  
MTBE=50,000 mg/L  
NaCl = 357,000g/L  
Sugar = 909,000 g/L

\* Both Sorb to Surfaces  
PFOS > PFOA

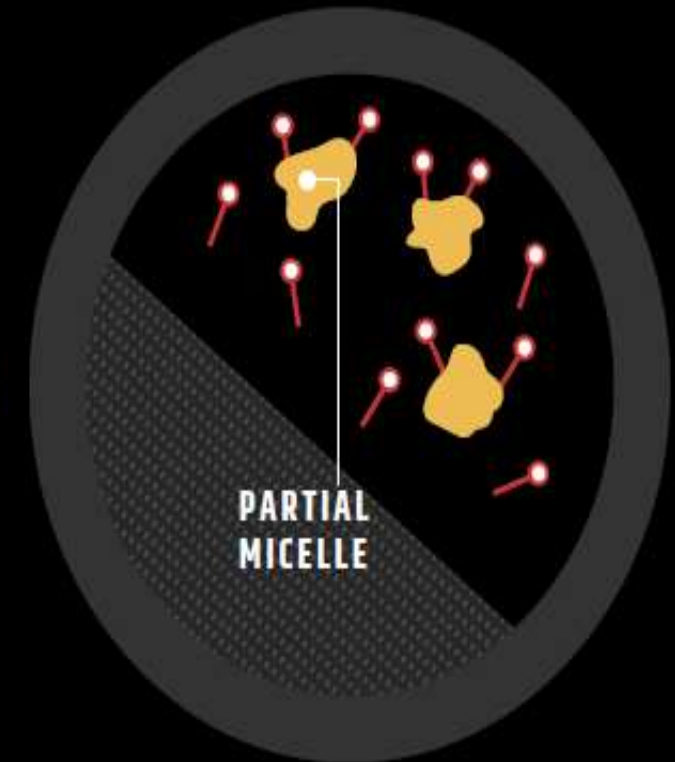
## Limited Availability



+

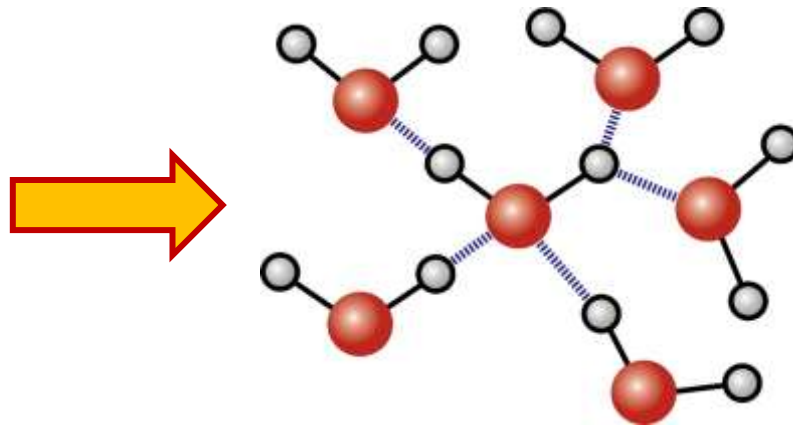
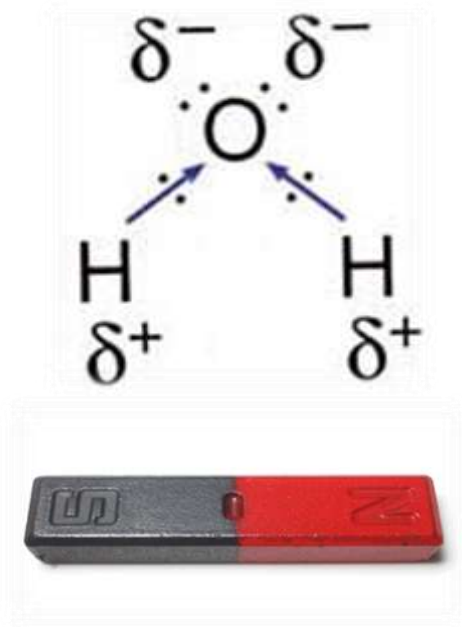


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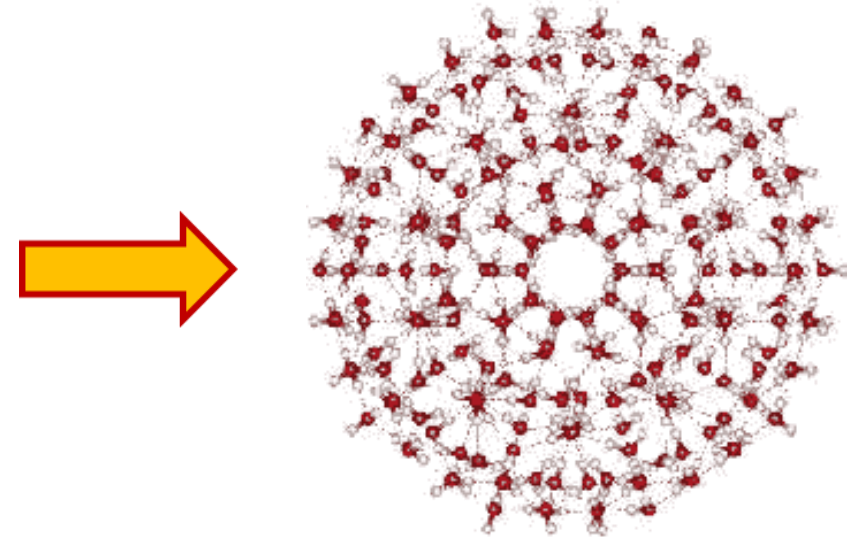


## Increased Availability

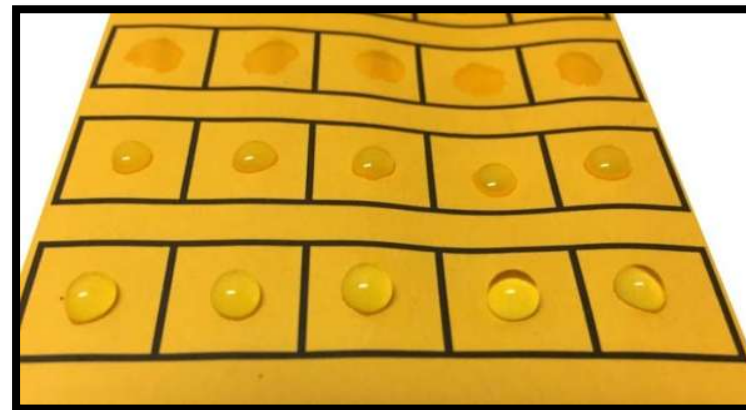
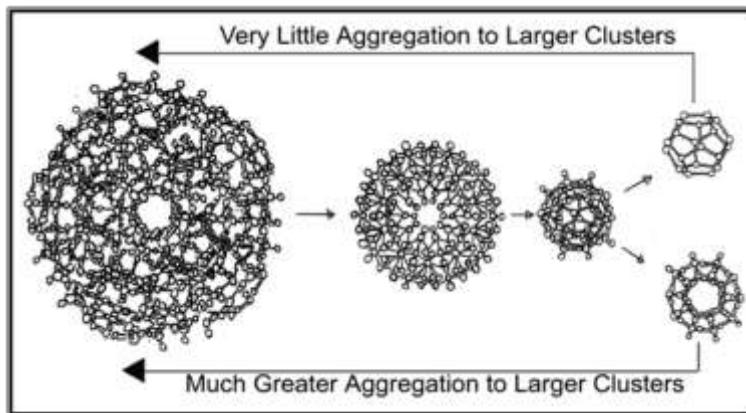
# Water Is Not H<sub>2</sub>O But A 3-Dimensional Cluster



**Hydrogen Bonding**



**Water Cluster**



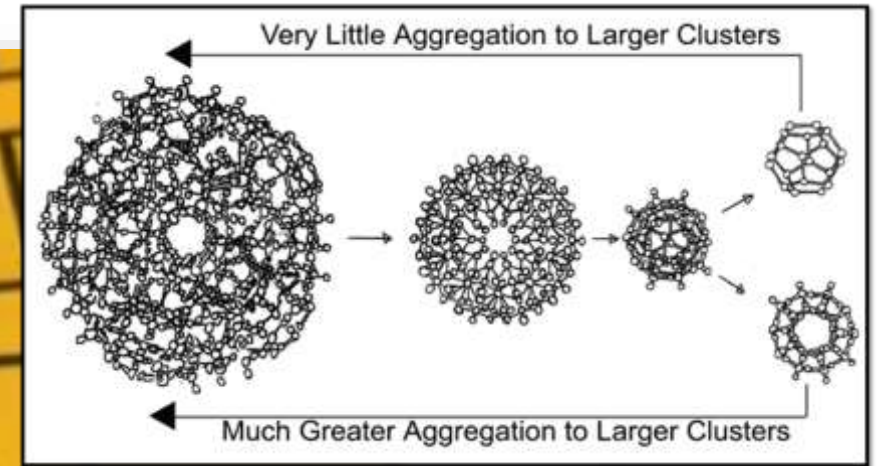
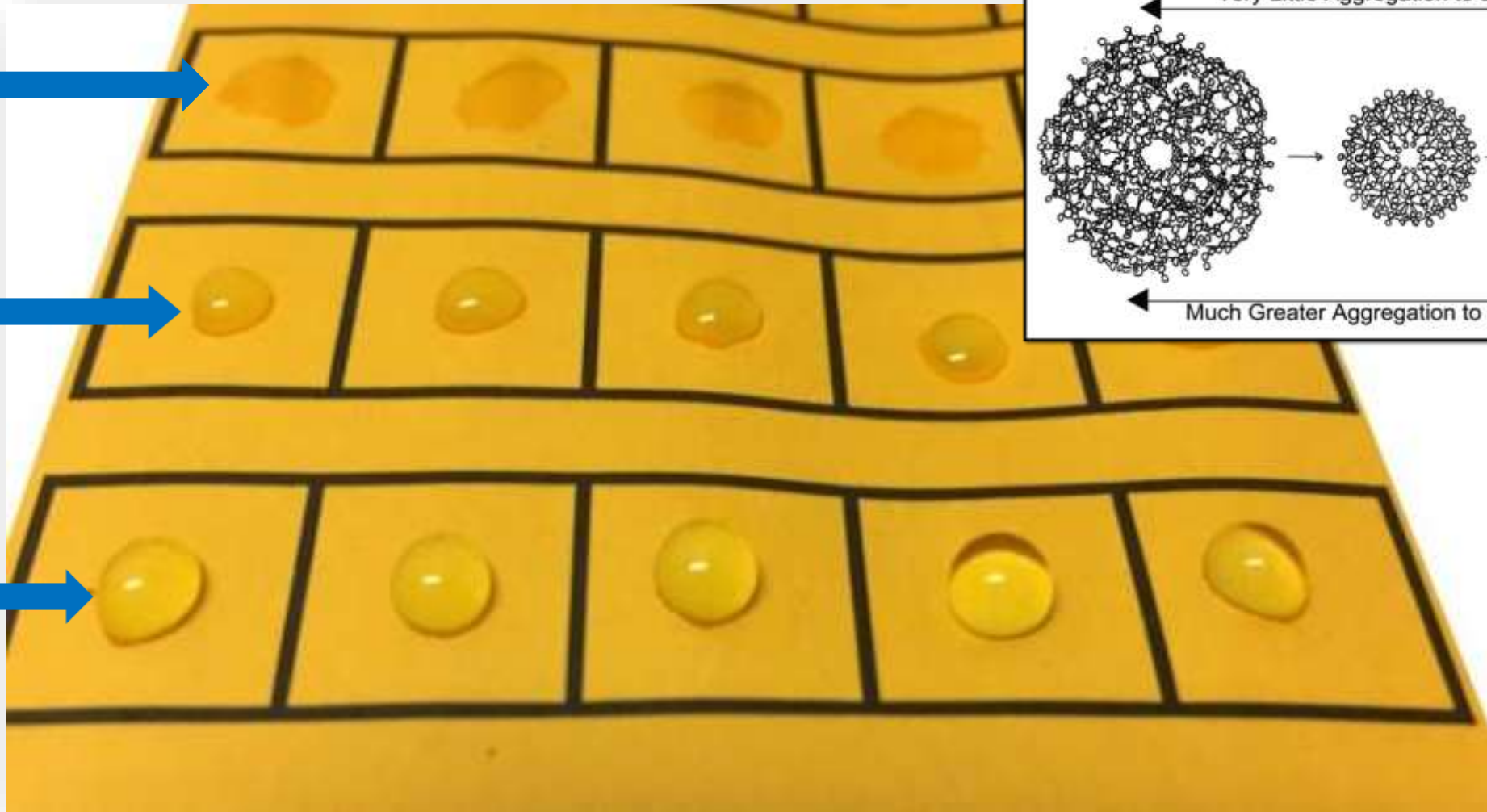


# Ivey Surfactants Can Make Water Clusters Smaller So Move Within Smaller Spaces More Easily

Surfactant  
Present

Trace of  
Surfactant  
Present

No  
Surfactant  
Present



# Agglomeration

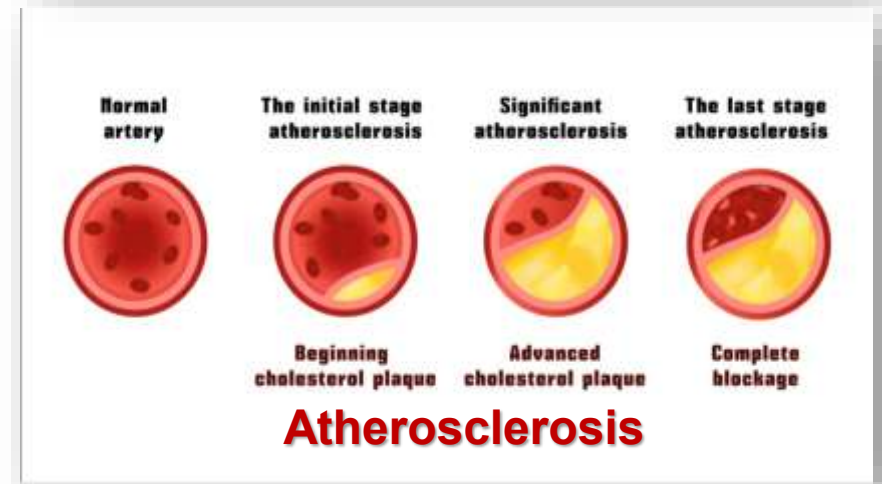
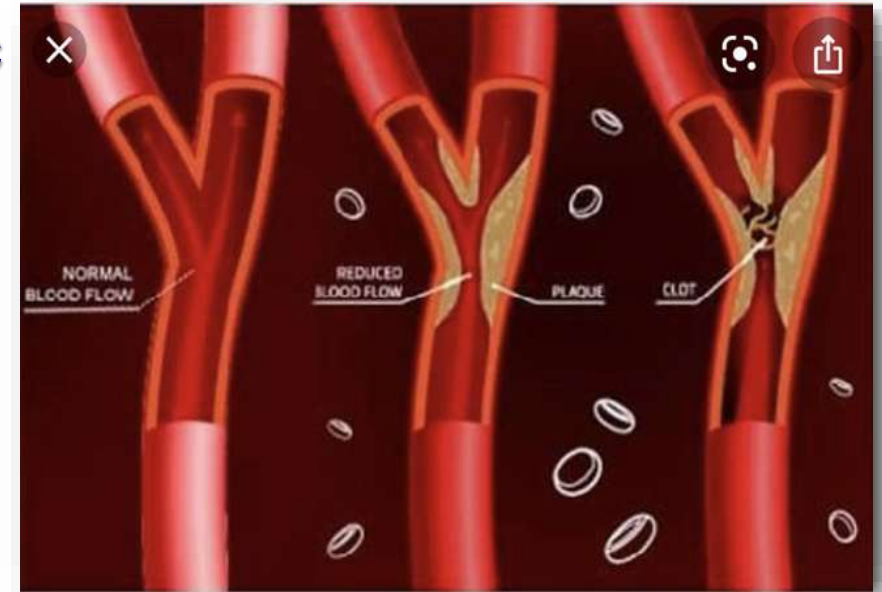
Contaminant **Agglomeration** is the 'sticking' of organic molecules to one another. With contaminant Sorption on soil surfaces, the sorption layer will increase in thickness.

*(In Chemistry 'like dissolves like' and 'like attracts like')*

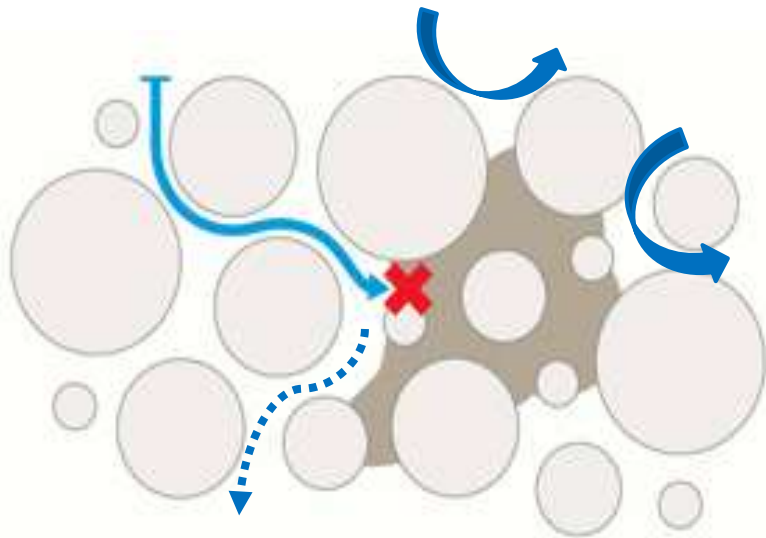
**Agglomeration** can amass to cause *Restricted Pathways*, to phase-separated **NAPL** in soil and groundwater regimes.  
*(medical analogy - clogging of arteries)*

Within hydrogeology, this causes Caking, Bridging, and Blockage of effective pathways = '**Pathway Interference**'

*(Measurably reduce Transmissivity = Slower Injection and/or Extraction issues!)*



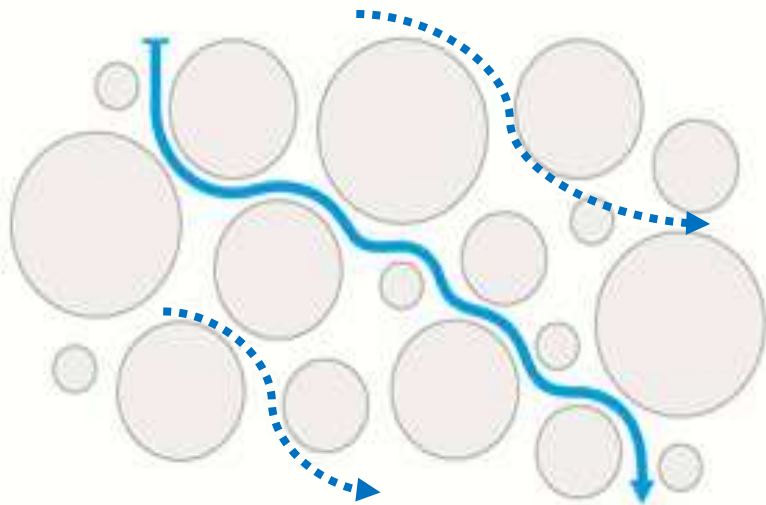




## Lower Permeability + Lower Transmissivity Due To:

Phase-Separated Oil  
Contaminant Mass Present  
(Sorbed, Agglomerated, NAPL)  
That Is Blocking Pore Pathways

*Restricted To Blocked Pores  
= Non-Effective Porosity  
= Challenging Remediation*



## Compared To: Good Permeability + Good Transmissivity

*Pores Are Open  
= Effective Porosity  
= Easier Remediation*

EFFECTIVE  
TO  
NON-EFFECTIVE  
POROSITY  
PERMEABILITY  
&  
TRANSMISSIVITY  
COLLECTIVELY  
IMPACTS  
REMEDICATION



# Total PFAS Mass Recovery 242% to 622% / Application

PFAS

## Tests show surfactant-based technology effective in removing PFAS from soil and groundwater

By George (Bud) Ivey, David Holmes, and Cecilia MacLeod

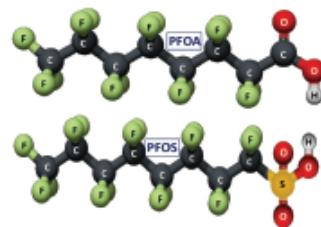
In recent years, several major corporations, including 3M, DuPont, and Chemours (a DuPont spinoff), have reached major settlements with municipal governments and other plaintiffs, agreeing to spend billions of dollars to remove PFAS from their production processes, products and the environment.

A substantial amount of these settlement funds will go towards helping water treatment facilities to remove PFAS from drinking water supplies. But significant dollars will also have to be spent to remediate PFAS-contaminated soil, bedrock, and groundwater.

The potential markets for PFAS remediation are numerous, ranging from chemical and other product manufacturing to electric power, wastewater treatment, real estate development, retail petroleum, landfill operations, mining ports and harbors, federal facilities, and more (Environmental Business Journal, Vol. XXXII, No. 5/6, 2019). All face significant future liabilities as the regulatory net and public awareness around PFAS grows and tightens. However, remediation contractors can face these future liabilities as well if their PFAS cleanup solutions prove inadequate to the task.

The traditional pump-and-treat solution has been applied to the remediation of PFAS-impacted groundwater, but it is expensive and can take decades to achieve any significant levels of removal.

Additionally, contamination in the more mobile, high-permeability groundwater zone can migrate into immobile, low-permeability subsurface zones, and pump-and-treat is not effective in removing contamination from those low-permeability zones. This can lead to future releases and back-diffusion into the high-permeability zone,



The PFAS family consists of nearly 15,000 chemicals.

and thereby failure to meet regulatory standards.

Some chemical and biological removal methods are being tested, but satisfactory results have not emerged. Methanol solvent extraction is used in laboratory soil extraction, and some small-scale testing. However, regulators are not likely to look approvingly at injecting many of these impactful chemicals into the ground.

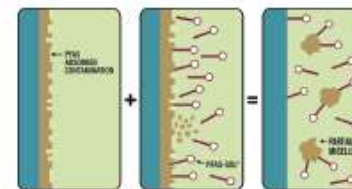
One potential solution, however, has been shown to be effective in recently completed tests. Ivey International Inc. (IVEY) has developed a new formulation from its Ivey-sol® enhanced remediation (SER) technology to address PFAS contamination in groundwater, soil, and bedrock regimes.

Tests of the PFAS-SOL® formulation conducted in the United Kingdom (UK) in collaboration with the University of Greenwich, with analysis by ALS, have shown significant PFAS mass removal rates. This formulation is non-toxic, biodegradable, and pH neutral. It is based on non-ionic formulations, with a novel additive, that can selectively desorb con-

taminants and render sorbed, globular and non-aqueous phase liquids (NAPL) soluble in the aqueous phase. This means it forms a non-emulsified mixture with water and can thus be more easily controlled and removed from impacted soil, fractured bedrock, groundwater, and surface water while maintaining plume control.

The PFAS-SOL surfactant structure consists of a hydrophilic head and a hydrophobic tail. The hydrophobic tail is by design, selectively attracted to the organic functional groupings on target contaminant molecules, while the hydrophilic head is attracted to groundwater.

Based on this modulated structure, these surfactants offer multiple properties that improve the effectiveness of most remediation strategies, predominantly by overcoming the limitations associated with contaminant sorption and low solubility. In addition, they lower the relative surface tension of water and overcome interfacial tension, thereby improving its wetting and associated hydraulic properties across



PFAS-SOL can selectively remove PFAS from sorbed soil and bedrock surfaces.

broader soil textures.

PFAS-SOL can selectively remove PFAS from sorbed soil and bedrock surfaces, from globular and/or NAPL phase-partitioned layers, to make them more available for enhance physical, biological, and/or chemical remediation.

For the column tests, one metre by 14 centimetre diameter columns were filled with a mineral sand (a building sand), with 10% activated carbon to act like natural organic carbon absorptive content within the soil. The columns were then slowly saturated with water from the base and drained to a set volume. They were next spiked with 250 mg each of PFOA and PFOS to mimic a PFAS source zone and then drained and filled, with the effluent sampled to show contaminant recovery in water.

The columns were filled again, one with methanol at a 50% concentration in water, the other with the PFAS-SOL surfactant formulation at a 4% concentration. They were then drained, with the increased concentration in the effluent in the PFAS-SOL column showing a large increase in PFAS concentration. The columns were then slowly taken apart to deliver a moisture profile and obtain soil samples to measure retained PFAS.

The results showed significant mass PFAS removal from the PFAS-SOL flushes. Flushes with water alone yielded PFAS recovery of approximately 5 micrograms per liter (µg/L), whereas surfactant flushes exhibited improved recovery of up to 30.45 micrograms per liter (µg/L). This meant an average improvement in PFAS removal of 240%, with concentration spikes of up to 622%. PFOA recovery averaged 160%, with best results of 185%. PFOS recovery averaged 297%, with best



The two test column tubes were spiked with 250 mg each of PFOA and PFOS to mimic a PFAS source zone.

results of 732%. Total PFAS recovery averaged of 242%, with best results of 622%.

Subsequent tests have shown similarly impressive results, suggesting a bright future for this surfactant-based PFAS remediation compared with other methods that are time-consuming and costly, and don't provide assurances against future back-diffusion risks liability associated with new sportive technologies.

Ivey International Inc. won the 2023 M&A Today Global Awards 'Best Environmental Technology Company' in recognition for their innovative technology developments. ■

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Dr. David Holmes, is with Geosyntec (UK). Email: david.holmes@geosyntec.com

Dr. Cecilia MacLeod is with the University of Greenwich (UK). Email: c.macleod@greenwich.ac.uk



### BREAKTHROUGH PFAS REMEDIATION TECHNOLOGY FOR PFAS MASS REMOVAL FROM SOIL, BEDROCK AND GROUNDWATER REGIMES..

PFAS-SOL® Sub CMC Selective Surfactant Desorption Technology

Our testing has shown that PFAS-SOL can reproducibly increase PFAS recovery from soil, and groundwater, several fold (240% to 732%) when combined with in-situ soil flushing

Our RAD results confirmed the following improved capacity:

- PFOA Mass recovery of 160% to 185%
- PFOS Mass recovery of 297% to 732%
- TOTAL PFAS Mass recovery of 242% to 622%



Improve physical, biological and chemical remediation of PFAS and PFAS for mobilisation

Technology overview and its capacity to remove PFAS from the environment

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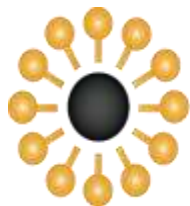
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# Evolution of PFAS-SOL® (Ca. 2019-2023)



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right solutions.  
right partner.

## Research Collaborators:

- **Dr. Cecilia MacLeod (University of Greenwich)**
- **David Holmes, Ph.D. (Geosyntec Consultant)**
- **George Ivey, B.Sc, CES, CESA, P.Chem, EP (Ivey International Inc.)**
- **ALS Laboratory (UK) (PFAS Soil and Water Testing Services)**

We started discussions regarding R&D column testing, to treat PFAS in **2019**, which eventually lead to graduate student testing, which was challenged by COVID. I am here to share some of the interim results within this presentation, with more data to become '*public domain*' following further work.

IVEY is working with collaborators to generate addition results we can share in the Public Domain, while taking a step-by-step approach to product/technology development.



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# Research and Development Column Studies



- ❑ Research question: '**Can the recovery rate of PFAS from soil/groundwater be improved?**'
- ❑ Large diameter columns were contaminated with PFOA and PFAS, and allowed to attenuate.
- ❑ Baseline sampling and post reagent application samples, of solids and liquids were carried out to evaluate the opportunity (**ALS** Laboratory).
- ❑ Graduate student doing M.Sc. Laboratory Work over many weeks conducted testing with supervision by Dr. Cecilia MacLeod and Dr. David Holmes.
- ❑ For this work Ivey International Inc. provided a novel Surfactant Solution, since trade marked globally as PFAS-SOL® (**Patent Pending 2023**)



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# Column Testing Process



- Mineral soil (a building sand)
- Mineral soil with 10% by mass powdered activated carbon (left) to provide organic sorptive content.
- The column was filled with dry media, slowly saturated from the base and then drained to a set volume. It was then re-filled and spiked with 250 mg of PFOA and 250 mg of PFOS (250 mg/kg = 250,000,000 ppt).
- The column was then drained and filled twice to show PFAS recovery in water.
- The column was re-filled with PFAS-SOL® at 4% and drained to show the PFAS recovery with surfactant.
- Results are presented for the activated carbon test.

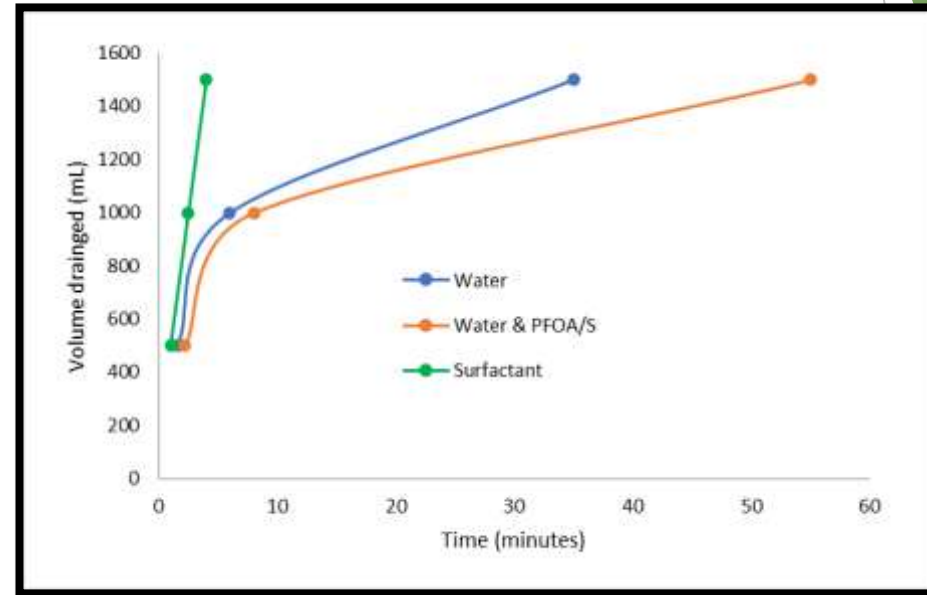




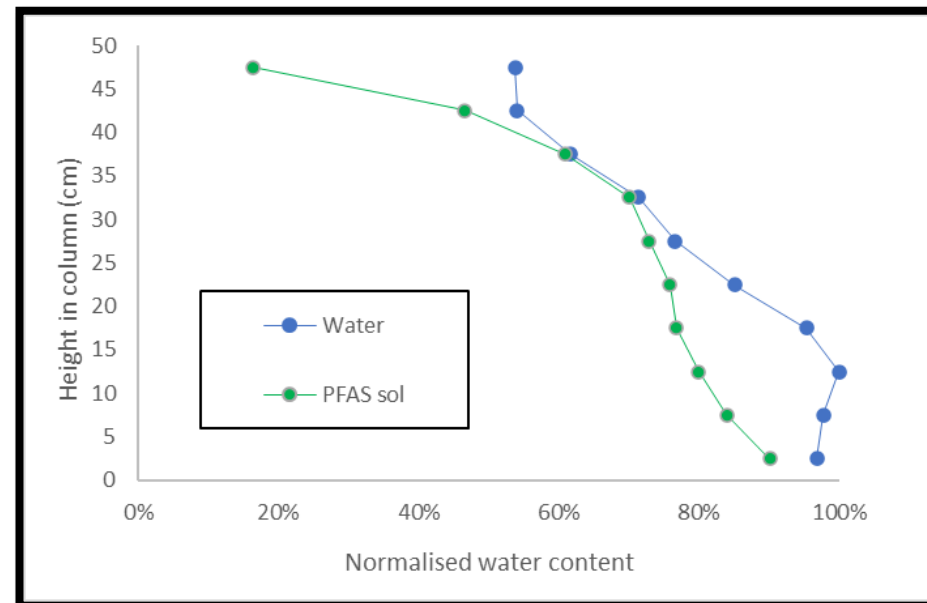
# Water Drainage: Surfactant Enhanced Drainage



- The PFAS-SOL<sup>®</sup> showed an improvement in soil drainage - surfactant lowers the surface tension, lowering capillarity effects of the soil (*smaller clusters*)
- In *subsequent* work, the effect of PFAS-SOL<sup>®</sup> on water retention was studied on a similar soil
- Similar test were carried out (fill and drain), and following drainage, the columns were deconstructed, and moisture content measured at discrete levels
- The results showed the distribution of retained water in the columns
- The graph shows that PFAS-SOL<sup>®</sup> allows *more water to drain*, increasing the ability of a treatment to mobilize more volume of water (*with liberated PFAS mass*).



Water drains normally  
Surfactant drains very rapidly  
Water + PFAS very slowly  
(Transmissivity Lower!)



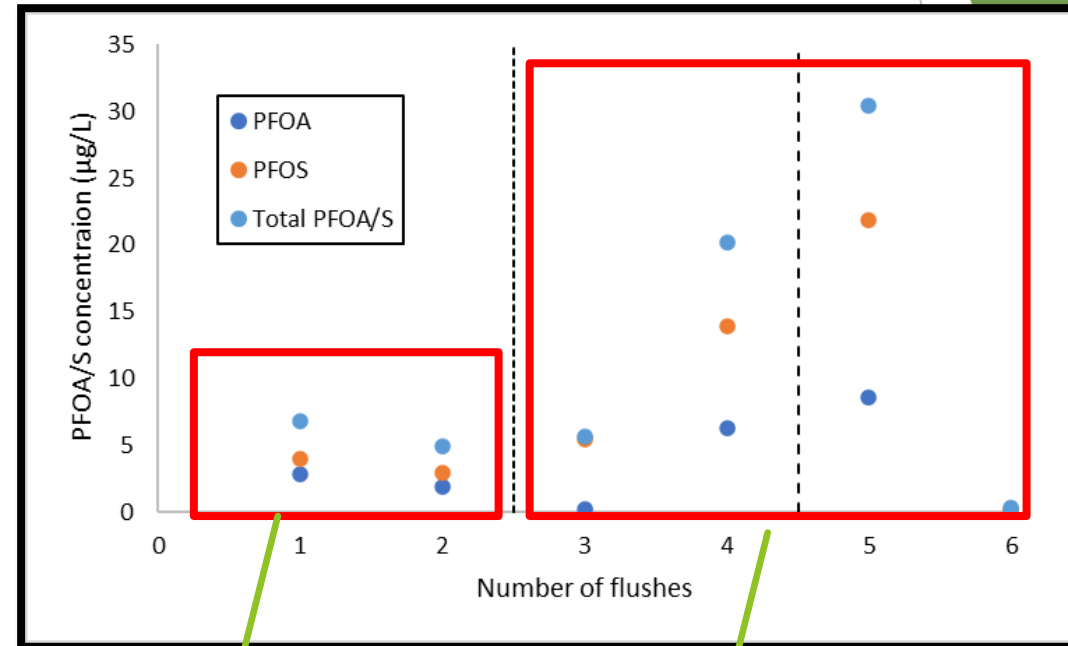
# Activated Carbon Soil Column Testing Results



- In the first two flushes with water alone effluent was around **5 µg/L**
- The would be expected to be peak (with PFAS from water in large, connected pores)
- However, subsequent PFAS-SOL® flushes improved PFAS recovery to an average of **14 µg/L**, ranging from **0.319 µg/L** (final sample) to **30.45 µg/L** (*3 to 6X - Simulating In-situ Soil Flushing*)
- This is an average improvement in removal of **240%**, with removal rates of up to **622 %**
- These results present a first look at surfactant-enhanced recovery of PFAS® (*Pre-Patenting*)

## SOIL WASHING TEST (Separate Testing):

- Furthermore, a subsequent soil wash (200 g soil with 200 ml PFAS-SOL® solution) for <1 minute mixing (room temp.) showed 5.85 mg/L PFAS – potentially near total recovery



Water

PFAS-SOL®



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# Preliminary Interpretation of Colum Test Results:



Ivey International Inc. (IVEY) interim interpretation, in order of data in table below:

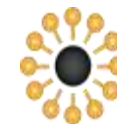
Column flushing tests using 4% PFAS Sol in a in a soil with 10% activated carbon:

- ☐ PFOA Improvement in recovery average of **160%**, with best results of **185%**
- ☐ PFOS Improvement in recovery average of **297%**, with best results of **732%**
- ☐ TOTAL PFAS Improvement in recovery average of **242%**, with best results of **622%**

Moderate mixing (Soil Washing) of sub-sample for less than 1 minute:

- ☐ TOTAL PFAS Effluent had 5.85 mg/L PFAS (3.29 mg/L PFOA and 2.56 mg/L PFOS)  
*Getting both PFOA and PFOS out, while many say you cannot get PFOS out easily.*

These data show that PFAS-SOL® can increase recovery of PFAS in groundwater pumping several fold, and when combined with in-situ soil flushing. This can result in significantly improved PFAS desorption from soil (and activated carbon), when applied in soil, bedrock, and groundwater regimes.



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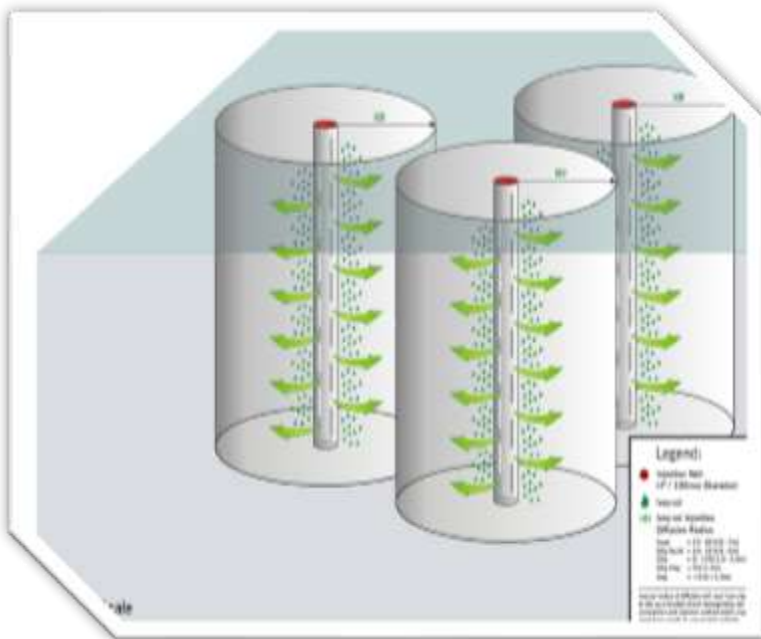


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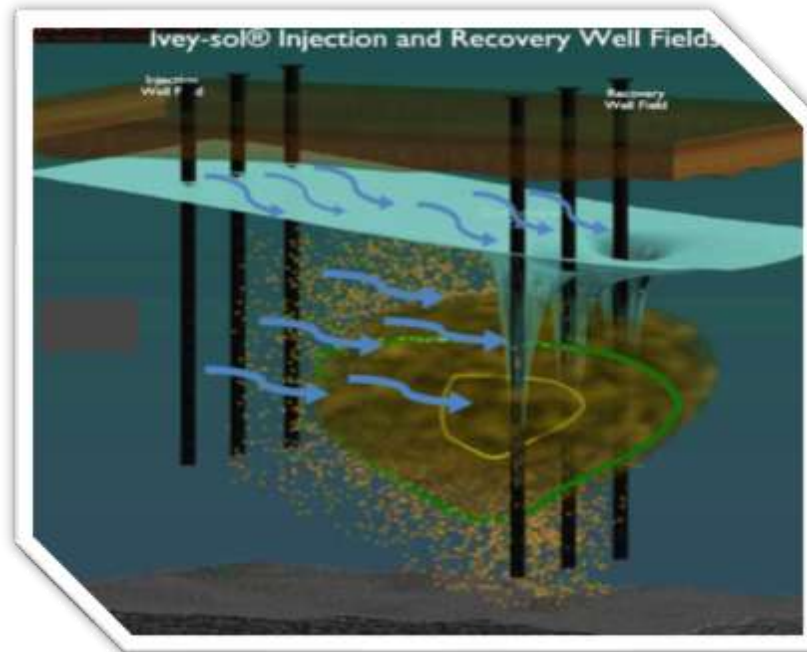


# IN-SITU PFAS-SOL<sup>®</sup> SOIL, BEDROCK & GROUNDWATER REMEDIATION METHODS

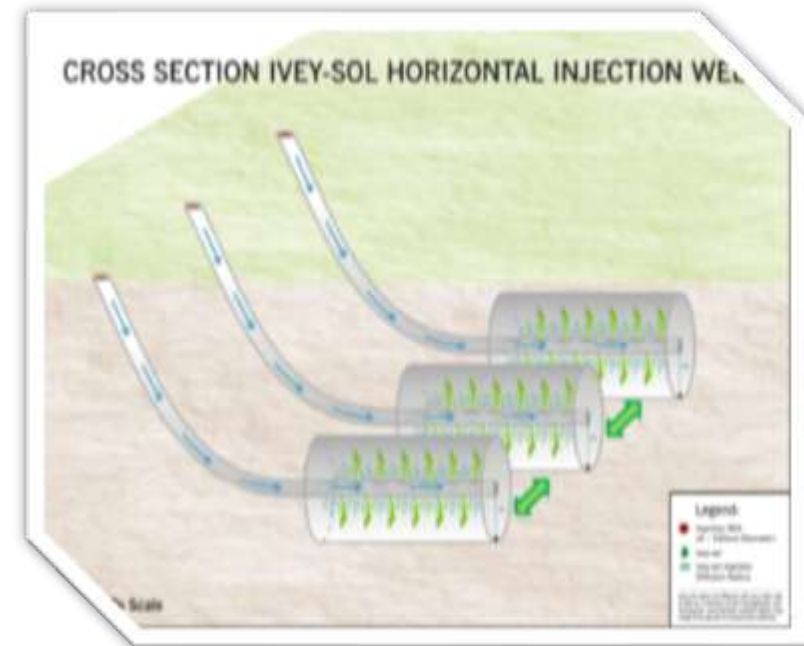
## Push-Pull



## Sweep



## Horizontal Well



**All methods designed to enable PFAS mass removal from impacted soil, bedrock and groundwater regimes.**





# In-situ Push-Pull Application For PFAS Mass Removal From Soil And Groundwater Aquifers







# USA SUPERFUND CLEANUP SITE APPLICATION

Site in mid-west USA with combination of petroleum hydrocarbons, chlorinated solvents and PFAS in soils and groundwater regimes.

In-situ PFAS-SOL '*Push-Pull*' and '*Sweep*' applications to effect PFAS mass removal.

We hope to share results later in 2026.



# SOIL WASHING FOR PFAS MASS REMOVAL

- ▶ Bench-scale PFAS-SOL soil washing simulation was undertaken on 200 g PFAS impacted soil;
- ▶ 200 ml PFAS-SOL® (4%) was used.
- ▶ This was mixed for ~1 minute, and then decanted.
- ▶ The PFAS analysis showed 5.85 mg/L (not ug/L) This results was near total PFAS mass recovery
- ▶ *These results would indicate PFAS-SOL could be used to enhanced ex-situ PFAS Soil Washing processes, by make the PFAS contaminants more 'Physically Available' to decontaminate soils for sustainable reuse.*
- ▶ *Pilot-Scale Applications Occurring on soils and sediments.*







# 99.99998% PFAS Mass Removal

PFAS

## Decontaminating fire-fighting equipment to prevent PFAS from entering water supplies

By J. Scott Poyner

Although there is still much to learn, we know that the class of chemicals known as per- and polyfluoroalkyl substances, referred to generally as PFAS, is ubiquitous in the environment and poses risks to human health and the environment. Of utmost concern lately, PFAS in water supplies has become recognized as a special risk, and municipal water systems, or government agencies acting on their behalf, have taken the lead in suing manufacturers to phase out PFAS production and provide the funds for remediation.

Meanwhile, the development of technologies for removing PFAS from the environment is playing catch-up. These environmental endpoints include not only water and soil but surfaces of all kinds of products and equipment that present human exposure risks. Although multiple technology development efforts are underway, there remains a lack of efficient, scalable, cost-effective, and environmentally benign technologies to deal with this broad range of contamination issues.

One promising technology was recently successfully deployed at a petroleum storage facility, which faced PFAS problems associated with its fire-suppression equipment. The facility operator, recognizing the rapidly advancing tide of PFAS-related action, sought to address contamination in certain equipment, in the interest of liability and risk management and out of concern for potential employee exposures.

The equipment in question consisted of a fire-fighting system, including piping that stored aqueous film-forming foam (AFFF), a fire-fighting liquid that contains PFAS compounds.

Replacing the PFAS-contaminated equipment was not viable, due to cost considerations and, even more, to the time required for procurement and installation



The facility operator agreed to GST's recommendation that PFAS-SOL be deployed to reduce the concentrations of PFAS residues on the fire-fighting system piping and equipment surfaces.

of new equipment. Fire-fighting systems at petroleum storage facilities are required to be operational essentially full-time, so removing the residual PFAS from the existing equipment was deemed the preferred option.

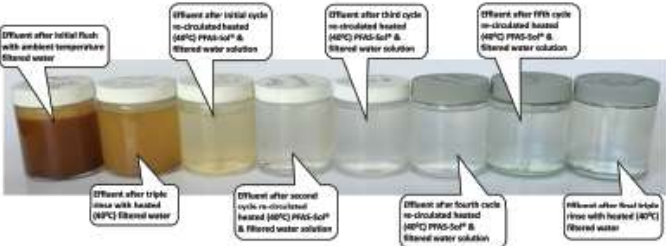
Following removal of the AFFF from the system, residual concentrations of PFAS were detected on the equipment surfaces. The facility operator performed a thorough, high-pressure flushing of the system using filtered municipal potable water, but that action left a PFAS concentration of 342,645 ng/100 cm<sup>2</sup> on the equipment's interior surface, a level deemed significant and falling short of the facility operator's decontamination goals.

The facility operator then engaged Geologic Science and Technology Group (GST), an environmental consulting firm with which the operator had fre-

quently worked in the past, to undertake the equipment decontamination project. The objective of the project was to reduce residual concentrations of detected PFAS constituents to the maximum extent possible using currently available technology.

In initial discussions with the facility operator, GST reviewed the known available options for removing PFAS from surfaces. Flushing with an alcohol-based solvent (ethanol or methanol) has historically worked better than flushing with water, but it is known to leave PFAS concentrations in residue of about 30%, which was substantial and considered to be too high.

GST then presented a surfactant-based solution that had shown the potential to achieve substantially improved removal rates compared with alcohol-based solvents. PFAS-SOL<sup>®</sup> is a patent-pending,



The remediation project then proceeded with a series of five flush cycles using combinations of PFAS-SOL and filtered municipal potable water.

non-ionic surfactant developed by British Columbia based Ivey International Inc. (IVEY) that is pH neutral, non-caustic, non-corrosive, non-toxic, and biodegradable.

In extensive bench-scale testing, PFAS-SOL<sup>®</sup> has demonstrated the capacity to desorb PFCA and PFOS, which are associated with AFFF, from a broad range of impacted surfaces, including metal, plastic, glass, ceramics, and composites. The technology has also been tested for more than 157 chemical impurities, with some at parts-per-quadrillion (ppq) levels, including the compounds contained in the removed AFFF.

The facility operator agreed to GST's recommendation that PFAS-SOL<sup>®</sup> be deployed to reduce the concentrations of PFAS residues on the fire-fighting system piping and equipment surfaces. The equipment decontamination project was undertaken in early March 2024, with a series of sequential phases.

Tanks for blending the surfactant with municipal potable water were staged by the pipe fittings on the portion of the fire-fighting system to be decontaminated, both upstream and downstream to create a closed-loop system.

The emptied piping system was initially flushed with filtered potable water at an ambient temperature (approximately 15°C) and then flushed three times with filtered potable water heated to 40°C. Following this flushing and wipe sampling at the discharge point, laboratory analysis detected a total of 12 PFAS ana-

SUMMARY OF PFAS COMPOUNDS DETECTED ON INTERIOR SURFACE OF FIREFIGHTING PIPING SYSTEM AFTER AFFF REMOVAL

Type	Compound	DETECTED PFAS		AFTER SYSTEM AFFF REMOVAL		AFTER HEATED PFAS-SOL <sup>®</sup> WASH AND HEATED WATER RINSE	
		Conc.	Prevalence	Conc.	Prevalence	Conc.	% Reduction
Acids	Perfluorooctanoic acid (PFPA)	575.222	303.9 ng	<0.001 ng	0	<0.001 ng	> 99.99997%
	Perfluorohexanoic acid (PFHx)	2753.905	538.9 ng	<0.001 ng	0	<0.001 ng	> 99.99997%
	Perfluorodecanoic acid (PFDA)	187.34.4	2,888.9 ng	<0.001 ng	0	<0.001 ng	> 99.99997%
	Perfluorododecanoic acid (PFDD)	175.30.9	91.9 ng	<0.001 ng	0	<0.001 ng	> 99.99997%
	Perfluorotetradecanoic acid (PFTe)	175.81.1	2,888.9 ng	<0.001 ng	0	<0.001 ng	> 99.99997%
	Perfluorohexadecanoic acid (PFHx)	175.81.1	168.9 ng	<0.001 ng	0	<0.001 ng	> 99.99997%
	Perfluorooctadecanoic acid (PFOD)	175.81.1	412.9 ng	<0.001 ng	0	<0.001 ng	> 99.99997%
	Perfluorooctadecanoic acid (PFOD)	175.81.1	168.9 ng	<0.001 ng	0	<0.001 ng	> 99.99997%
	Perfluorooctadecanoic acid (PFOD)	187.00.0	191.9 ng	<0.001 ng	0	<0.001 ng	> 99.99997%
	Perfluorooctadecanoic acid (PFOD)	175.323.1	<12 ng	0	0	<0.001 ng	> 99.99997%
Sulfonates	2,2,2-Trifluoroethyl sulfonate acid (R2-FTS)	175.16.00.0	84,888.9 ng	<0.001 ng	0	<0.001 ng	> 99.99997%
	2,2,2-Trifluoroethyl sulfonate acid (R2-FTS)	175.16.00.0	84,888.9 ng	<0.001 ng	0	<0.001 ng	> 99.99997%
Sum of detected PFAS		572,843 ng	6,683 ng	<0.001 ng	0	<0.001 ng	> 99.99997%

NOTE: 1. A sample size of 1 L of the flushing fluid was analyzed for PFAS residues in accordance with EPA Method 1631. 2. 1 L of the flushing fluid was analyzed for PFAS residues in accordance with EPA Method 1631. 3. Laboratory results were performed by Ivey International Inc. (IVEY) using a modified EPA method 1631 by adding laboratory grade PFAS standards, spiked with Carbon 13 (C13) isotopes, allowing for accurate quantification and reporting of PFAS concentrations.

lytes on the piping interior surface. These analytes consisted of nine acid compounds and three sulfonate compounds.

The remediation project then proceeded with a series of five flush cycles using combinations of PFAS-SOL<sup>®</sup> and filtered municipal potable water. In each cycle, the surfactant-water solution was heated to 40°C and recirculated for one to 1.5 hours by redundant pumps at high velocity under increased pressure. Following each cycle, the piping system was purged with filtered potable water heated to 40°C to remove all traces of the solution before applying it again in the next cycle. One final triple rinse followed cycle five.

A wipe sample was collected at the discharge point over a 100 cm<sup>2</sup> area of piping and compared with a baseline wipe sam-

ple that had been collected prior to the initial flush. The decontamination process reduced residual PFAS contamination on the equipment surfaces by an additional 99.99998%, to 0.0838 ng/100 cm<sup>2</sup>, beyond what the AFFF removal and potable water flushing were able to achieve.

Another significant outcome was the fact that decontamination with the PFAS-SOL<sup>®</sup> surfactant-water solution significantly reduced residues of the longer- and shorter-chain PFAS compounds, such as C4 through C12, and not just the C8 chains that have garnered much of the attention for decontamination.

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# AFFF Fire Suppression System Equipment PFAS Decontamination Case Study

## Background Objective:

- Aqueous Film Forming Foam (AFFF) containing PFAS was stored in a petroleum facility's firefighting equipment, which was removed for non-fluorinated replacement.
- Draining AFFF flowed by a potable water flush left substantial PFAS residual concentrations on equipment surface ( $372,643 \text{ ng}/100 \text{ cm}^2$ ) – FAA Approach ☹️
- A proprietary decontamination process using a heated pressured application of **PFAS-SOL®** solution (Patent Pending) was used to flush the equipment interior of residual PFAS.
- Geologic Science and Technology Group, Inc. (GST) was contracted to provide decontamination of specified firefighting equipment.





# APPROACH

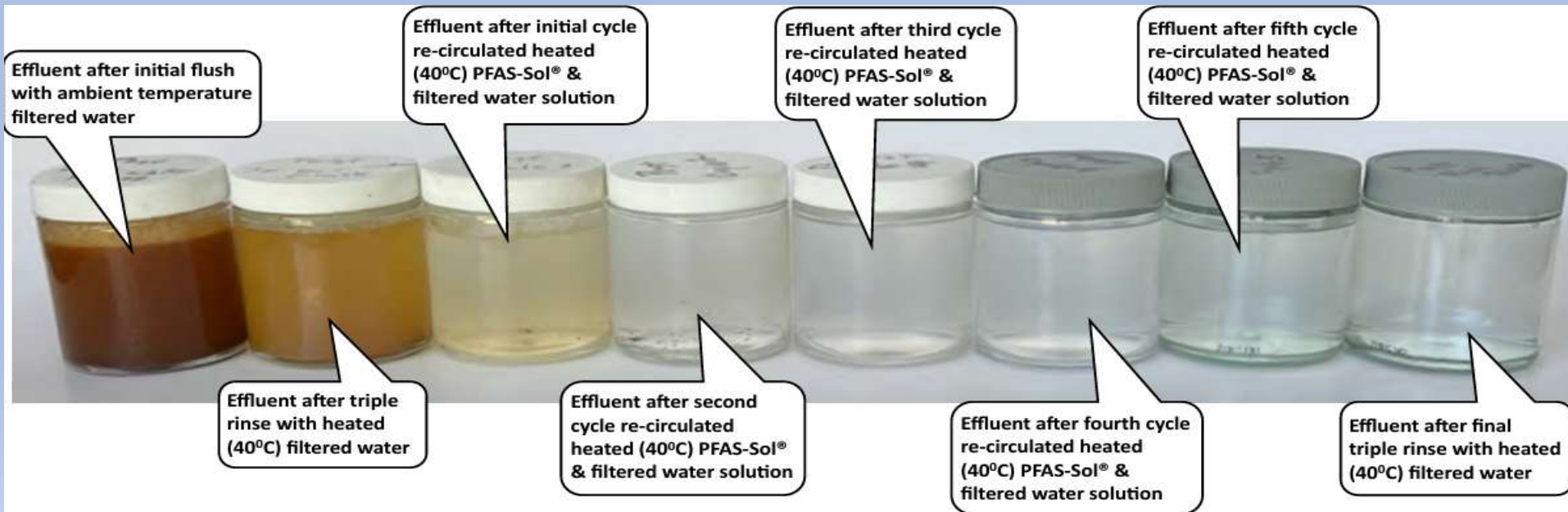
- GST selected a specialty surfactant uniquely formulated for PFAS liberation from impermeable solid surfaces know by the trademark name: PFAS-SOL®
- PFAS-SOL® is a patent pending non-ionic surfactant formulation that is pH neutral, non-caustic, non-corrosive, and biodegrade. PFAS-SOL® has the unique capacity for desorbing PFAS compounds, associated with AFFF, from a broad range of impacted surfaces.
- Blending tanks were staged next to pipe fittings on the portion of the fire-fighting system to be decontaminated. The blending tanks were connected to the upstream and downstream piping connections to establish a closed-loop re-circulation system.
- The decontamination was staged in sequential phases. Decontamination fluids were heated to 40°C, recirculated by redundant pumps at high velocity under increased pressure. Heat and pressure were carefully monitored to ensure gasket and fitting tolerances were not exceeded. Each decontamination phase included 1 to 1.5 hours of heated high pressure, high velocity recirculation.

# APPROACH Continued:

- Tanks for blending the surfactant with municipal potable water were staged by the pipe fittings on the portion of the fire-fighting system to be decontaminated, both upstream and downstream to create a closed-loop system.
- The emptied piping system was initially flushed with filtered potable water at an ambient temperature (approximately 19°C) and then flushed three times with filtered potable water heated to 40°C. Following this flushing and wipe sampling at the discharge point, laboratory analysis detected a total of 12 PFAS analytes (PFAS C<sub>4</sub> to C<sub>12</sub>) on the piping interior surface. These analytes consisted of nine acid compounds and three sulfonate compounds.
- The remediation project then proceeded with a series of five (5) flush cycles using combinations of PFAS-SOL® and filtered municipal potable water.
- The cycles used varying balances of the surfactant and water (by volume) in the following sequence:
  - ❑ Cycle 1: **5%** PFAS-SOL®, 95% filtered potable water.
  - ❑ Cycle 2: **4%** PFAS-SOL®, 96% filtered potable water.
  - ❑ Cycle 3: **3%** PFAS-SOL®, 97% filtered potable water.
  - ❑ Cycle 4: **2%** PFAS-SOL®, 98% filtered potable water.
  - ❑ Cycle 5: **1%** PFAS-SOL®, 99% filtered potable water.

# AFFF Equipment PFAS Decontamination

- The decontamination process reduced equipment surface residual PFAS contamination an additional **99.99998%** beyond AFFF removal with the potable water flush (*FAA Approach*).
- The PFAS-SOL<sup>®</sup> solution has the ability to penetrate into much smaller pore spaces than water alone. Accessing smaller pore spaces results in higher surface removal efficiency and minimizes rebound potential.
- The samples collected over the course of the five (5) PFOS-SOL<sup>®</sup> decontamination flushes, as shown below, becoming successively clearer and clearer





# Results AFFF Equipment Decontamination

## SUMMARY OF PFAS COMPOUNDS DETECTED ON INTERIOR SURFACE OF FIFREFIGHTING PIPING SYSTEM AFTER AFFF REMOVAL

DETECTED PFAS			AFTER SYSTEM AFF PURGE & WATER RINSE	AFTER TRIPLE HEATED WATER HIGH-VELOCITY WASH		AFTER HEATED PFAS-SOL <sup>®</sup> WASH and HEATED WATER RINSE	
Type	Compound	CAS	Pre-Decon	Post-Water Flush	% Reduction	Post-Decon	% Reduction
Acids	Perfluorobutanoic acid (PFBA)	375-22-4	365.0 ng	<96.0 ng U	> 86.85%	<0.288 ng U	> 99.96055%
	Perfluoropentanoic acid (PFPeA)	2706-90-3	336.0 ng	<14.1 ng U	> 97.90%	<0.0424 ng U	> 99.99369%
	Perfluorohexanoic acid (PFHxA)	307-24-4	2,800.0 ng	110 ng J	96.07%	<0.0245 ng U	> 99.99956%
	Perfluoroheptanoic acid (PFHpA)	375-85-9	311.0 ng	19.6 ng	> 96.85%	<0.0497 ng U	> 99.99201%
	Perfluorooctanoic acid (PFOA)	335-67-1	1,260.0 ng	76.7 ng J	93.91%	<0.0312 ng U	> 99.99876%
	Perfluorononanoic acid (PFNA)	375-95-1	108.0 ng J	<5.2 ng U	> 97.59%	<0.0156 ng U	> 99.99278%
	Perfluorodecanoic acid (PFDA)	335-76-2	472.0 ng	19.1 ng J	> 97.98%	<0.0330 ng U	> 99.99650%
	Perfluoroundecanoic acid (PFUnDA)	2058-94-8	39.9 ng J	<9.87 ng U	> 87.63%	<0.0296 ng U	> 99.96291%
	Perfluorododecanoic acid (PFDoA)	307-55-1	151.0 ng	<11.6 ng U	> 96.16%	<0.0349 ng U	> 99.98844%
Sulfonate	Perfluorooctanesulfonic acid (PFOS)	1763-23-1	<10 ng U	<10 ng U	N/C	0.0209 ng J	N/C
	6:2 Fluorotelomer sulfonic acid (6:2 FTS)	27619-97-2	284,000.0 ng	14,000.0 ng	95.07%	0.0629 ng	99.99998%
	8:2 Fluorotelomer sulfonic acid (8:2 FTS)	39108-34-4	82,800.0 ng	6,010.0 ng	92.74%	<0.0190 ng U	> 99.99999%
Sum of detected PFAS			372,643 ng	20,235 ng	94.56976%	0.0838 ng	99.99998%

NOTE: A surrogate value = 1/2 of the reporting level was used for Non-Detects in calculating percent reduction. N/C = not calculatable.

**Non Detectable  
Post Five (5)  
PFAS-SOL<sup>®</sup>  
Application**

The decontamination process reduced residual PFAS contamination on the equipment surfaces by an additional **99.99998%** beyond what the AFFF removal and potable water flushing were able to achieve, down to **0.0838 ng/100 cm<sup>2</sup>**.



# PFAS Decontamination of Fire Pumper Trucks



## ❑ PFAS Containing AFFF Fire Suppression Product Change Outs Are Undertaken Globally For Many Reasons Including:

- Comply With Local **Regulations** (Environmental & Health Risk)
- Response To **Worker Health & Safety** (Fire Unions) Concerns
- Legal **Liability** Management
- Tightening **Insurance** Pressure
- **Stakeholder + Public** Pressures (*Social License*)
- **Manufacturer Supply Chain** pressure to Use New Products



*Lots of Piping, Valves, and Holding Tank Infrastructure to Decontaminate In Fire Trucks*

- ❑ **PFAS-SOL Application To Decontaminate AFFF Fire Trucks For Safer Change Outs To Non-Fluorinated Fire Suppression Products**
- ❑ **To Avoid Risk Of Potential Residual PFAS Cross Contamination**

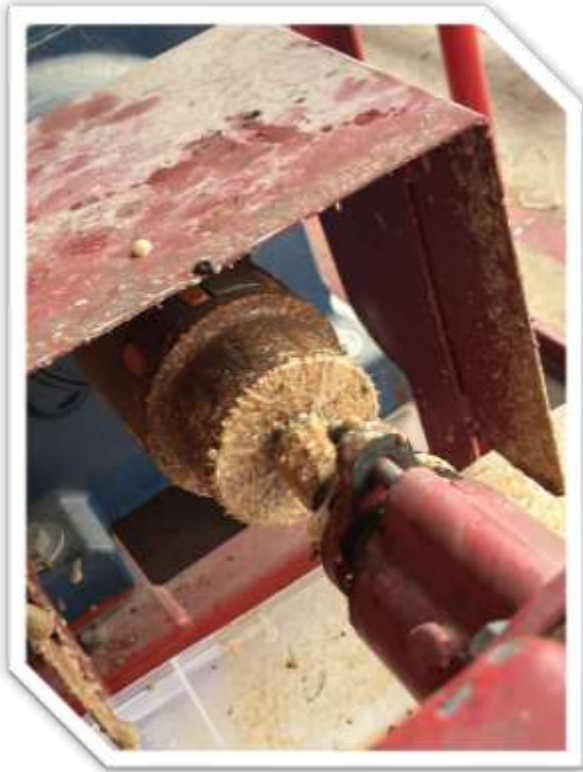
*“The Use of PFAS-SOL® For Decontamination of Fire Trucks At A Refinery Site In USA Exceeded The Client’s Expectations! They Are Actively Planning PFAS Decontamination Of Additional Assets In 2026, Using PFAS-SOL®.”*

**Scott Poynor, President, GST** (Project Technical Advisor)





# Decontamination of AFFF Fire Suppression System PFAS Contaminated Pump



← Before And After →  
**PFAS-SOL®**





# Combined Technology Applications



- **To lower In-situ PFAS Concentration Prior To In-situ Carbon Injections**  
*So residual [PFAS] is stoichiometrically within the limits the Carbon mass that can be physically injected, to avoid PFAS rebound, and have improve plume control.*
- **To lower In-situ PFAS Concentration Prior To In-situ Modified Clay Injections**  
*So residual [PFAS] is stoichiometrically within the limits the Modified-Clay mass that can be physically injected to avoid PFAS rebound, and have improve plume control.*
- **To lower In-situ PFAS Concentration Prior To In-situ ISCO Injections**  
*So residual [PFAS] is stoichiometrically within the limits the ISCO that can be physically injected, for better PFAS reductions, to avoid PFAS rebound, and better plume control.*
- **To lower In-situ PFAS Concentration Prior To In-situ ISCR Injections**  
*So residual [PFAS] is stoichiometrically within the limits the ISCR that can be physically injected, for better PFAS reductions, to avoid PFAS rebound, and better plume control.*
- **To Aid PFAS Desorption To Enhanced Physical 'Availability' for Multi-Phase Extraction (MPE)**  
*So that the MPE mass recovery does not level off (asymptotic) to maximize [PFAS] recovery and plume liability control.*
- **To Aid PFAS Desorption To Enhanced Biological 'Availability' for Remediation (In/Ex-situ)**  
*So that the PFAS is more Bio-Available to the microorganisms (bacteria, fungi, algae, etc.) to maximize [PFAS] degradation rates and improve results.*
- **To lower PFAS Concentrations To Risk-Based Site Remediation Closure**  
*So that the PFAS concentration can be reduced to the site specific risk-based closure objectives using PFAS-SOL or combined technology approaches.*
- **To lower PFAS Concentrations In Sediments During Ex-situ Physio-Chemical Remediation**



# PFAS-SOL<sup>®</sup> Technical References:

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*More References  
Available Upon  
Request*

# ENVIRONMENTAL BUSINESS JOURNAL®

## BUSINESS ACHIEVEMENT AWARD

This certificate hereby witness that

**Ivey International Inc.**

has been selected for the honor of

**Technology Merit: PFAS Mass Removal**

*awarded by Environmental Business Journal® for outstanding business achievement in the environmental industry in 2023*

*San Diego, California, USA*

*March 25, 2024*



A handwritten signature in black ink, appearing to read "Grant Ferrier".

**Grant Ferrier**  
CEO & Editor







LE GOUVERNEMENT  
DU GRAND-DUCHÉ DE LUXEMBOURG  
Ministère de l'Économie

*Le Ministre de l'Économie, des PME,  
de l'Énergie et du Tourisme,*

Vu la loi du 20 juillet 1992 portant modification du régime des brevets d'invention, telle que modifiée ;

Vu le règlement grand-ducal du 17 novembre 1997 concernant la procédure et les formalités administratives en matière de brevets d'invention ;

Vu le dépôt de la demande de brevet luxembourgeois daté du : **05/08/2024** ;

Arrête :

**Art. 1<sup>er</sup>.** Il est délivré à la (aux) personne(s) mentionnée(s) sur le tableau des données bibliographiques attaché au présent arrêté, sous le numéro de code 73, un

**BREVET D'INVENTION N° LU601231**

pour : Composition and Method for Remediation of PFAS Contaminants

**Art. 2.** Le brevet est délivré sans examen préalable de la brevetabilité de l'invention, sans garantie de l'exactitude de la description et aux risques et périls des demandeurs.

**Art. 3.** Le présent arrêté est expédié au(x) mandataire(s) agréé(s), mentionné(s) sur le tableau des données bibliographiques attaché au présent arrêté, sous le numéro de code 74 ou, à défaut, à la (aux) personne(s) visées(s) à l'article 1<sup>er</sup>.

Luxembourg, le 29/12/2025

*Pour le Ministre de l'Économie, des PME,  
de l'Énergie et du Tourisme,*

**Corinne Müller**  
Conseiller  
Office de la propriété intellectuelle

# PATENT COOPERATION TREATY (PCT) GLOBAL PATENT APPLICATION

## LUXEMBOURG APPROVAL

ON

DECEMBER 29, 2025

THE FIRST OF MANY  
GLOBAL (>50) PATENT  
APPLICATIONS

[WWW.IVEYINTERNATIONAL.COM](http://WWW.IVEYINTERNATIONAL.COM)



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