

Monitoring of PFAS pollution plumes and the effects of hydraulic containment barriers

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The Valais and contaminated sites

▲ Rhône Plain aquifer extends over more than 110 km

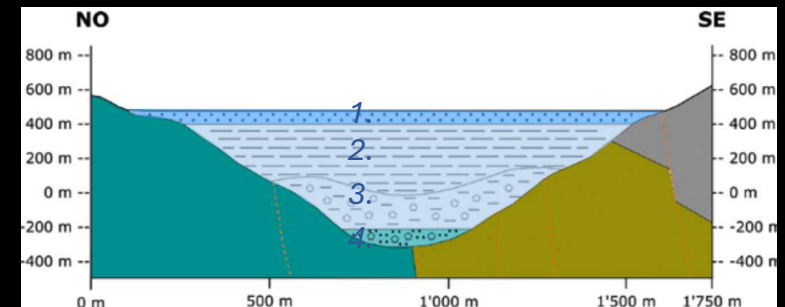
■ Highly vulnerable to pollution

- *shallow depth of the groundwater table*
- *industrial activity since the beginning of the last century*

⇒ 3 aluminum electrolysis sites

⇒ 3 large chemical plants

⇒ 1 refinery



1. coarse alluvium and flood deposits
2. lacustrine deposits
3. morainal deposits
4. torrential deposits

The Valais and contaminated sites

- ▲ Large landfill sites complement the long-established industrial areas
 - Pollution from fluorides, mercury, PAHs, solvents and anilines
 - Covers the entire industrial past of Valais



The past: Pont Rouge industrial landfill

- ▲ Completely sealed excavation hall and containers (between 2012 and 2015)
 - 110'000 m³ of materials thermally treated off-site
- ▲ Treatment of polluted subsoil by in situ thermal desorption (2015-2016)
 - Extraction of 5.5 to of pollutants in 20,000 m³ of subsoil



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The past: soil pollution by mercury

- ▲ More than 170 plots of land in residential areas have been remediated
 - Replacement of all polluted soils > 2 ppm Hg
- ▲ 6.5 ha of agricultural land has been remediated
 - Replacement of all polluted soil > 7.5 ppm Hg



The past: aluminium electrolysis sites

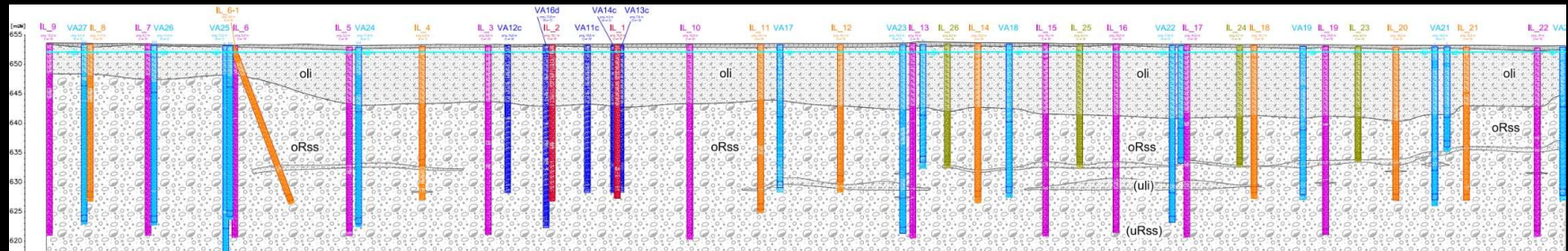
- ▲ Former aluminum electrolysis facilities in Steg and Chippis
- ▲ Remediation by excavation
 - 232'000 tonnes of heavily polluted materials
 - Rehabilitation of two brownfield sites: more than 20 ha involved

Pour cause de pollution nous
ne produisons plus en ce lieu...
Nos points de production et vente
se situent à:
Corin s/ Sierre (rte de Chermignon Crans)
Saxon rue du Vacco



The challenges: Former Gamsenried landfill

- ▲ Extraordinary dimensions
 - 29 ha | ~3 mio. m³ | 4-5 mio. tonnes
 - Aniline, benzidine, aminobiphenyl, Hg ...
 - 3 km long plume of pollution
- ▲ Containment since 1990
 - Improvements from 2016
 - Downstream air sparging treatment barrier



- Watertight wall (to be built from 2026)
- ▲ Remediation of pollution sources under study (huge volume of organic and Hg pollution)

The emergence of the PFAS challenge

investigation and remediation of fluorides, mercury, PAHs,
solvents and anilines pollution

2008 2010 2012 2014 2016 2018 2020 2022 2024 2026 2028 2030 2032 2034

setting a value for tolerable weekly intake (TWI)
for PFAS of 4.4 ng/kg bw per week

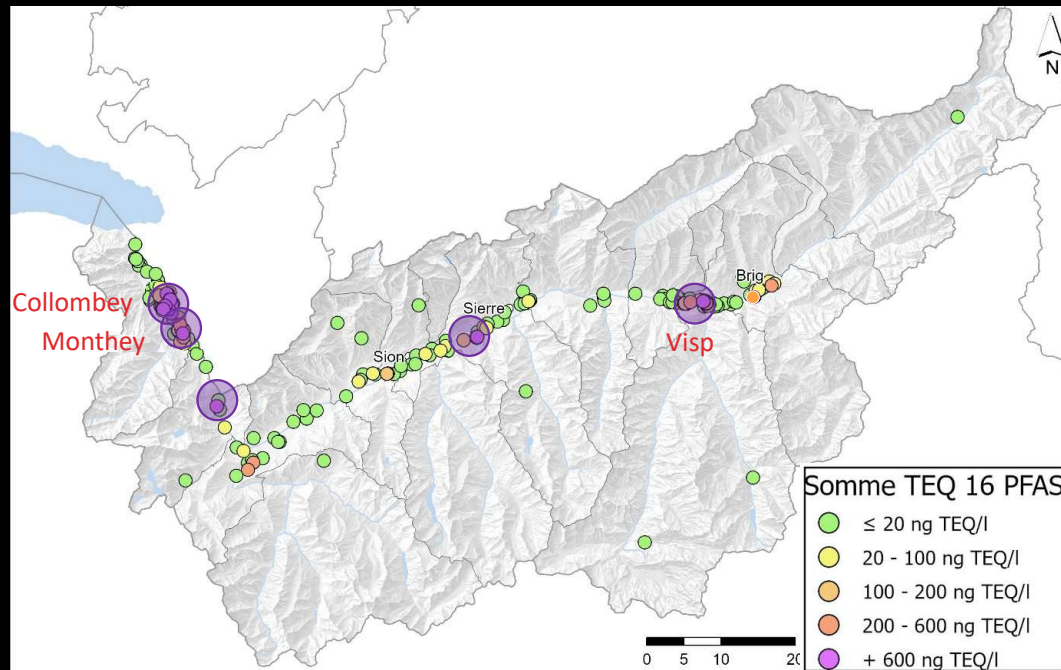
investigation and remediation of PFAS pollution

EFSA, 17 September 2020
Risk to human health related to the presence of PFAS in food

The emergence of the PFAS challenge

Targeted investigations from 2020

- 5 contaminated sites with pollution plumes $\gg 600$ ng TEQ/l (all related to the use of fire-fighting foams with PFAS)



Priority measures requested

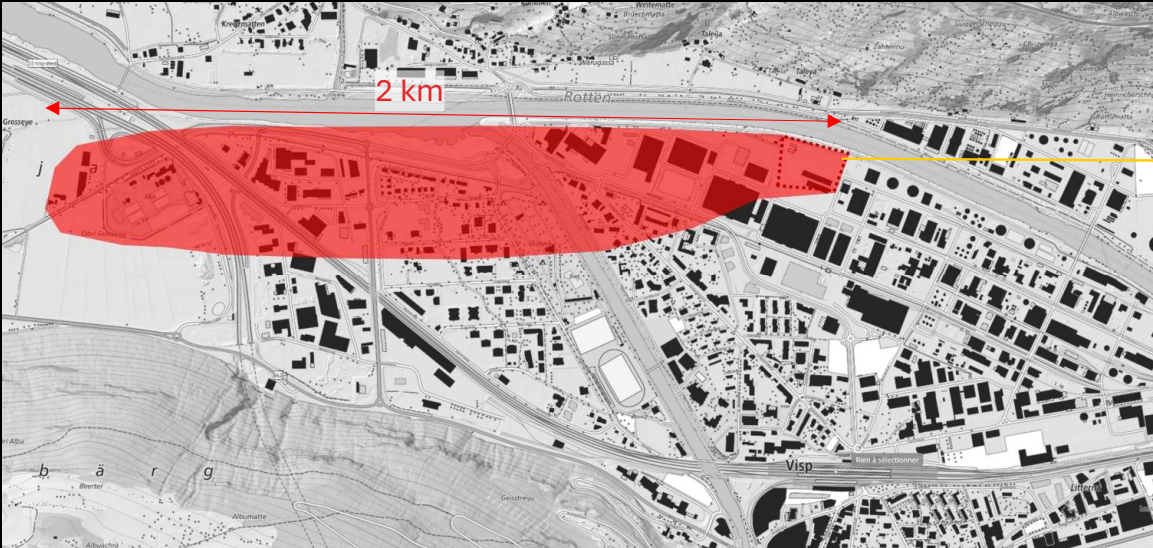
- ▲ PFAS-free emulsifiers for all fire brigades (2023)
- ▲ Hydraulic containment immediately downstream of pollution sources (from 2020)
 - Transitional measure pending remediation of pollution source



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Visp former firefighters training site

- Investigations in 2017
 - Extent of the impact that the use of PFAS-based foams could have on the groundwater



PFAS concentrations in groundwater at a depth of 5-10 m

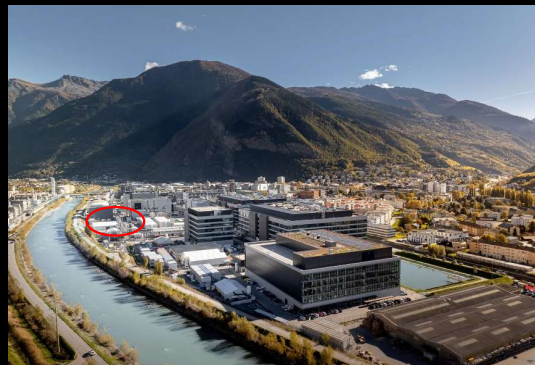


	Annual average 2017 [ng/l]				
	VK11b	VK12	VK16	VL07	VL08b
PFHxA	25'000	16'000	22'000	36'000	27'000
PFHxS	18'000	3'600	10'000	31'000	41'000
PFOA	2'700	200	9'800	5'900	8'900
PFOS	1'800	70	30	490	2'600
Sum TEQ	17'350	2'660	16'080	25'840	38'970

Visp former firefighters training site

▲ Remediation between August 2020 and July 2022

- A total of 373 kg of PFOS and 64 kg of PFHxS were removed by excavating 68,094 tons of soil and subsoil material
- Treatment by soil-washing and cement plant
- Pumping the groundwater beneath the contaminated area
- In a year and a half, 11.4 kg of PFAS were extracted
 - ⇒ a total of 10 substances, including 4.0 kg of PFHxS, 2.5 kg of PFHxA, 0.6 kg of PFOA and 0.2 kg of PFOS



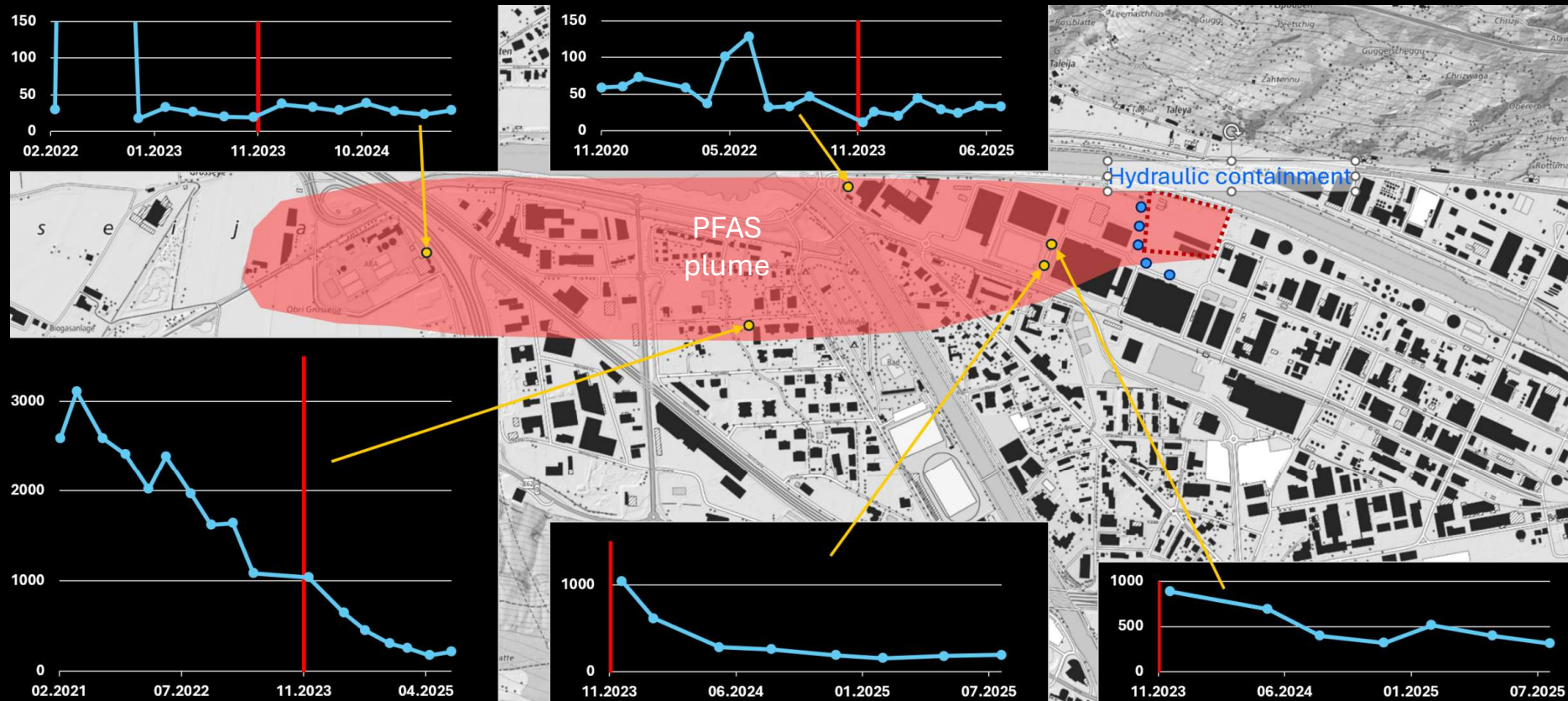
© Christian Pfammatter

Visp former firefighters training site

▲ Hydraulic containment of the site (since August 2020)

- 2 kg of PFAS extracted per year
- 200 m downstream, the PFAS concentration decreased by a factor of 4 since the end of 2023

Σ 9 PFAS in
groundwater
[TEQ ng/L]



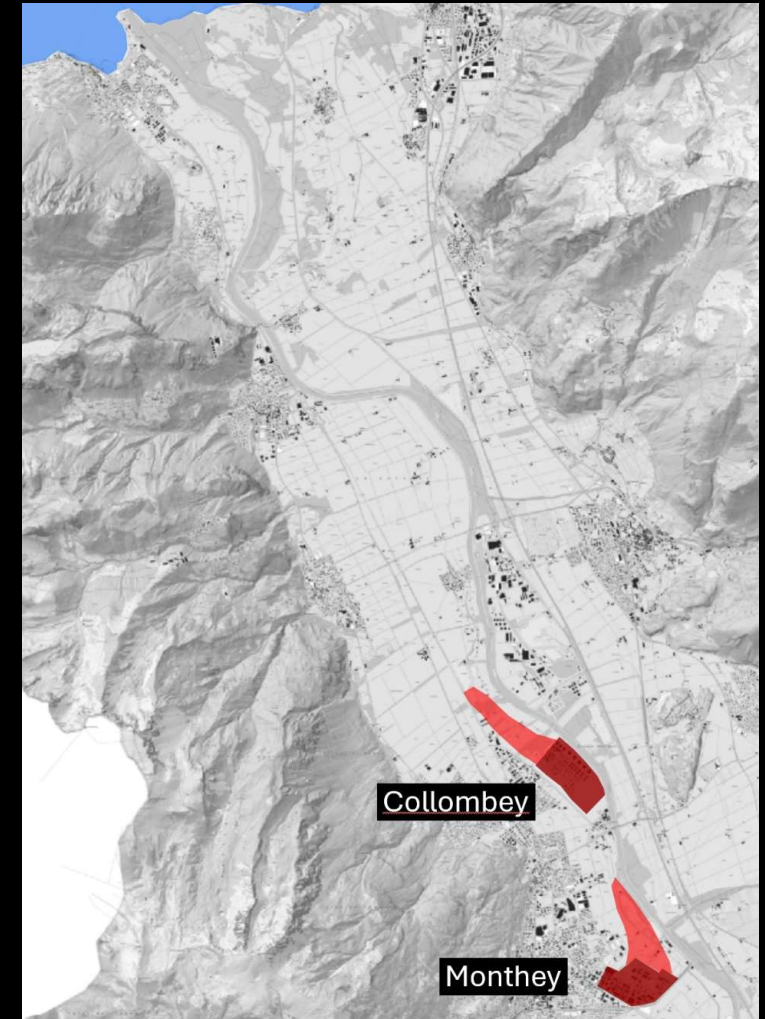
From firefighters training sites to the fishes

- Two PFAS plumes upstream from the lake of Geneva



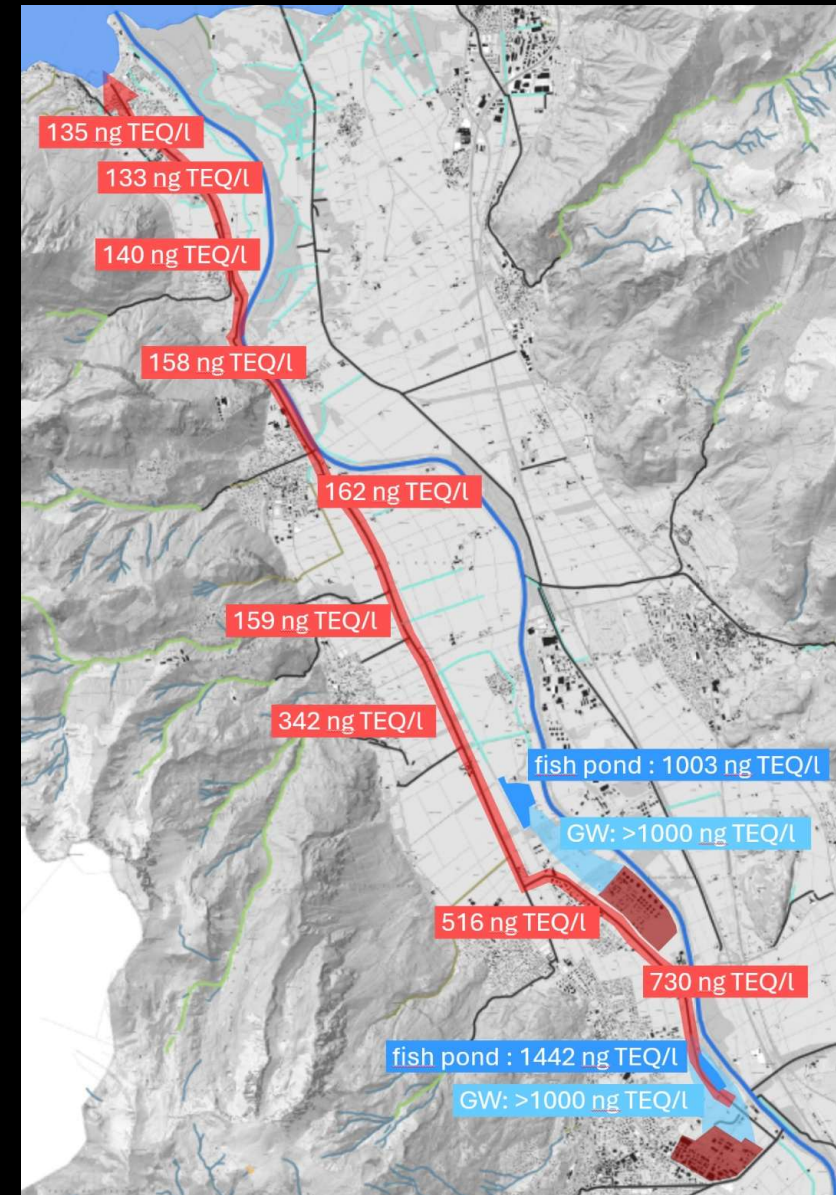
From firefighters training sites to the fishes

- Two industrial sites covering a total area of more than 120 hectares, are contaminated with PFAS
 - Regular use of PFAS-based foam concentrates
 - Plumes with high PFAS concentrations
 - 2.0 and 2.5 km long
 - Hydraulic containment

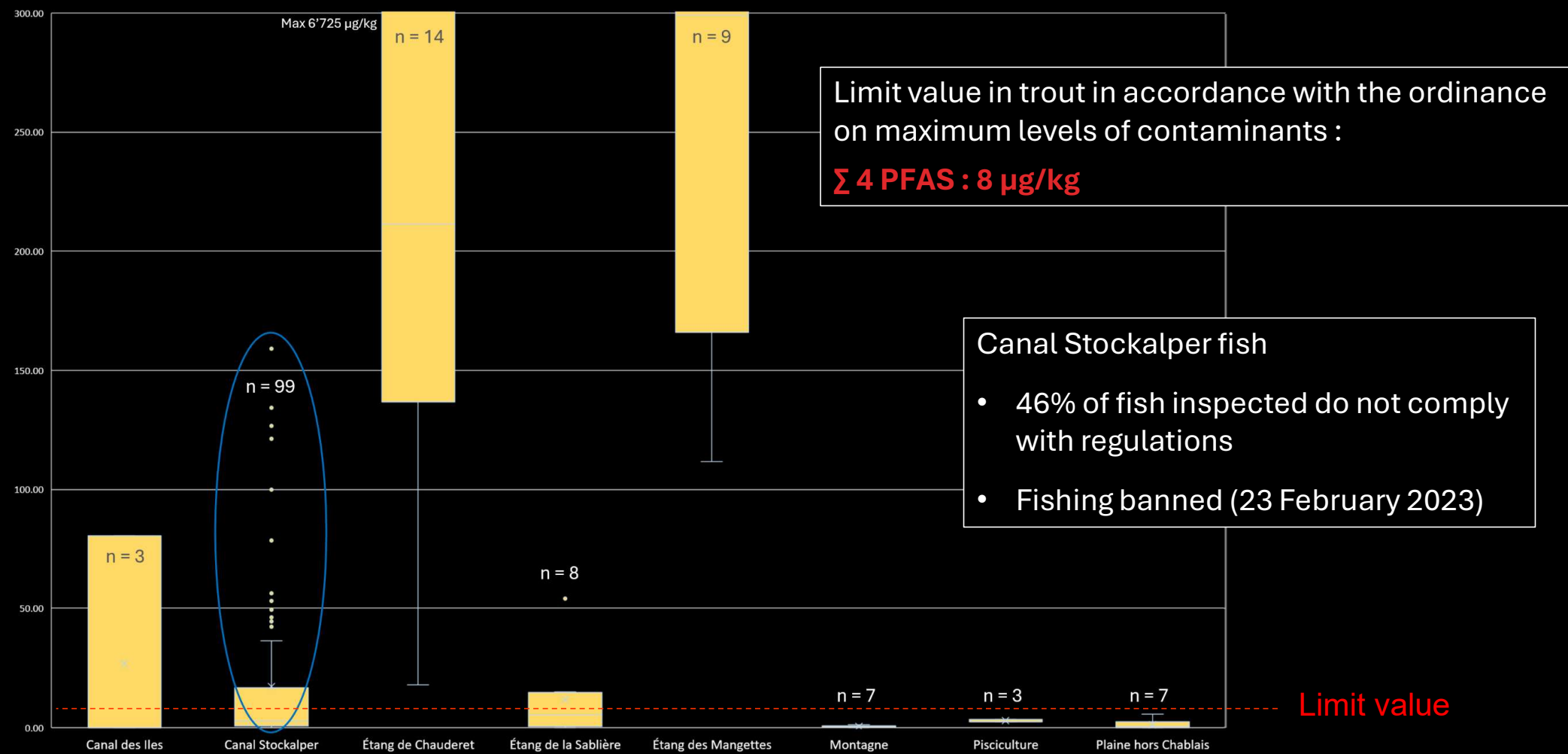


Regional impact : surface water

- ▲ Located 3.5 km apart, each has a significant impact on groundwater quality and, consequently, on the surface water
 - two large fish ponds
 - the Stockalper Canal
 - PFAS in the waters of the canal
 - over a distance of more than 16 km, all the way to Lake Geneva
 - low-water flow estimated at 850 l/s

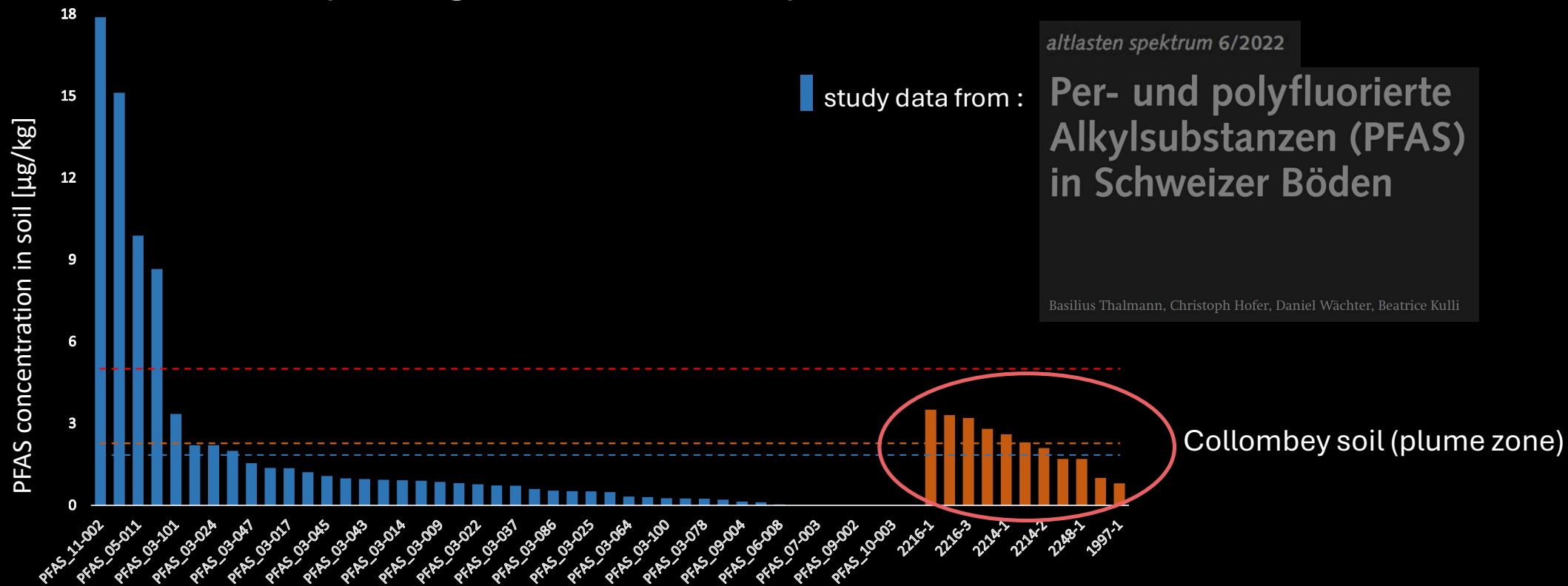


Regional impact : sum of PFAS in fish flesh (µg/kg)



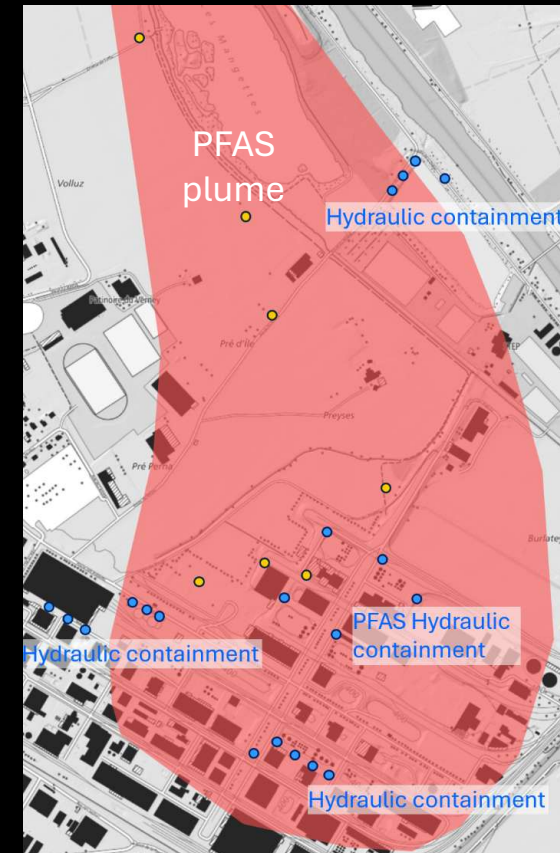
Regional impact : occasionally irrigated soils

- ▲ Farmers can no longer use groundwater or certain canals to irrigate their fields
- ▲ Need to control plants grown on the most polluted soils



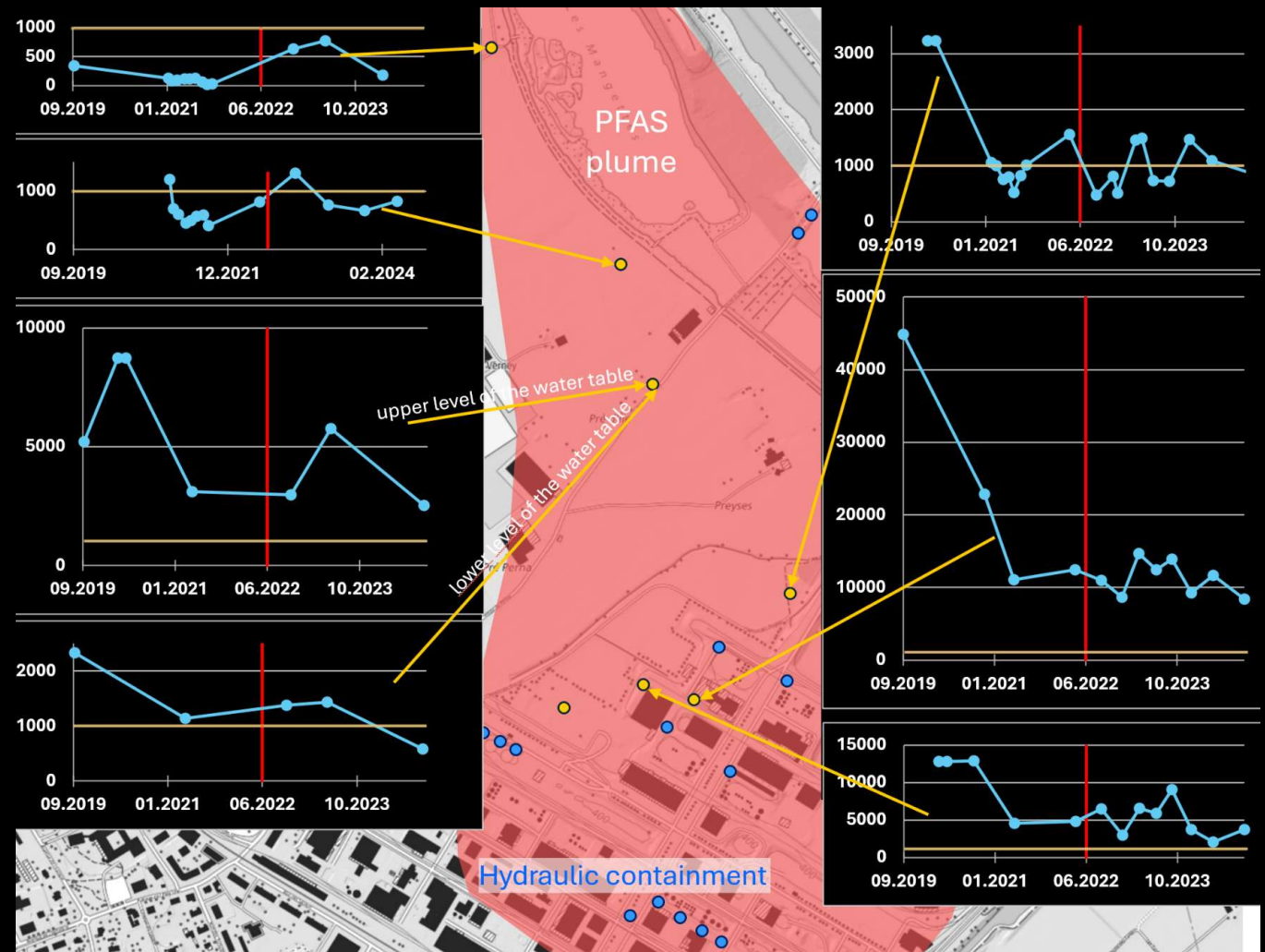
Hydraulic containment of sources: chemical site in Monthey

- ▲ 18 pumping wells were installed in 2009 as a temporary measure
 - aims to contain solvent and aniline pollution
 - most of which has now been cleaned up
- ▲ These hydraulic containment barriers had to be reinforced in 2022 to contain PFAS pollution
 - observed since 2019 several kilometres downstream from the site.



Hydraulic containment of sources: chemical site in Monthey

- ▲ The effect of the various containment barriers is well documented for solvents and anilines
 - degradable pollutants
- ▲ Less is known about PFAS
 - groundwater monitoring for these substances only started in 2019



Hydraulic containment of sources: chemical site in Monthey

▲ Context

- The thickness of the unsaturated zone in Monthey ranges between 5 and 12 meters
- There are multiple sources of PFAS pollution, not all of which are likely to be known yet

▲ Persistence of high PFAS concentrations downstream of certain containment barriers

- unidentified sources of pollution located downstream of the pumping stations
- heterogeneity of the aquifer, with fine grained areas that retain more PFAS and release them over the long term

Hydraulic containment of sources: former refinery of Collombey

▲ Hydraulic containment barrier

- in operation since January 2024, all the way downstream
- 9 pumping wells with each a capacity of 20 m³/h
- Study of the impact of the hydraulic barrier to the distribution of PFAS downgradient the refinery

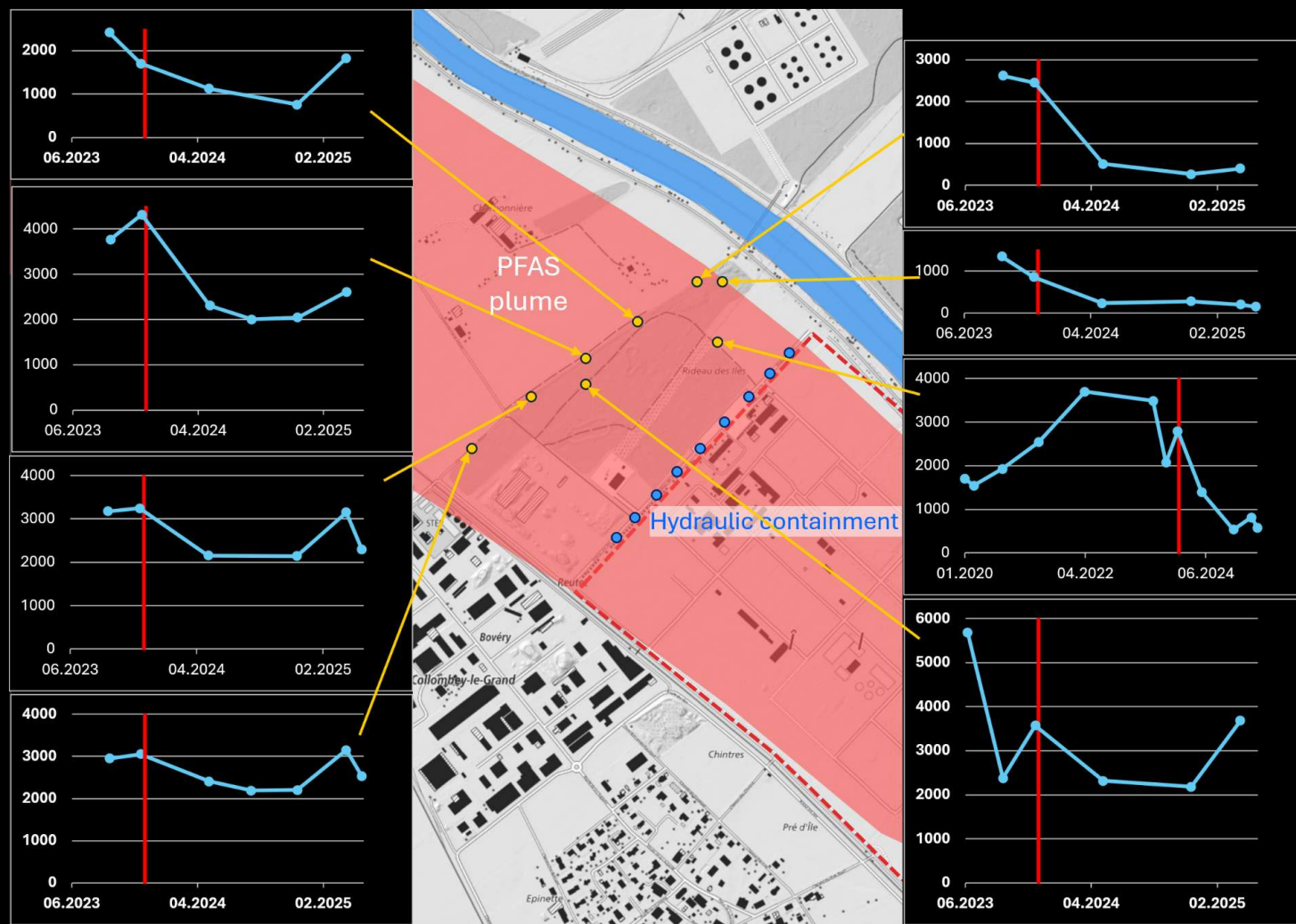


Hydraulic containment of sources: former refinery of Collombey

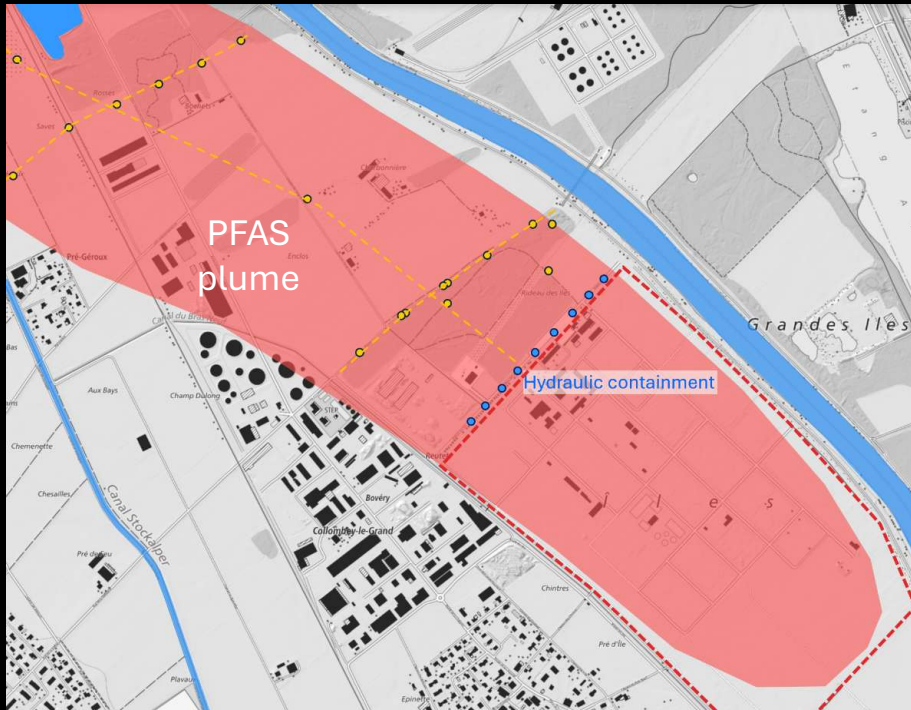
▲ Effect of the hydraulic barrier

- already noticeable 300 m downstream
- PFAS concentrations have fallen by around 30% in the first year

Σ 9 PFAS in groundwater
[TEQ ng/L]

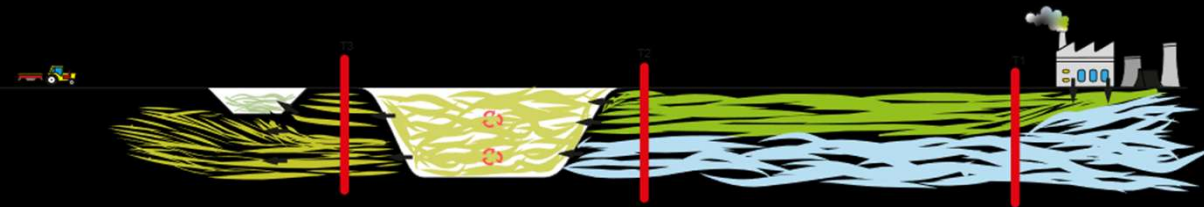


Behavior of PFAS in groundwater and surface water - former refinery



- How does the relative composition of PFAS compounds evolve along the contaminant plume?
- What is the influence of differences in mobility on the transport of PFAS?
- How does PFAS composition vary during groundwater discharge to surface waters and subsequent recharge to the aquifer ?
- Over what timescale do PFAS concentrations in groundwater and surface water decrease once the contamination source has been contained?

→ study in progress :



Different hydrogeological context

▲ Former refinery of Collombey

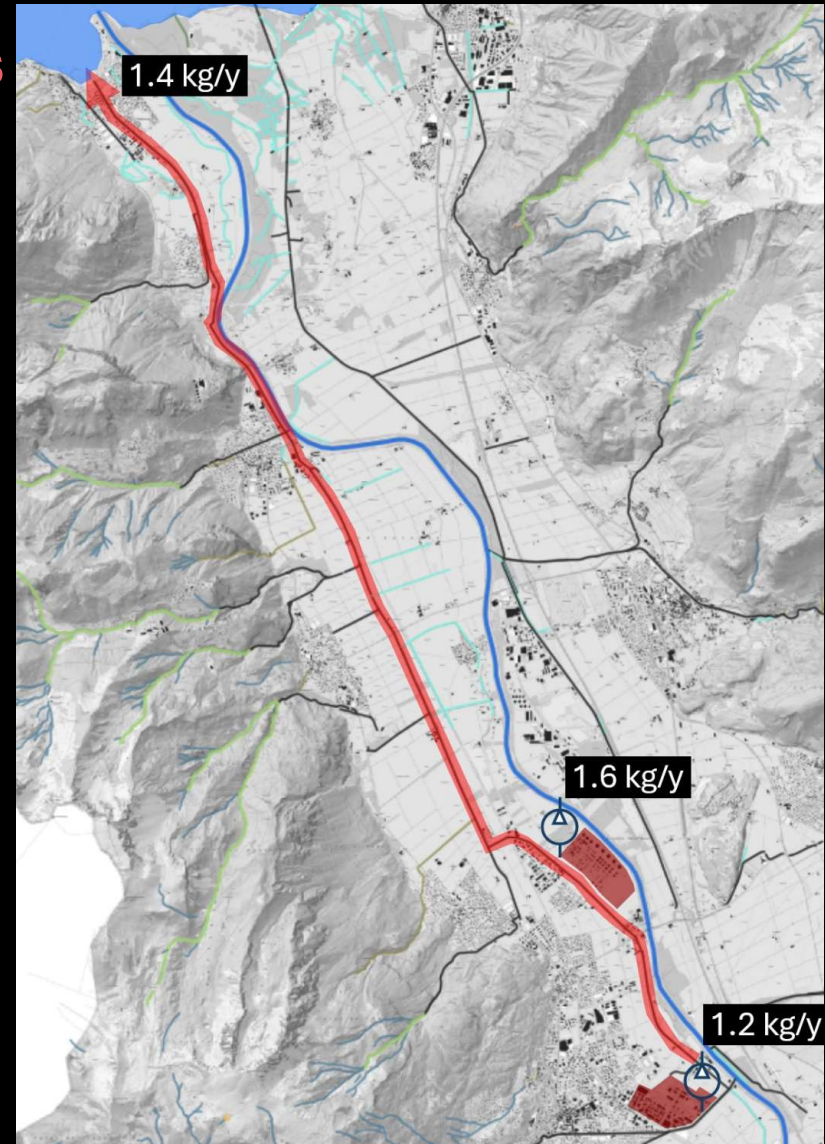
- 70 hectares characterized by its proximity to the water table (2 m)
- Influence of the Rhône in feeding the water table (fresh water!)

▲ Chemical plants of Visp and Monthey

- Visp : presence of a thick layer of fine alluvium
- Monthey : thick unsaturated zone
- Significantly delays the emissions of long chains such as PFOS

Hydraulic containment of sources: benefits

- ▲ The PFAS loads extracted by the hydraulic barriers operating at the Monthey chemical site and downstream of the former refinery total more than 2.8 kg per year
 - considering only the sum of the four main PFAS (PFOS, PFHxS, PFOA and PFNA)
- ▲ By way of comparison, before the installation of PFAS-specific barriers, the PFAS load transported by the Stockalper Canal was estimated at 1.4 kg per year.



Hydraulic containment of sources: benefits

- ▲ As a reminder, results of remediation measures in Visp:
 - 373 kg of PFOS and 64 kg of PFHxS disposed of per excavation
 - 11.4 kg of PFAS extracted by pumping between August 2020 and July 2022
 - 2 kg of PFAS extracted per year since July 2022
- ▲ It would therefore take more than 150 years for the Monthey and Collombey hydraulic barriers to extract the same mass of PFAS
 - The need to remediate the sites corresponding to the sources of pollution

Overview

▲ PFAS are ubiquitous in soil

- 0.3 à 1.2 µg/kg in agricultural soils
- 0.5 à 8.5 µg/kg in forests and towns
- 0.6 à 1.2 µg/kg in mountains

▲ PFAS polluting locally groundwater in the Rhône Plain

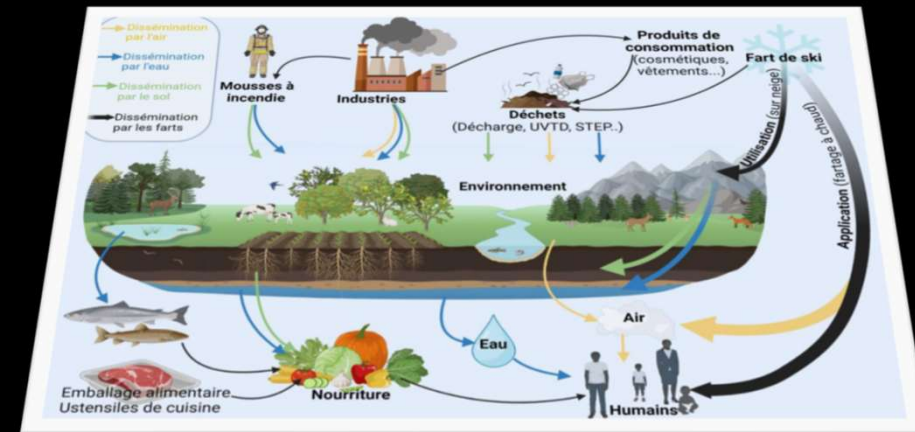
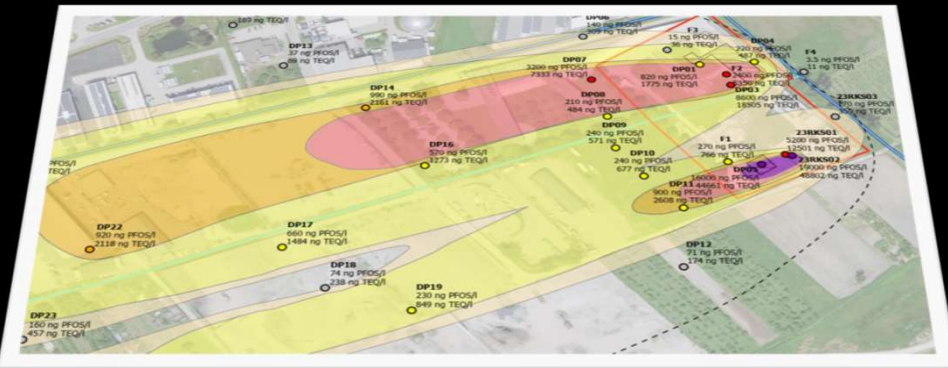
- Originate from sites contaminated by the repeated use of fire-fighting foams containing these substances

▲ Persistence and mobility of PFAS

- Urgent action

Conclusion

- ▲ The priority is to “turn off the tap” as quickly as possible by hydraulically confining PFAS-contaminated sites
- ▲ Cleaning up the sources of pollution is essential and remains the only way to ensure long-term protection of water resources against PFAS



Conclusion

- ▲ It is essential to have effective techniques for cleaning up sites contaminated by PFAS
 - Treatment of water pumped into pollution plumes
 - In situ treatment of pollution sources
 - On-site treatment of excavated materials
 - Off-site treatment of excavated materials
- ▲ The establishment of pragmatic values for Type B landfills, enabling the application of Art. 19 al. 3 OLED during remediation work