Process Development for removal of Ultra-Short-Chain PFAS and TOC using regenerable resin

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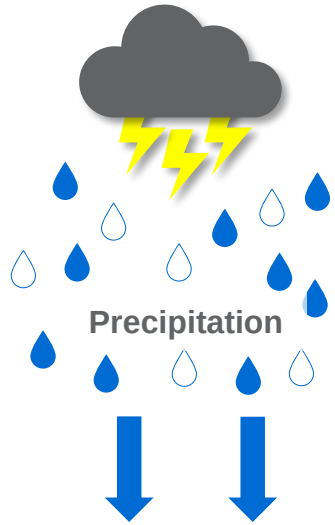
Ultra-Short-Chain PFAS in Rainfall

Due to degradation of fluorinated refrigerants as well as from industrial discharges

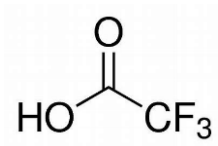
Atmospheric breakdown of fluorinated refrigerants HFC-134a

Source: kanvag /Fololia.com

Trifluoroacetic acid from fluorinated refrigerants contaminates rainwater | Umweltbundesamt

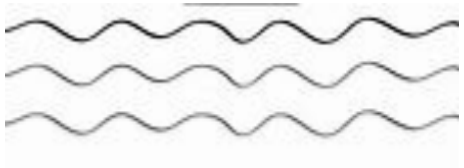


100 ppt



very hydrophilic
Low toxicity

Trifluoroacetic Acid (TFA)
a type of PFAS in rainfall
+
Industrial discharges at ~5,000 ppt levels



160 – 200 ppt in oceans

- TFA target in Germany < 10 ppb
- Trihaloacetic Acids (THAAs) target in USA < 60 (ppb) will likely include TFA
- ~ 5 to 5000 ppb industrial discharges in Europe
- Very low removal rates on both GAC and Resin ~1000 to 3000 BV
- Economically unfeasible to use Single-use resins
- Better to use regenerable resins

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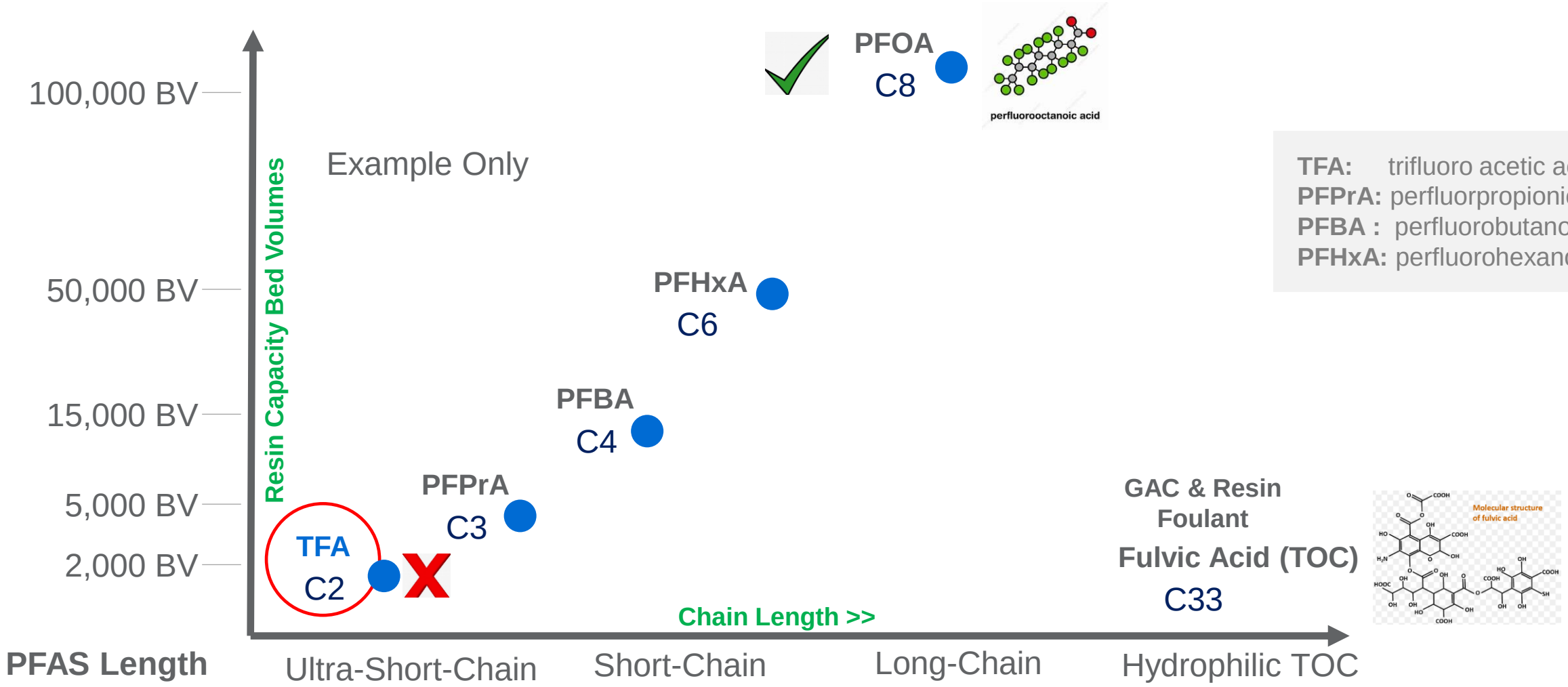
Rapidly declining resin capacity vs. PFAS chain length



TFA: trifluoro acetic acid
PFPrA: perfluorpropionic Acid
PFBA : perfluorobutanoic acid
PFHxA: perfluorohexanoic acid

Regenerable resin needed | Single-use resin Okay | TOC removal with GAC or IX

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Customer Goals

Comply with PFAS Regs	Remove Ultra-Short, Short- and Long-Chain PFAS
Reduce TOC interference on IX PFAS capacity	Reduce TOC to avoid major loss in PFAS capacity of single-use resin
Comply with DBP Regs	Keep THAAs + TFA < 60 ppb THAAs = tri-haloacetic acids; TFA = trifluoroacetic acid (which is an ultra-short-chain PFAS)
Easily Disposable Waste	No brine haulage – Want to dispose of wastewater at local WWTP
Easy to Operate Process	Minimal operation attention - automatable

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Purolite's Process Concept

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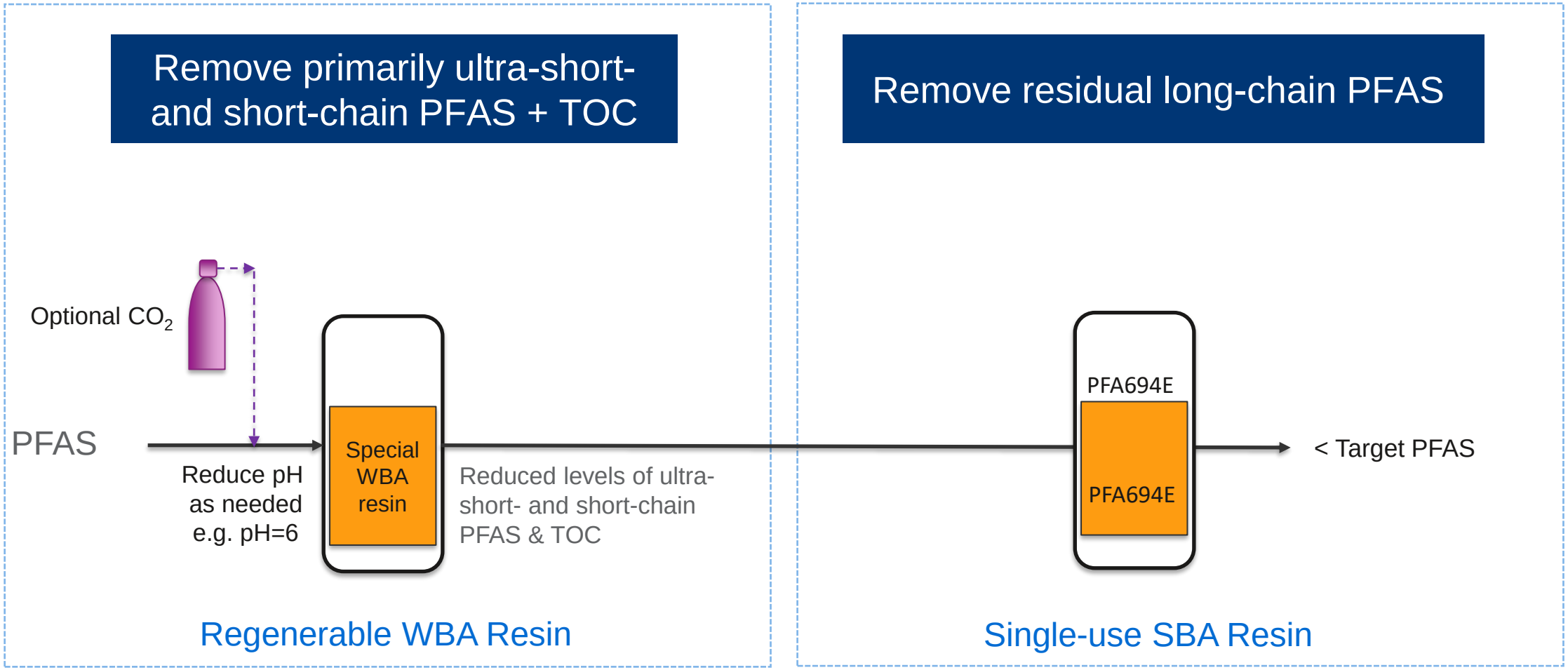
Service

Remove Ultra-Short, Short- and Long-Chain PFAS



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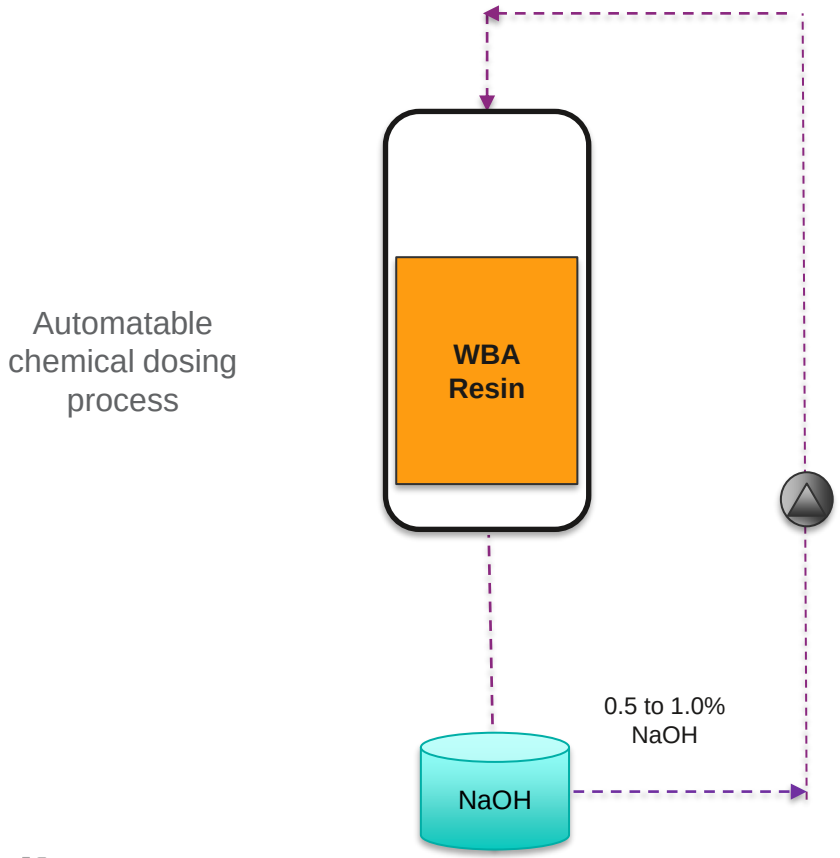
Example 1000 – 3000 BV

Example 100,000 – 300,000 BV

Regeneration

Dilute NaOH - Recirculated
Multiple Recovery/Reuse of Spent Regenerant



- Very dilute NaOH regenerant (e.g. 0.5 to 1%) is recirculated & reused over multiple regenerations.
- This is expected to elute largely the ultra-short- and short-chain, but also a small portion of the long-chain PFAS.

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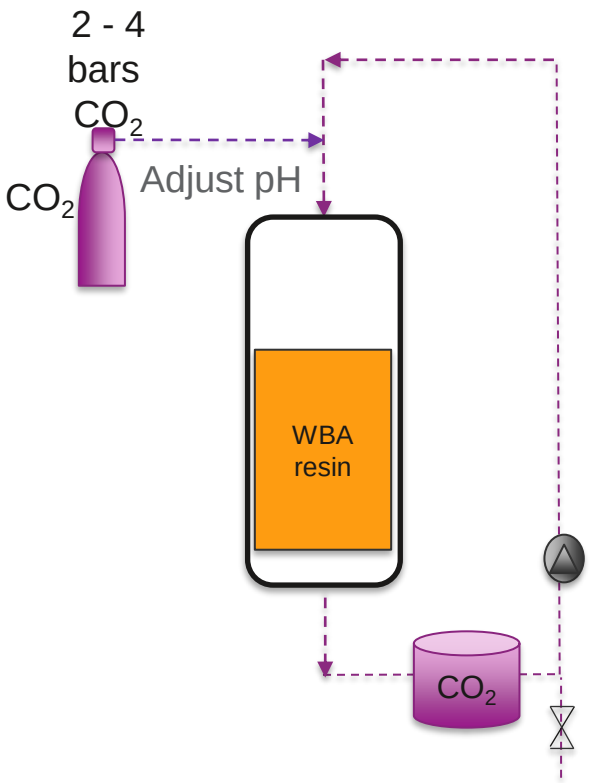
Rinse

Recirculate CO2-infused rinse water to neutralize resin



CO_2-infused rinse water is used to neutralize residual caustic and the rinse is recirculated & reused for multiple regenerations.

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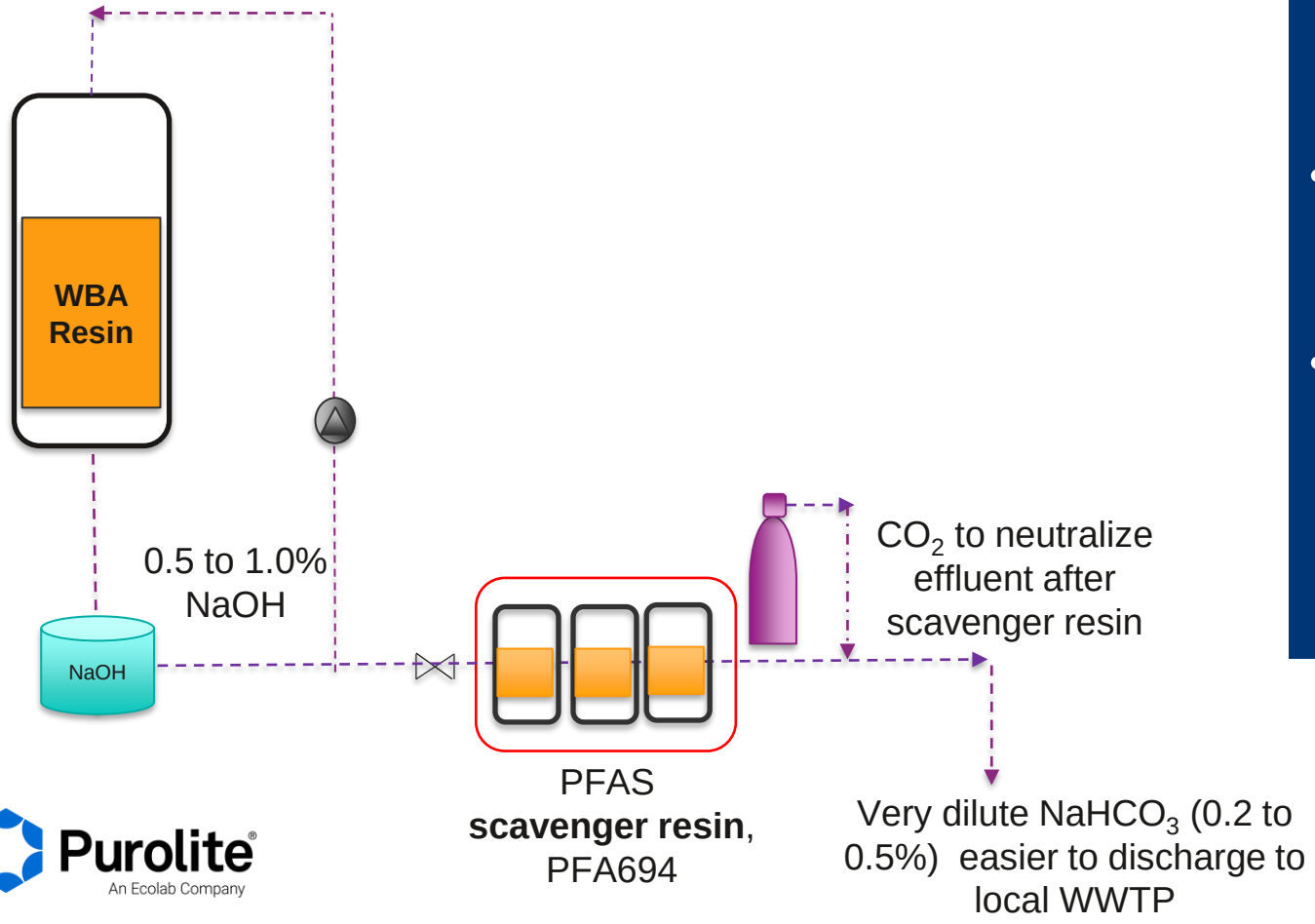
Wastewater Disposal Option

Use Scavenger Resin to remove PFAS from spent regenerant; Dispose wastewater at local WWTP



- Use single-use PFA694 resin to remove PFAS from spent caustic regenerant.
- Use CO2 downstream to neutralize NaOH before discharge.
- The resulting dilute sodium bicarbonate (0.2 to 0.5%) is easily disposed at local wastewater plant (no expensive offsite brine hauling/disposal is needed).

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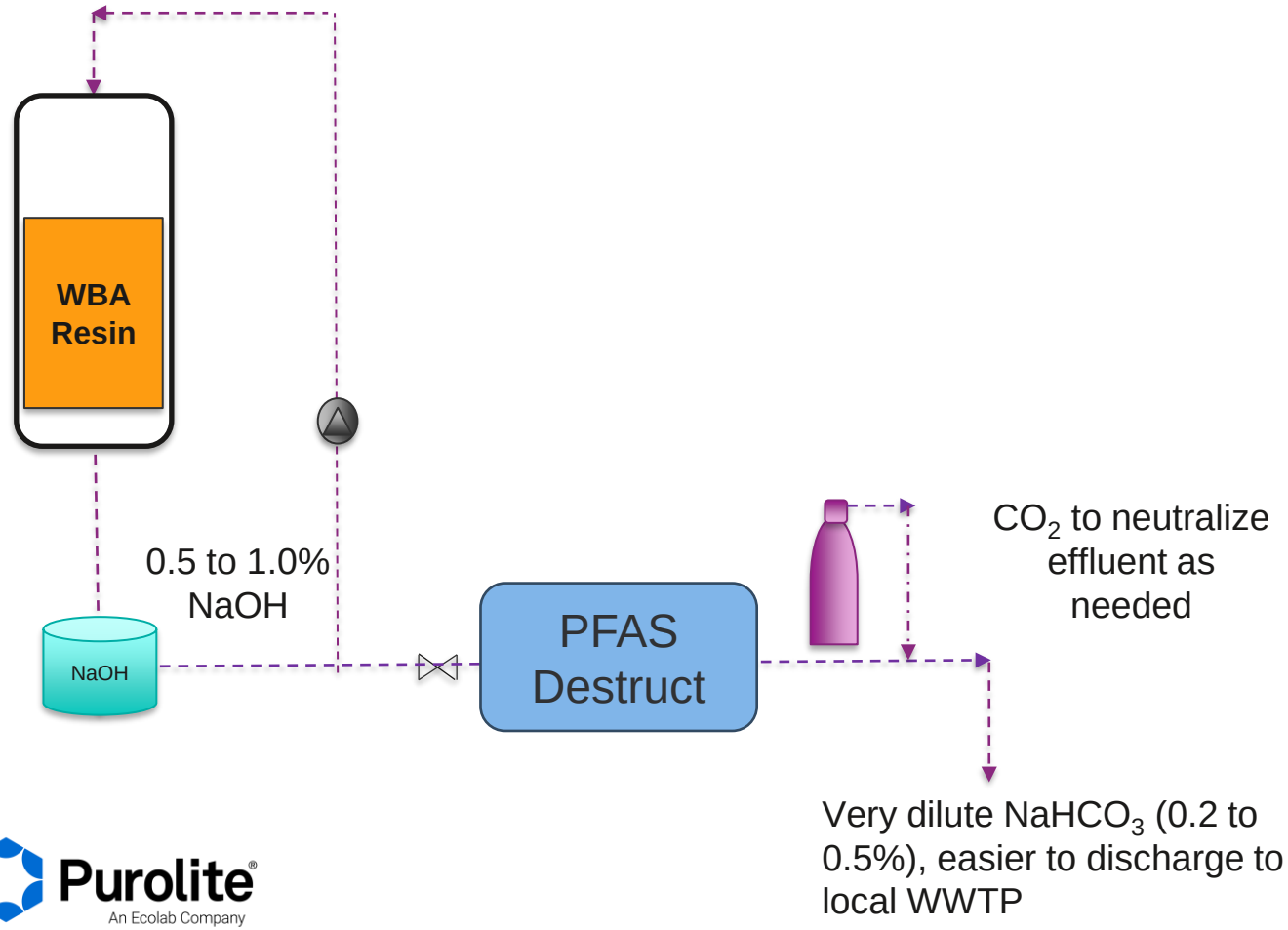
Wastewater Disposal Option

Use PFAS Destruct Process then dispose at local WWTP (e.g. SCWO, Electrochemical, Sonochemical, Plasma)



- Use SCWO, Plasma, Electrochemical, or Sonochemical process to destroy PFAS.
- Neutralize NaOH with CO2 as needed.
- Easily dispose of the resulting dilute (0.2 to 0.5%) sodium bicarbonate to local wastewater plant (no expensive offsite brine haulage needed).

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Example Rough Cost Estimate:

PFAS + TOC Removal

PFAS + TOC removal WBA Capacity 1000 BV; 0.2% wastewater SBA Capacity 100,000 BV	EUR € Per Million Liters
WBA resin: Ultra-Short- and Short-Chain PFAS + TOC	53
CO_2 for pH	25
Scavenger resin	28
Caustic	3
Rinse water	1
SBA resin: Long-Chain PFAS	123
Combined OPEX	**233**

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Based on $500/MT NaOH, $220/MT CO2; combined OPEX ~$0.88/1000 gallons

Customer benefits from the process concept

Greater Compliance - remove ultra-short-, short-, and long chain PFAS + TOC

Lower OPEX – No expensive offsite brine haulage

Extended life of downstream PFAS-selective single-use resin

The process can be automated with minimal operator input

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