REGENESIS®

CASE STUDY

Sustainable PFAS Remediation

Comparing the environmental impact of long-term in situ sequestration to pump & treat

Why Consider Sustainability for the Remediation of PFAS?

Per- and Polyfluoroalkyl substances (PFAS) contamination is a widespread global issue due to its extensive use, mobility and recalcitrance. The challenge facing contaminated land practitioners is how to remediate such widespread pollution while avoiding the production of extra greenhouse gas emissions, exacerbating climate change.

By using sustainability assessments on each PFAS project, the wider impact of the remediation activities on the environment, society and economy, can be considered.

PFAS are everywhere!

PFAS soil and groundwater contamination is widespread across the globe. A number of attributes of PFAS compounds help to explain why this is the case.

Firstly, PFAS are very versatile and have been widely used in commercial and domestic products and coatings. They are also regularly discharged on to the ground in the form of fire fighting foam.

Once discharged, the contamination presents several challenging behaviours that exacerbate the risk posed:

- Retained in soils for decades
- Very mobile once in groundwater
- Recalcitrant to degradation
- Toxic at low concentrations
- Large, very dilute plumes
- Impacting large areas

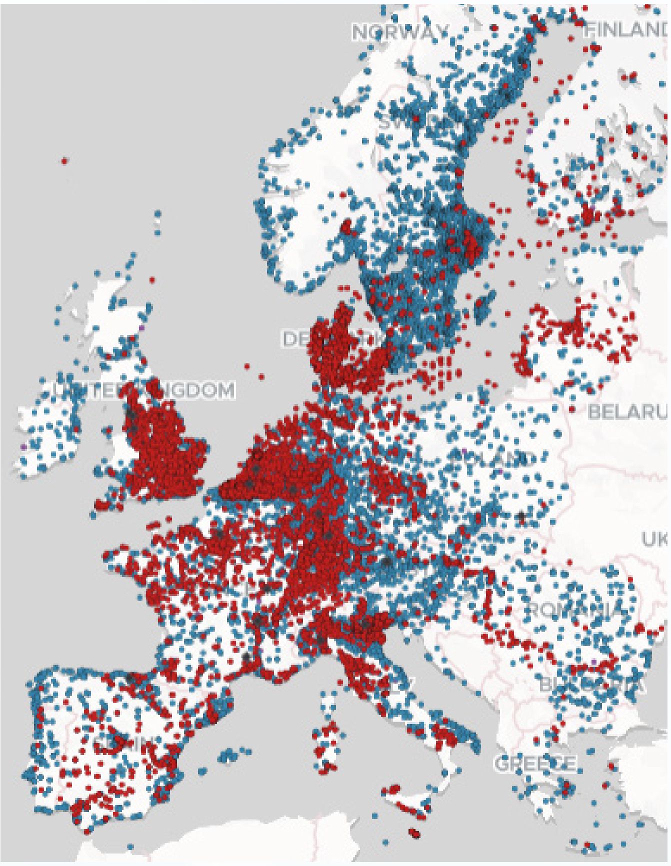


Fig. 1 'The Map of Forever Pollution in Europe'
Source: Le Monde

In Situ Sorption and Enhanced Attenuation using PlumeStop®

A Passive Approach

Remediation often focuses on extraction, disposal or destruction; however, these approaches may have a significant carbon footprint associated with them.

Enhanced Attenuation (EA) using PlumeStop® Colloidal Activated Carbon (CAC) is an alternative approach that works by reducing PFAS leachability and migration in situ. Already **used on over 40 sites worldwide, this passive approach requires no operational energy, maintenance or creates waste.**

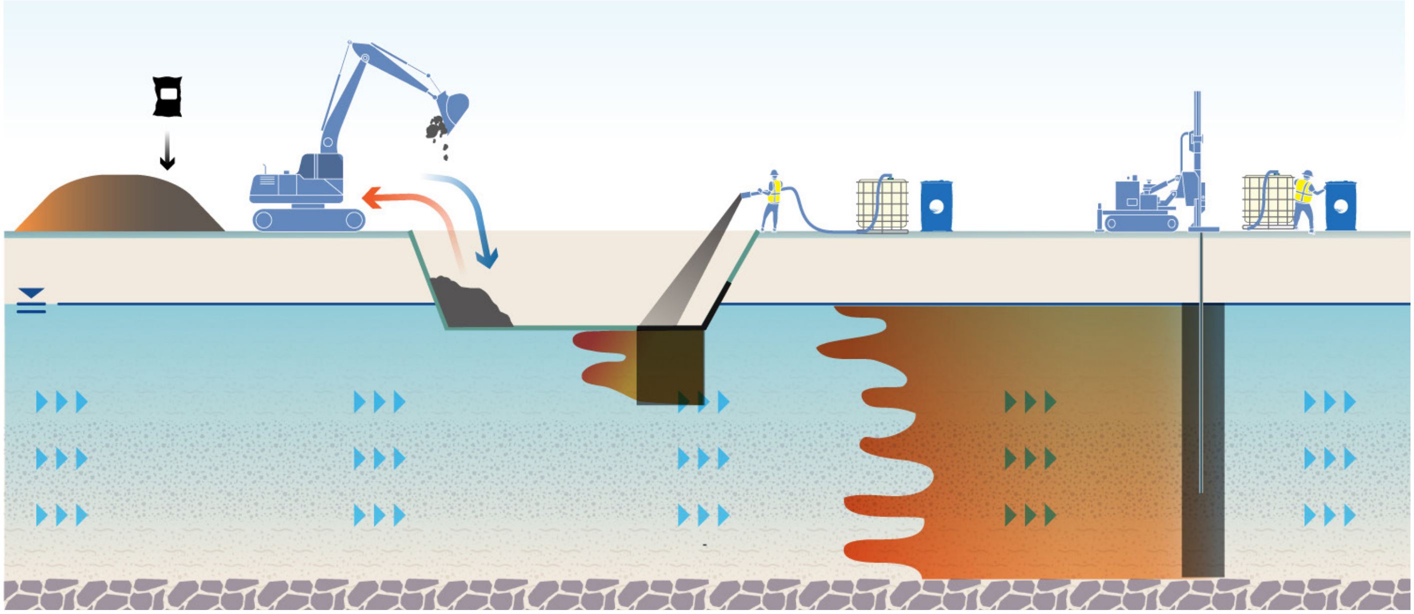


Fig. 2 Source and plume treatment using CAC

Verification using Life Cycle Analysis

This would suggest that the approach is more sustainable than alternative ex situ methods. To verify this, a Life Cycle Analysis (LCA) was conducted on the CAC material, with boundaries encompassing 'cradle to grave': considering upstream material sourcing, core manufacturing processes and the downstream processes of transport and injection.

The LCA was undertaken by Ramboll according to ISO14044/ISO14025 by using GaBi Professional software in order to meet EN15804 standards to create an Environmental Product Declaration (EPD).

Sustainability Comparison of a Site

Sustainability analysis was completed on a real-world PlumeStop application, located downgradient of a PFAS source at a commercial airport. A comparison was made by designing two alternative ‘pump and treat’ (P&T) systems, with filtration either by granular activated carbon (GAC) or foam fractionation (FF). The carbon footprint of each approach was completed using Life Cycle Inventory Analysis, using GaBi Professional software.

SURE
by Ramboll

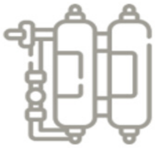
Additionally, a Life Cycle Cost Analysis (LCCA) was completed using net present value. Finally, a Tier 2 sustainability assessment using Ramboll’s SURE model, considering 15 sustainability indicators, was completed for each remedial approach.

A

Immobilization with PlumeStop® (CAC)

VS

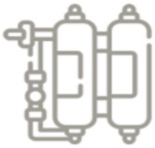
B1



Pump & Treat pumping with GAC filtration

VS

B2



Pump & Treat: pumping with Foam Fractionation

Site Designs

Immobilization with PlumeStop (A)

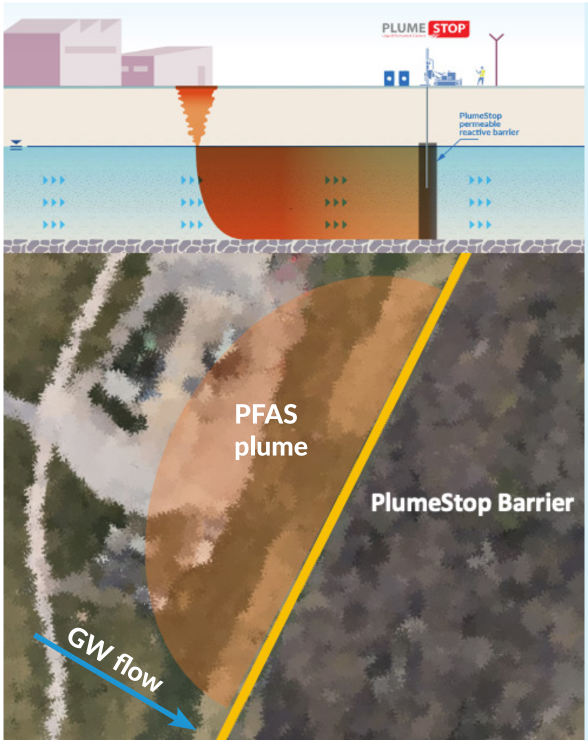


Fig. 3: Section and plan view of actual in situ remediation project

- Single injection round
- Designed for minimum 15 years of efficacy
- 102 injection points
- 110 m long
- 33 600 kg PlumeStop
- 1 600 l fuel used for injection
- 3 monitoring wells, 10 m deep
- 2 times/yr environmental monitoring

Pump & Treat with GAC Filtration (B1) or Foam Fractionation (B2)

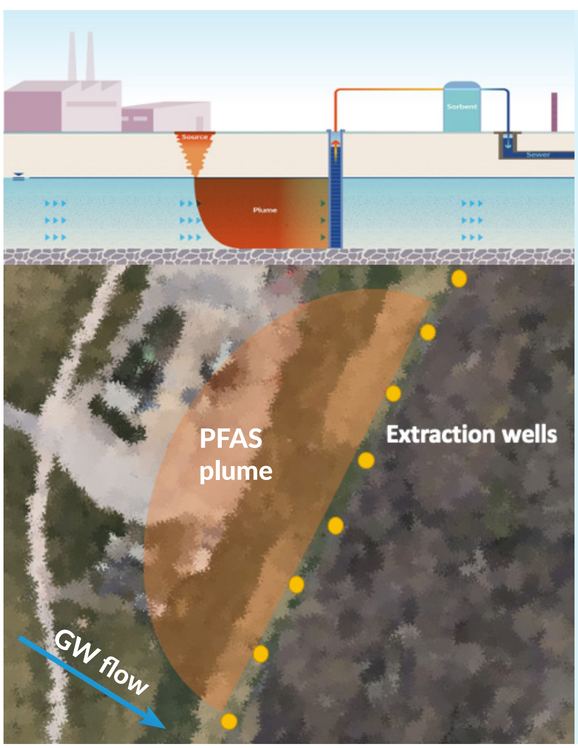


Fig. 4: Section and plan view of alternative P&T systems

- Based on consensus from 3 P&T designers
- Fixed equipment installation
- Continuous operation 15 years, 95% uptime
- 8 extraction wells, 8 m deep to avoid excess draw-down = vertical spread/smear
- 100 l/min pumping rate
- 24 000 kg/a GAC usage rate (B1)
- 100 mg/kg adsorption capacity (B1)
- 64 000 kWh/yr electricity consumption (B1)
- 4 times/yr O&M inspection from office
- 2 300 l fuel used for installation
- 3 monitoring wells, 10 m deep
- 2 times/yr environmental monitoring

Results

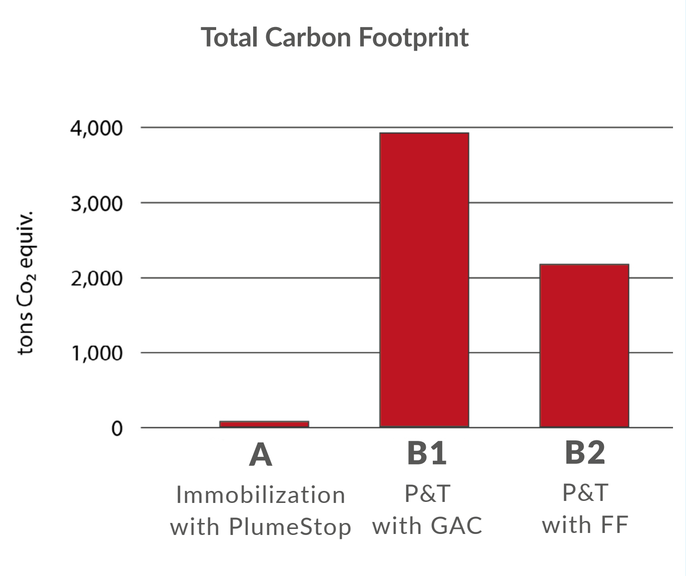
Total Carbon Footprint

The PlumeStop carbon footprint is 97.5 to 98.5% (i.e. 40-70 times) lower than the alternatives.

Regarding the Pump and Treat approaches:

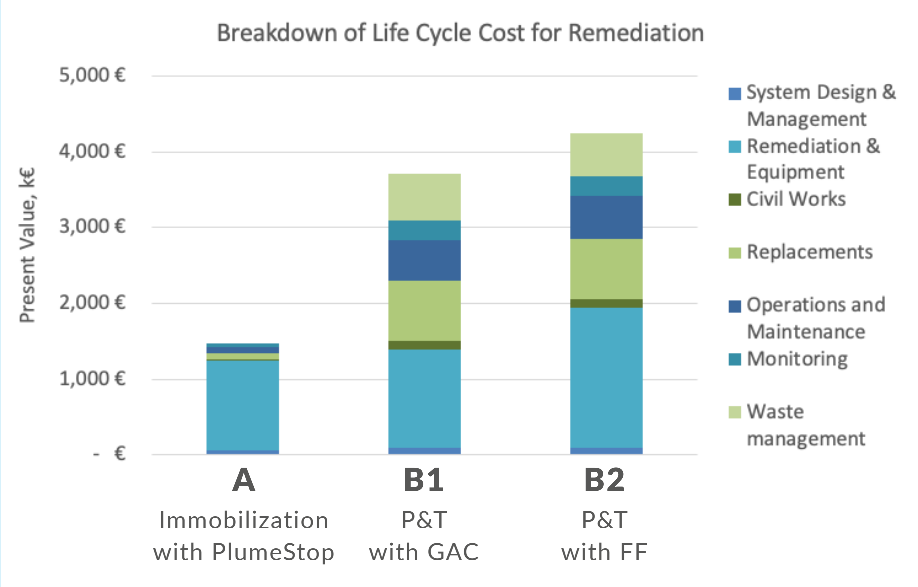
- The water extraction part of the process alone has a carbon footprint 1-2 Orders Of Magnitude higher than Immobilization with PlumeStop.
- Either filtration method increased the carbon footprint further i.e. changing the treatment approach did not provide a significant reduction in carbon footprint.

'Operation' and 'Waste management' were the Life Cycle Stages that had the greatest impact on the difference in carbon footprint between the in situ and ex situ methods.



Graph 1: Total carbon footprint for different remediation approaches

Life cycle cost analysis



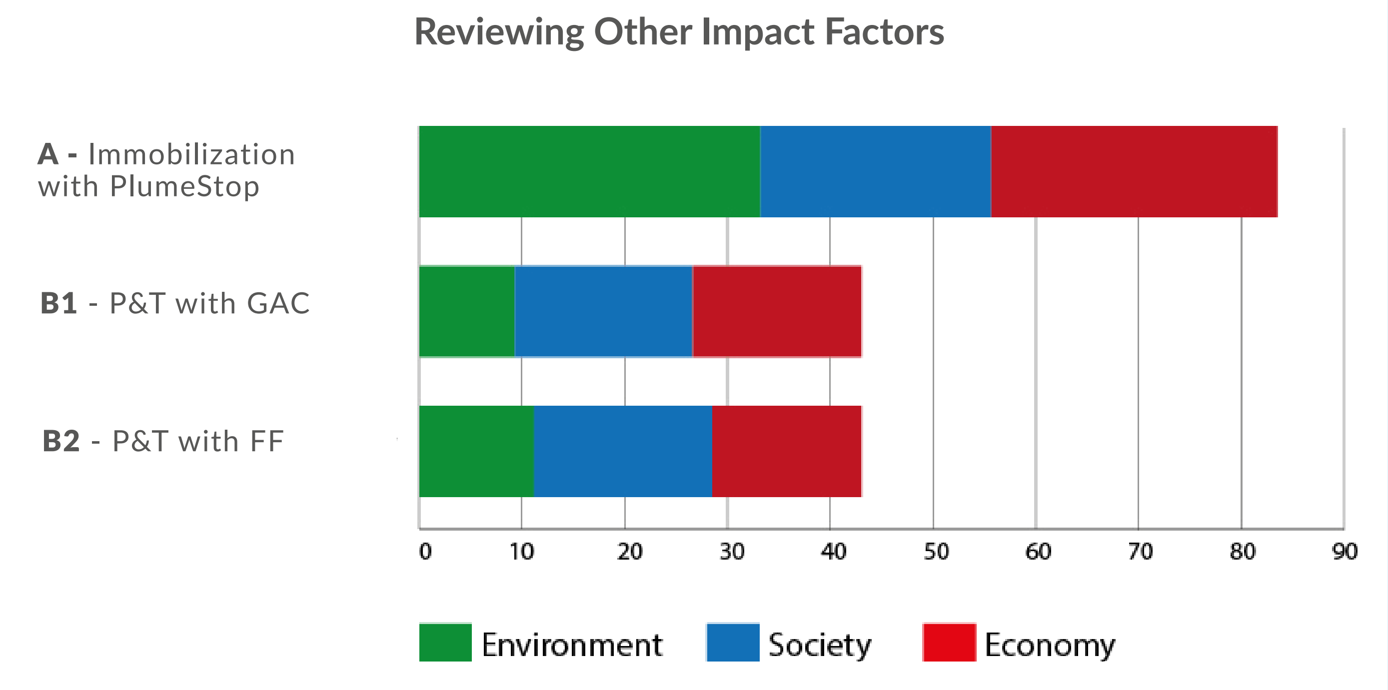
Graph 2: Life Cycle Cost analysis for different remediation approaches

Pricing analysis carried out by Ramboll has been based on a 15-year treatment duration with costs calculated at different times throughout.

Net Present Value:
PlumeStop = 1,476M €
P&T with GAC = 3,706M €
P&T with FF = 4,241M €

Immobilization with PlumeStop costs 61-65% less

Sustainability Score



Graph 2: Life Cycle Cost analysis for different remediation approaches

- A 'Tier 2' sustainability assessment was completed by using SURE by Ramboll (SURE). SURE is based on standards from ISO and ASTM, and aligned with the Sustainable Remediation Forum (UK) guidance.
- Linear-additive multi-criteria analysis (MCA) method and is designed to incorporate both qualitative and quantitative information.
- 15 sustainability indicators encompassing each sustainability domain weighted and scored.
- Comparison of remedial options: PlumeStop has a **100% higher Sustainability Assessement Score** than the ex situ alternatives

Conclusion

- Remediation Options Appraisals for PFAS impacted sites should include sustainability assessments to ensure that the site is not managed in isolation.
- PlumeStop has a carbon footprint that is 40-70 times lower than pump and treat
- ‘Pump and Treat’ has a carbon footprint for both components of the approach:
  - Water extraction, even considered alone, has a much higher carbon footprint than in situ treatment.
  - Either filtration method added further carbon footprint (as would any nascent destructive technique).
- The PlumeStop barrier has a much lower Total Cost of Ownership compared to pump and treat
- The overall Sustainabilty Assessment Score for PlumeStop was twice that of the alternatives. PlumeStop also exceeded pump and treat in each of the sustainability categories ‘Environment’, ‘Society’ and ‘Economy’.
- Enhanced attenuation, through the in situ retention of PFAS using PlumeStop (CAC) injection is an effective and sustainable approach to address a global pollution issue.

REGENESIS®

CONTACT

europe@regenesis.com
+44 (0)1225 61 81 61

WWW.REGENESIS.COM