International Congress

Management of Environmental & Health Risks

20/10/2022 – Paris

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the PFAS contamination to aquifers of central Veneto Region: assessing the risk and acting for solutions

Paolo Ronco, PhD

Head of Centro RIVE, Center for Water Resources of Veneto
Head of Research, Innovation and Sustainability of VIACQUA spa

VIACQUA

RIVE RISORSE IDRICHE VENETE

Contents:

I. Background, characterization and impact of the PFAS contamination in Veneto

II. Regulatory approach and risk assessment

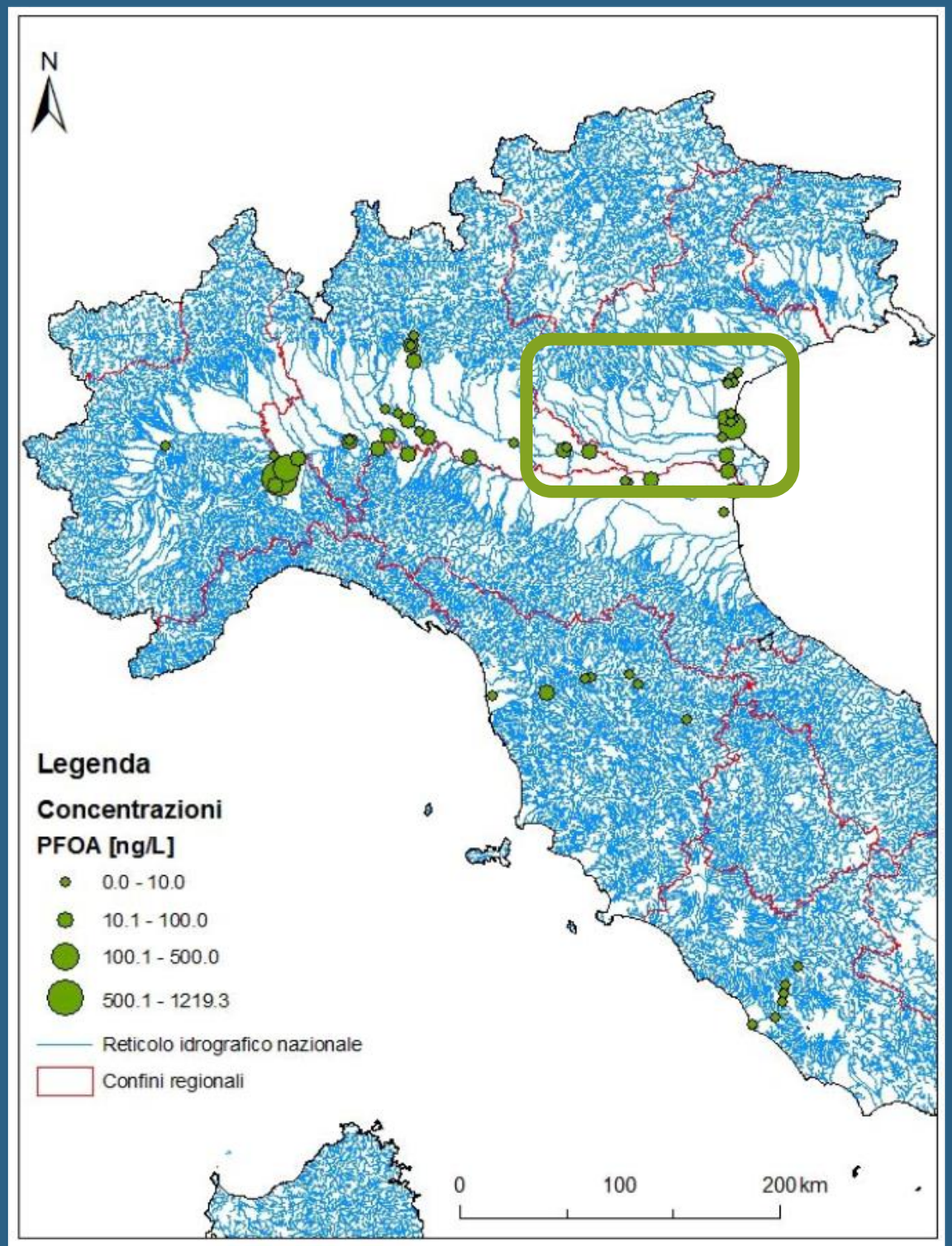
III. Risk mitigation plan

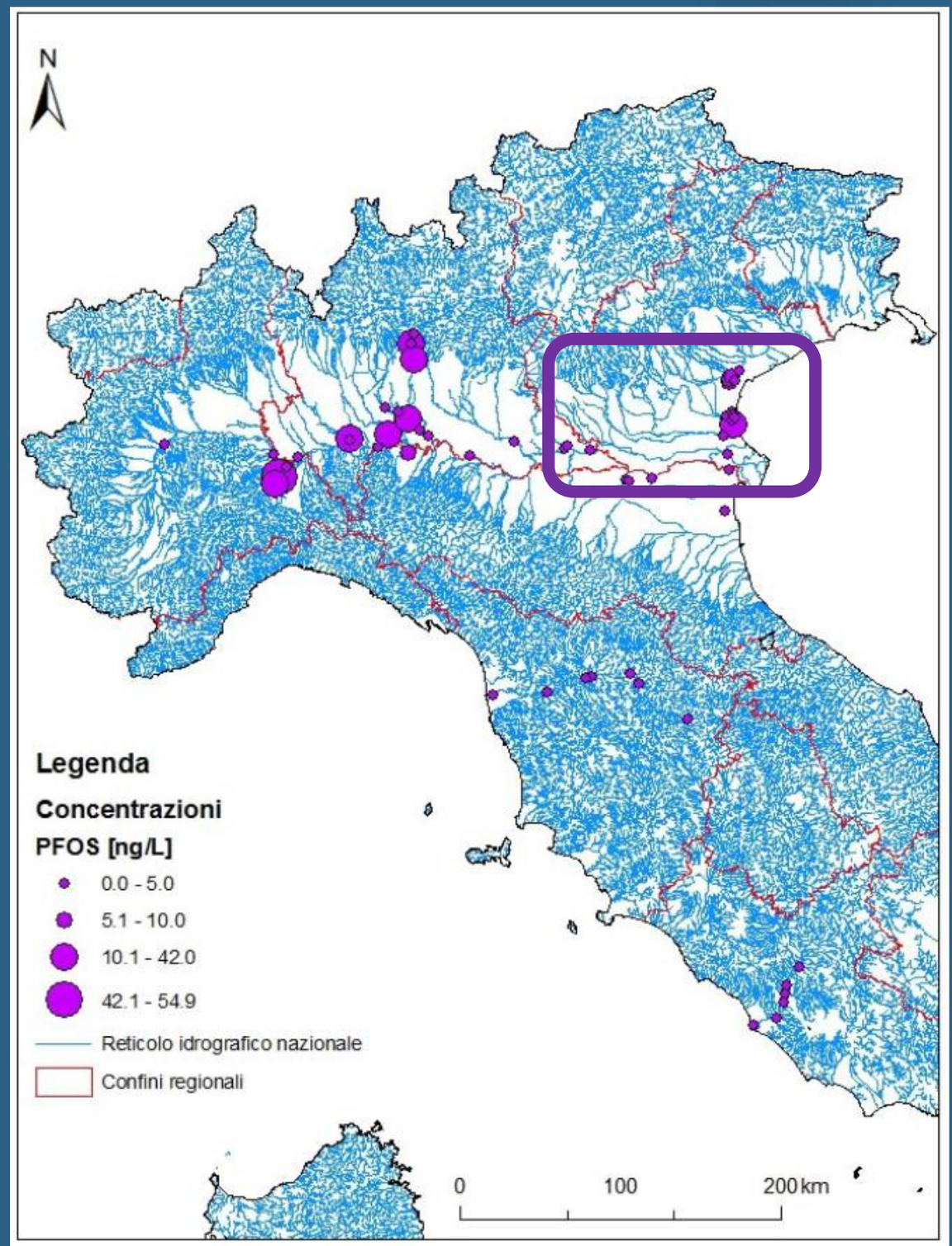
IV. EU LIFE Capture project

V. Conclusions

2011-2013: the EU PERFORCE project by the Ministry of the Environment and CNR-IRSA

To assess the occurrence and emissions of PFAS in the main Italian river basins





PFAS contamination to aquifers of central Veneto Region: assessing the risk and acting for solutions

ENVIRONMENTAL MONITORING

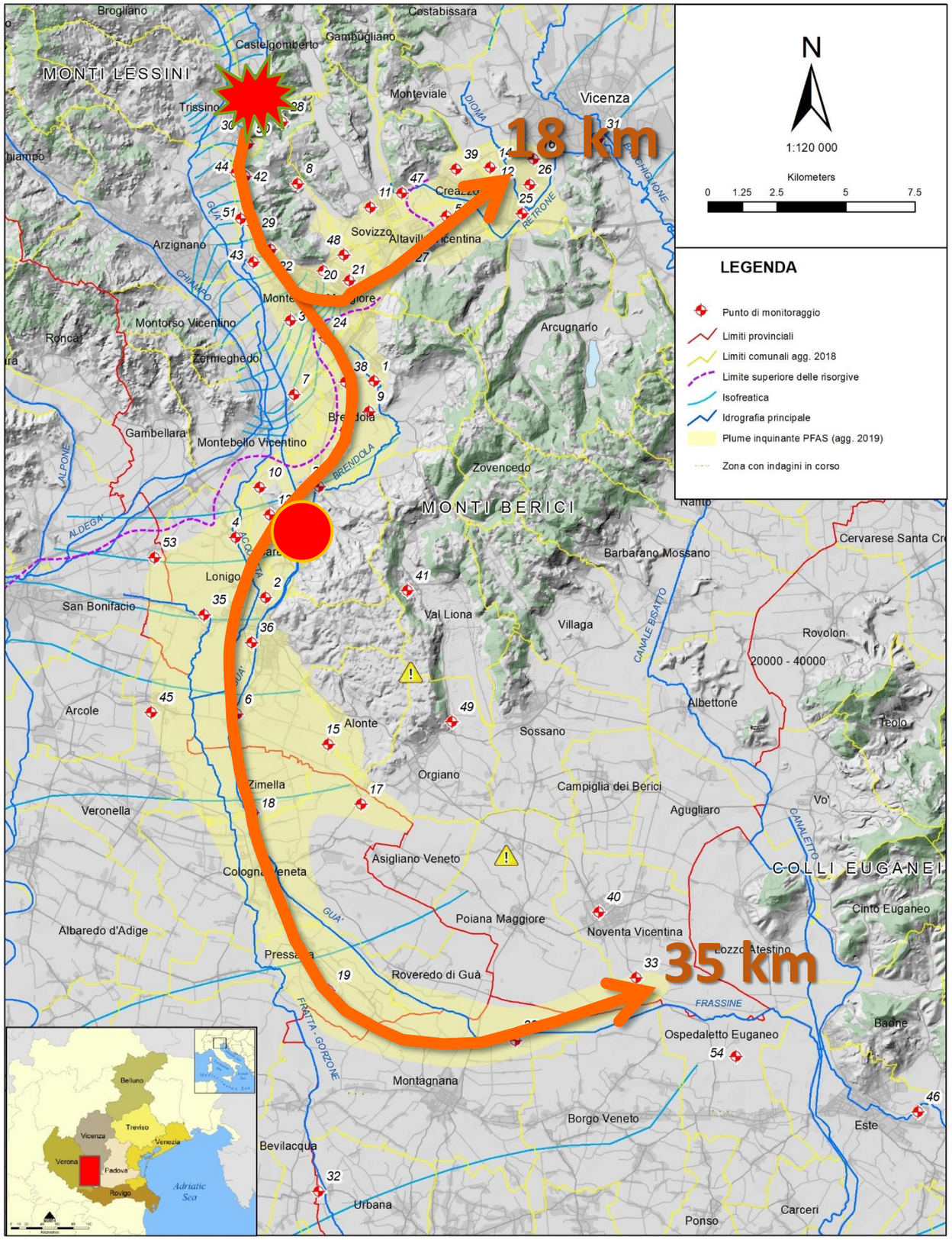
identification of the source of contamination

- the largest Italian PFAS manufacturing plant (tannery district)
- Producing since the ‘60ies
- From long-chain to “new generation” PFAS (GenX)

Public water supply

ENVIRONMENTAL MONITORING

the plume of the PFAS contamination



Since 2013 ARPAV has been conducting an **extensive environmental investigation** that led to the identification of the **source** and the **plume** of contamination.

Later, a monitoring network was established to map the **space-time evolution of pollution:**

- Groundwater monitoring network points: **52**
- Covered area: **>380 kmq**
- The maximum concentration detected in the groundwater (outside the site) is **72.500 ng/l as SUM of PFAS (2020)**
- **Open data** available at:
  https://www.arpa.veneto.it/dati-ambientali/open-data/idrosfera/concentrazione-di-sostanze-perfluoroalchiliche-pfas-nelle-acque-prelevate-da-arpav

PFAS contamination to aquifers of central Veneto Region: assessing the risk and acting for solutions

THE IMPACT

of the PFAS contamination event

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595 km²

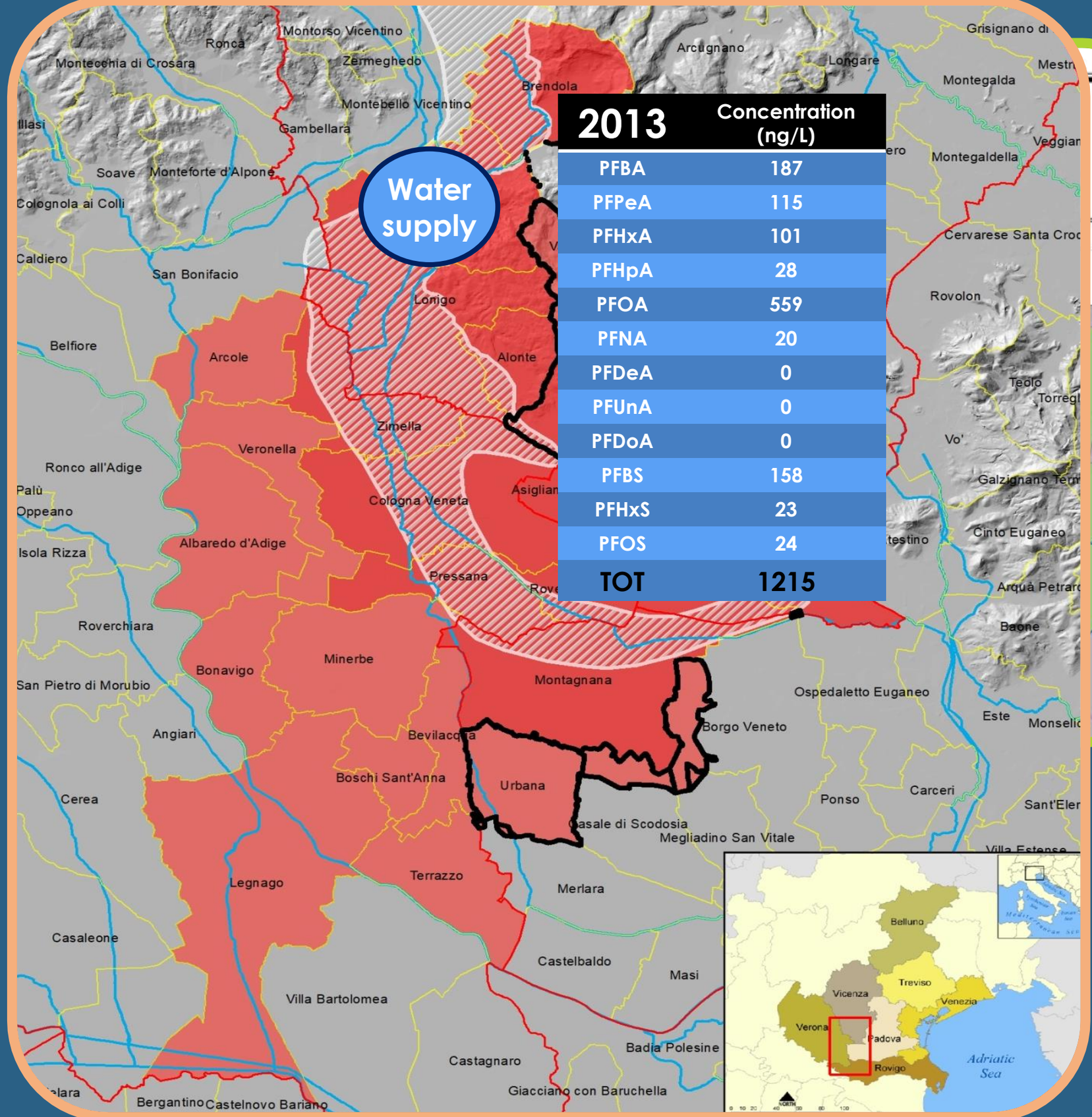
30 municipalities

140,000 inhabitants

Public water supply + private wells

Only public water supply

contamination plume



2013	Concentration (ng/L)
PFBA	187
PFPeA	115
PFHxA	101
PFHpA	28
PFOA	559
PFNA	20
PFDeA	0
PFUnA	0
PFDoA	0
PFBS	158
PFHxS	23
PFOS	24
TOT	1215

PFAS contamination to aquifers of central Veneto Region: assessing the risk and acting for solutions

THE REGULATORY RESPONSE

- Emergency and risk management
- Legislative and regulation measures
- Infrastructural mitigation measures

May 2013
- Discovery of the PFAS contamination
- First ISS Opinion on emergency management

June 2015
Start of the first epidemiological survey

2016:
Environmental survey and modelling

Sept 2016
Water Safety Plan

Oct 2017:
Classification of risk area

Oct 2022:
LIFE Capture project

New water supply sources and distribution network (90M€)

2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023

German PFAS limits

GAC filters installation and further expansion

Italian EQS for PFAS in ground-surface water

ISS Opinion: new limits on a statistical basis

Further expansion of the drinking water plant with 10+10 GAC in series

Regione Veneto Limits
"technical-zero" in red area
Other limits out of red area

Entry into force of the EU Directive 2184.2020 limits
Sum of PFAS < 100 ng/l

THE REGULATORY RESPONSE:
central and regional levels

National Health Institute – ISS

07/06/2013 (Ref. N° 0022264) ISS opinion:

- urgent adoption of alternative supplies to reduce PFAS exposure of the affected population;
- adoption of removal treatments from raw waters;
- implementation of a WSP;
- identification and removal of polluting sources

16/01/2014 (Ref. N° 0001584) ISS opinion

- short-medium and long-term actions pursuing the virtual absence of PFAS at the tap;
- provisional limits were recommended to be applied to drinking water supply:

  PFOS < 30 ng/l

  PFOA < 500 ng/l

  sum of other PFAS < 500 ng/l
- monitoring study of the PFAS contamination in the environment and in the food chain;
- a biomonitoring study of internal exposure markers

Legislative dec. 13/10/2015 n.172 and Ministerial Dec. 06/07/201611/09/2017 (Ref. N° 0026)

- Introduction into national legislation of environmental quality standards (EQS) for PFAS;
- adoption of PFOA and PFOS performance limit values of one order of magnitude lower than the previous ones

VENETO REGION

DGR 1590/2017
Performance limits for drinking water supplies :

PFOS	**≤ 30 ng/L**
PFOA + PFOS	**≤ 90 ng/L**
Sum of PFAS	**≤ 300 ng/L**

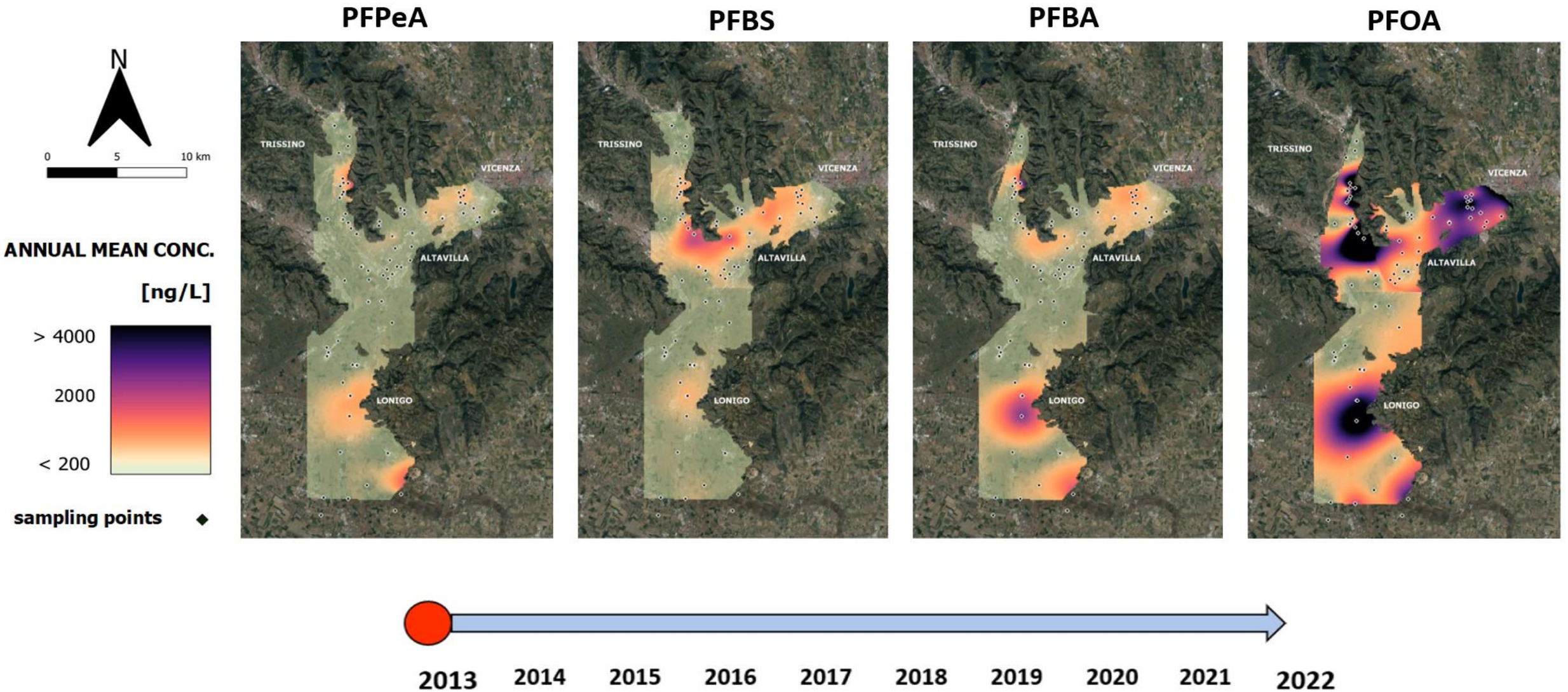
ENVIRONMENTAL MONITORING and DATA PROCESSING

VIACQUA RIVE RISORSE IDRICHE VENETE

RIVE RISORSE IDRICHE VENETE

KRIGING SPATIAL-TEMPORAL INTERPOLATION OF WATER QUALITY DATA (OPEN ACCESS)

- ARPAV open access data 2013-2022 (70/100 sampling points per year)
- Characterization of (PFAS specific) mobility patterns



PFAS contamination to aquifers of central Veneto Region: assessing the risk and acting for solutions

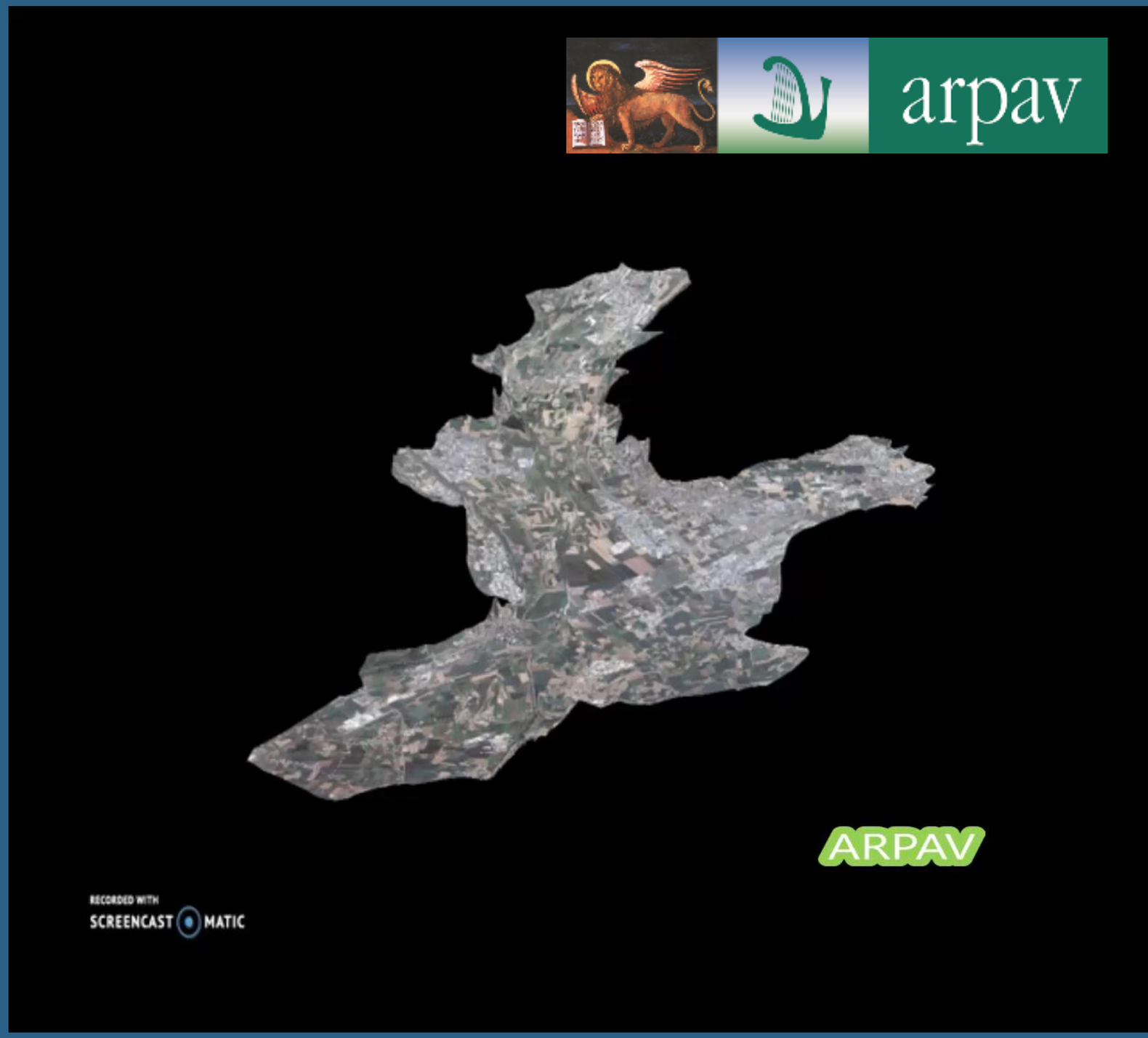
ENVIRONMENTAL MONITORING and MODELLING

Flow and Transport Numerical 3D Model

A 3D finite elements model (FEM) of the aquifer sedimentary basin was developed and tested. Advection, diffusion, hydrodynamic dispersion, adsorption have been simulated

Integrated forecast tools to support decision-making

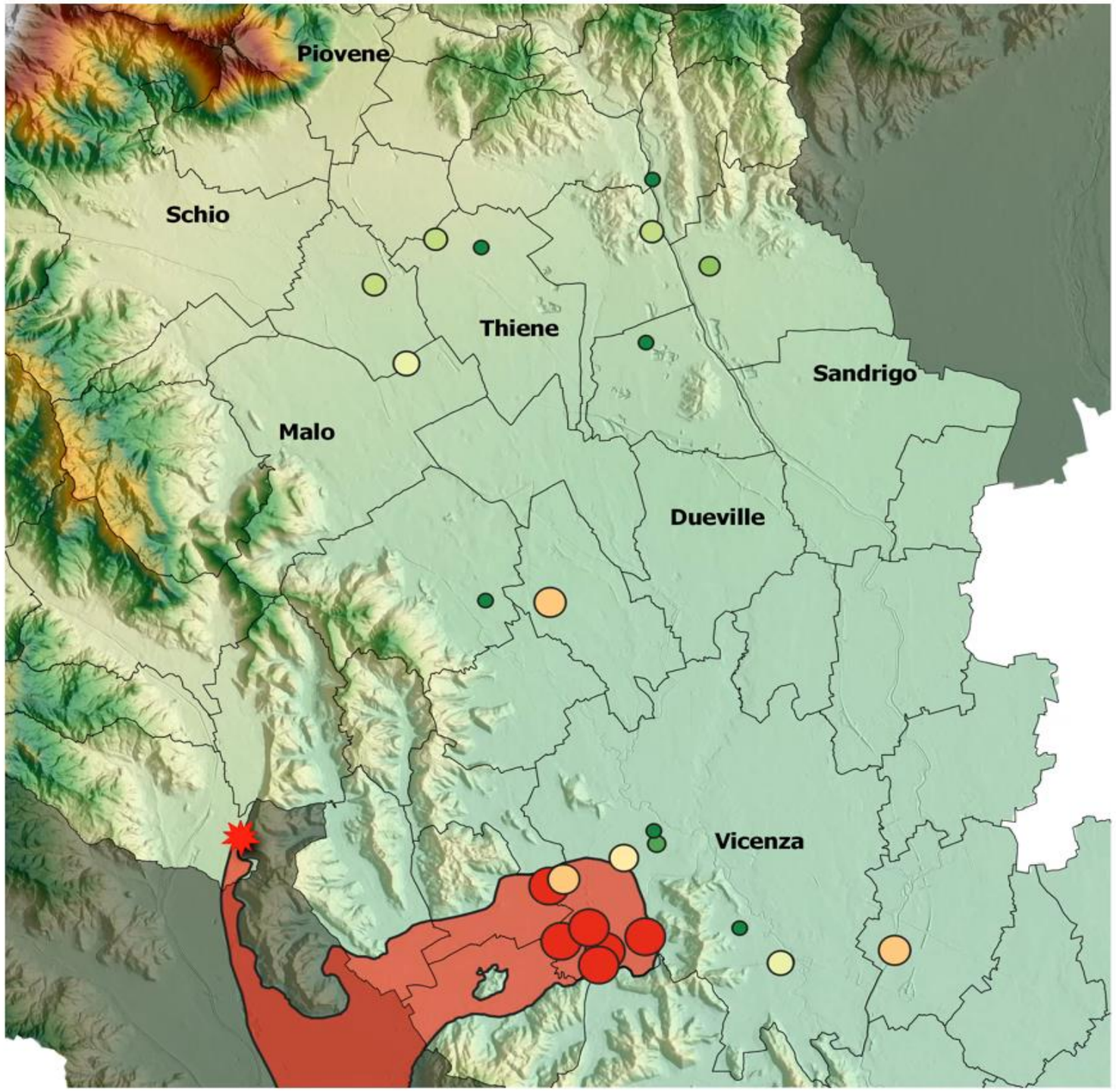
- When did the pollution start?
- How much contaminant has been spreading in the groundwater?
- Why do exist different contamination plumes (one for each PFAS species) and what kind of consequences?
- How long the pollution could be present?
- How long had the pollutants taken to reach the Almisano water supply fields?



https://www.lifephoenix.eu

PFAS contamination to aquifers of central Veneto Region: assessing the risk and acting for solutions

ENVIRONMENTAL MONITORING and DATA PROCESSING: OUT OF THE PLUME



N

0 5 10 km

Contamination site

Plume PFAS

Sum of PFAS [ng/L]

- < 5
- 5 - 10
- 10 - 20
- 20 - 30
- 30 - 50
- 50 - 100
- 100 - 200
- 200 - 300
- 300 - 500
- > 500

2013 2014 2015 2016 2017 2018 2019 2020 2021 2022

RIVE RISORSE IDRICHE VENETE

PFAS contamination to aquifers of central Veneto Region: assessing the risk and acting for solutions

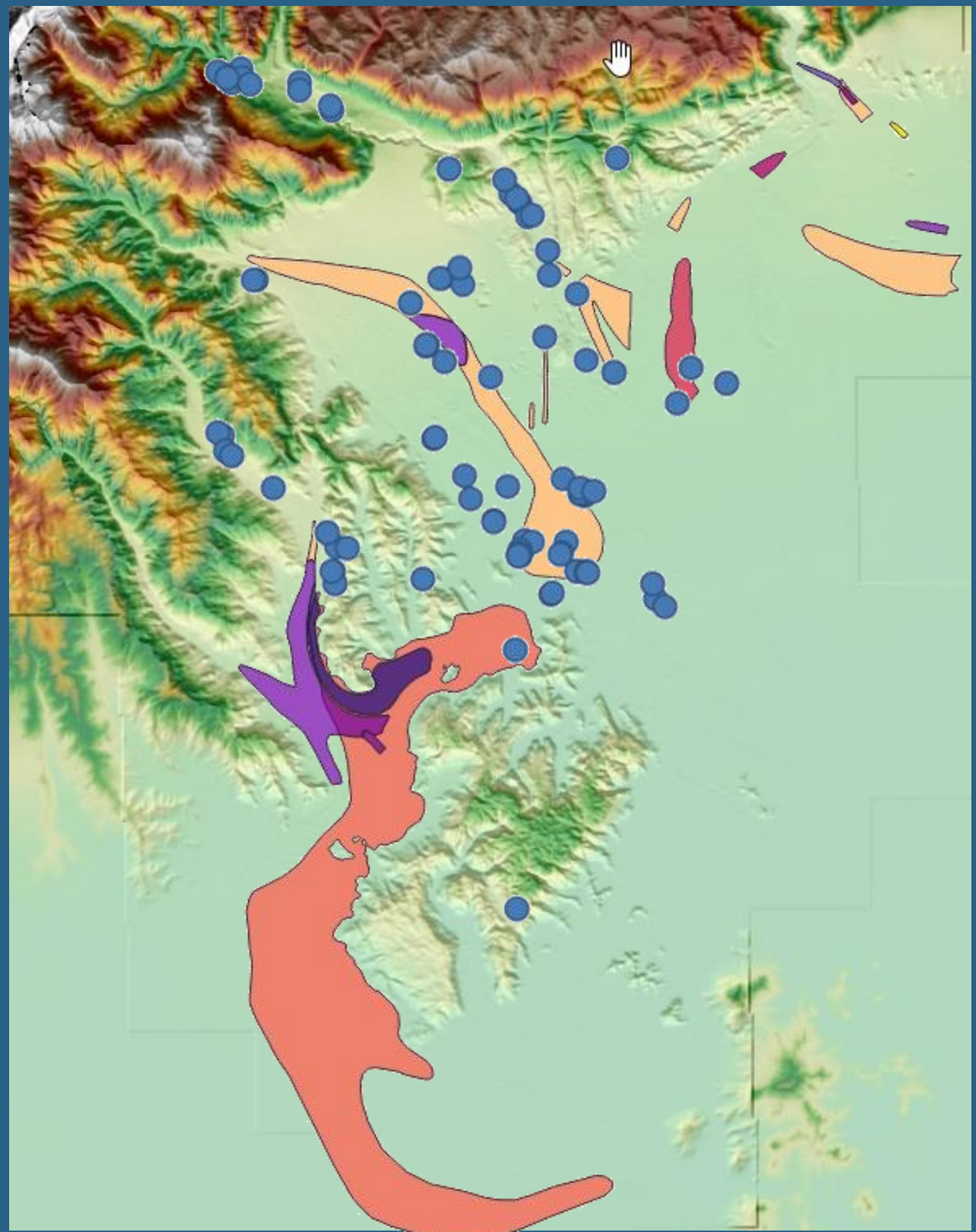
ENVIRONMENTAL MONITORING

contamination events in the aquifers of central Veneto (1980-2022)

Historical contaminations

- Benzotrifluoride (BFT)
- Chlorides, Sulfates, Chrome, Manganese
- Chrome
- Manganese
- Manganese, Zinc
- Perchloroethylene (PCE)
- PFAS
- Chlorinated solvents
- Chlorinated solvents, Chrome, Manganese

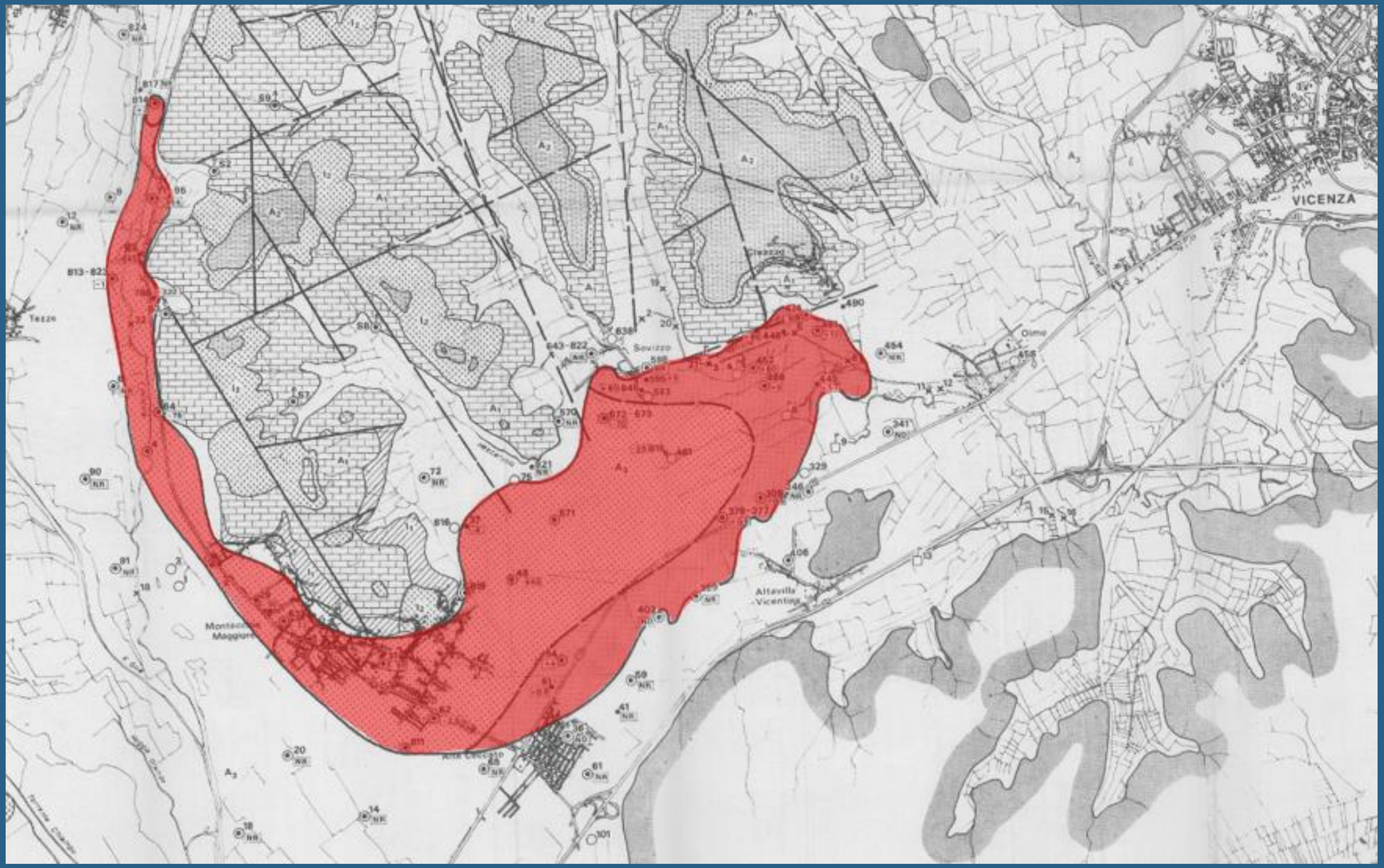
More than 20 large events of contamination in the past 40 years that directly affected the drinking water supply systems



PFAS contamination to aquifers of central Veneto Region: assessing the risk and acting for solutions

ENVIRONMENTAL MONITORING

correlating past contamination events to PFAS one



PFAS contamination to aquifers of central Veneto Region: assessing the risk and acting for solutions

ENVIRONMENTAL MONITORING

correlating past contamination events to PFAS one

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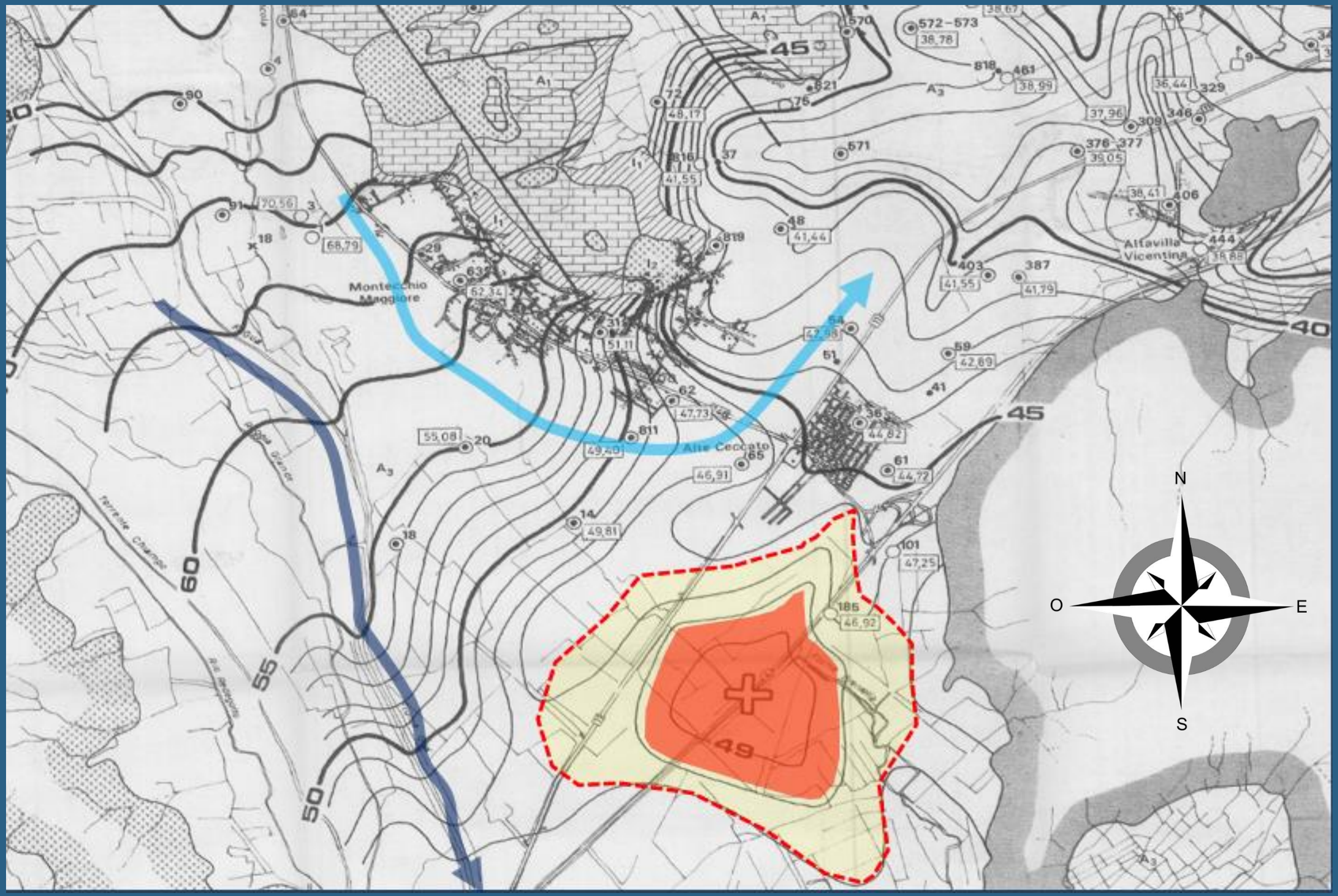
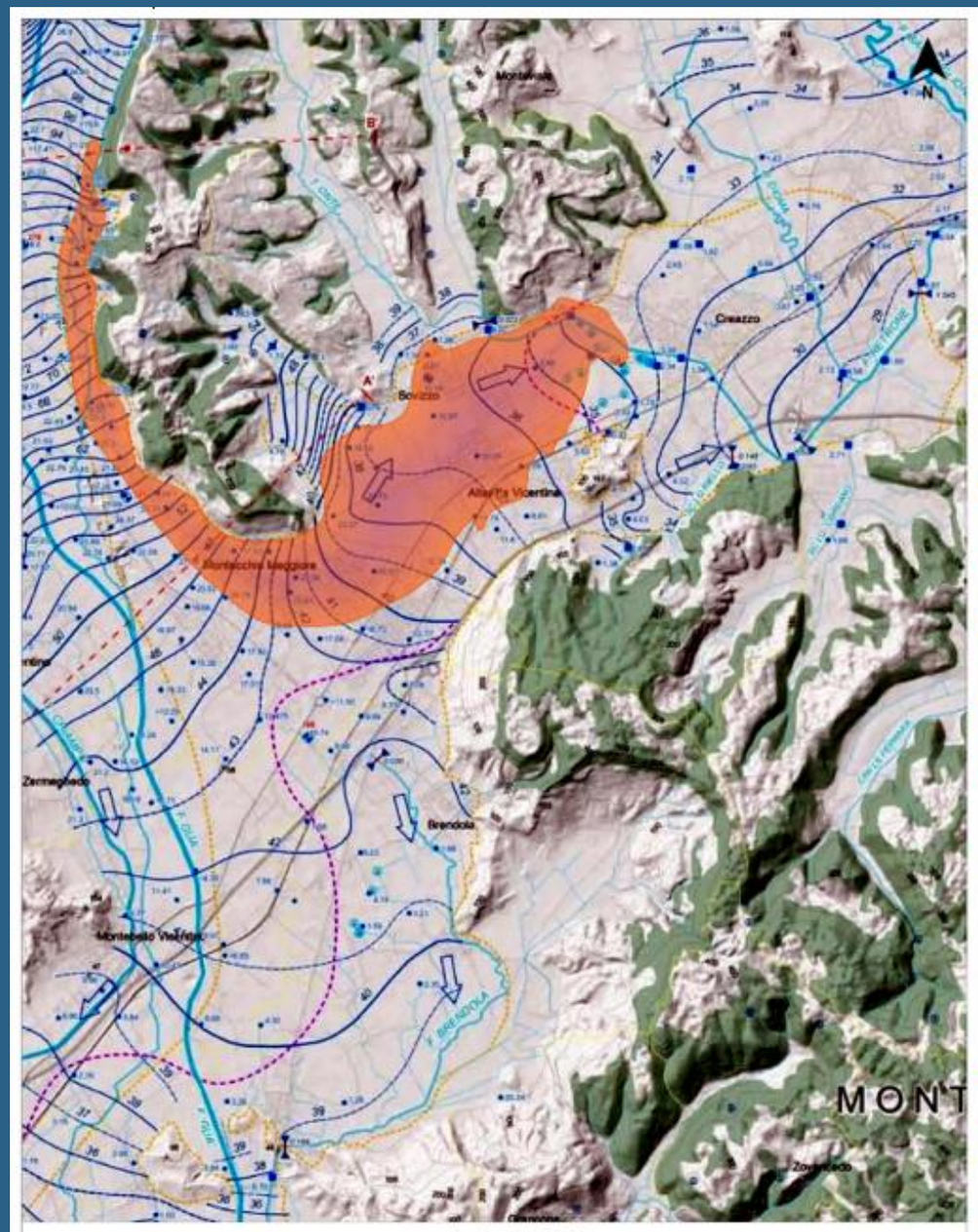
Sinergeo
SINERGIE GEOLOGICHE PER L'AMBIENTE



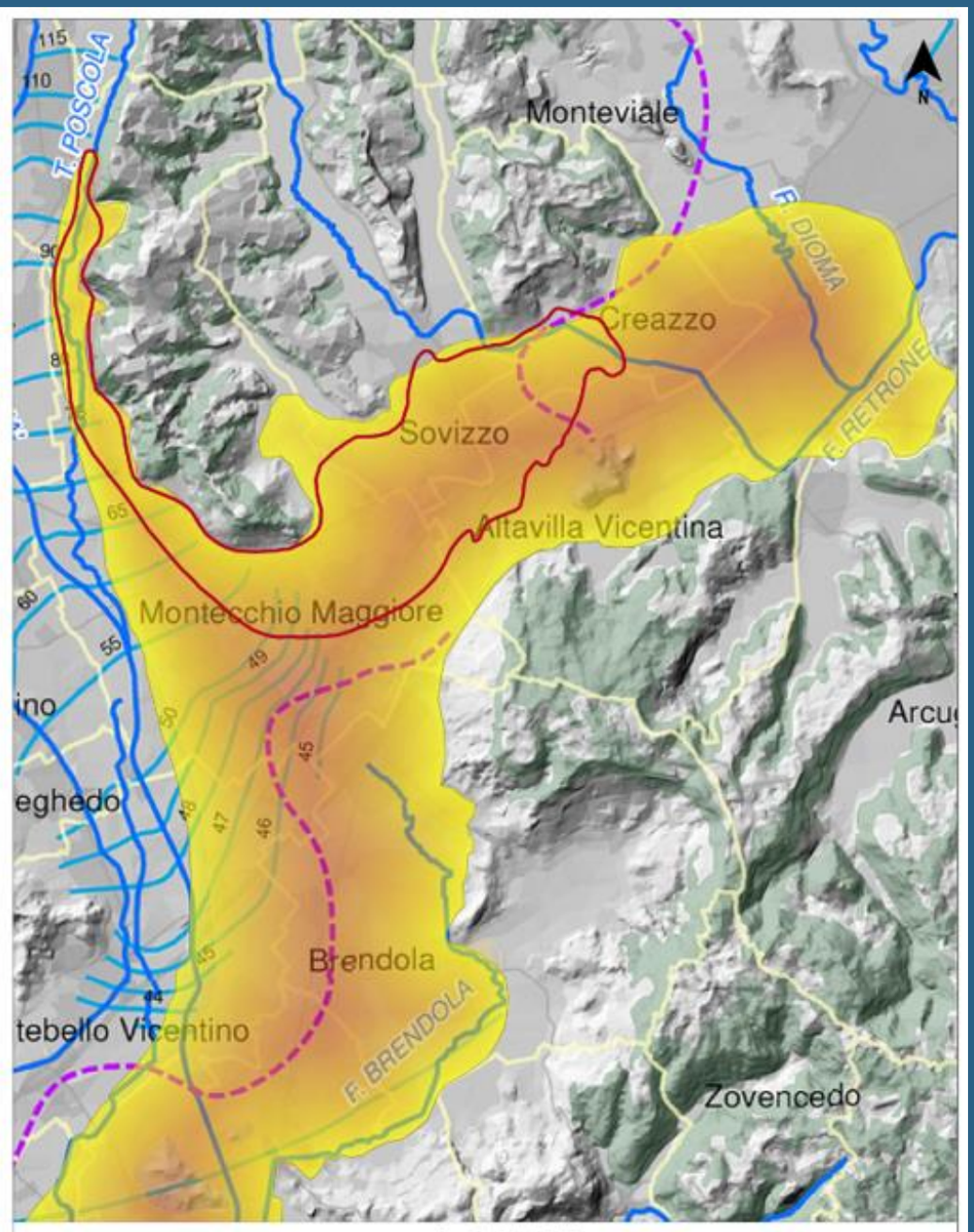
PFAS contamination to aquifers of central Veneto Region: assessing the risk and acting for solutions

ENVIRONMENTAL MONITORING

correlating past contamination events to PFAS one



BTFs plume (IRSEV, 1979)



PFAs vs. BTFs plume (2018)

1. Increasing of pumping (both private and public)
2. Depressurization of confined aquifers (- 10m in the last 50 years)

PFAS contamination to aquifers of central Veneto Region: assessing the risk and acting for solutions

THE IMPACT ON PUBLIC HEALTH
the Biomonitoring Survey (2015-2016)

Environment International 110 (2018) 149–159

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

Biomonitoring of perfluorinated compounds in adults exposed to contaminated drinking water in the Veneto Region, Italy

Anna Maria Ingelido[a,*], Annalisa Abballe[a], Simonetta Gemma[a], Elena Dellatte[a], Nicola Iacovella[a], Giovanna De Angelis[a], Franco Zampaglioni[a], Valentina Marra[a], Roberto Miniero[a], Silvia Valentini[a], Francesca Russo[b], Marina Vazzoler[b], Emanuela Testai[a], Elena De Felip[a]

[a] Istituto Superiore di Sanità, Dipartimento Ambiente e Salute, Roma, Italy
[b] Direzione Prevenzione, Sicurezza Alimentare, Veterinaria della Regione del Veneto, Venezia, Italy

Two random samples of population (20-50 yrs):

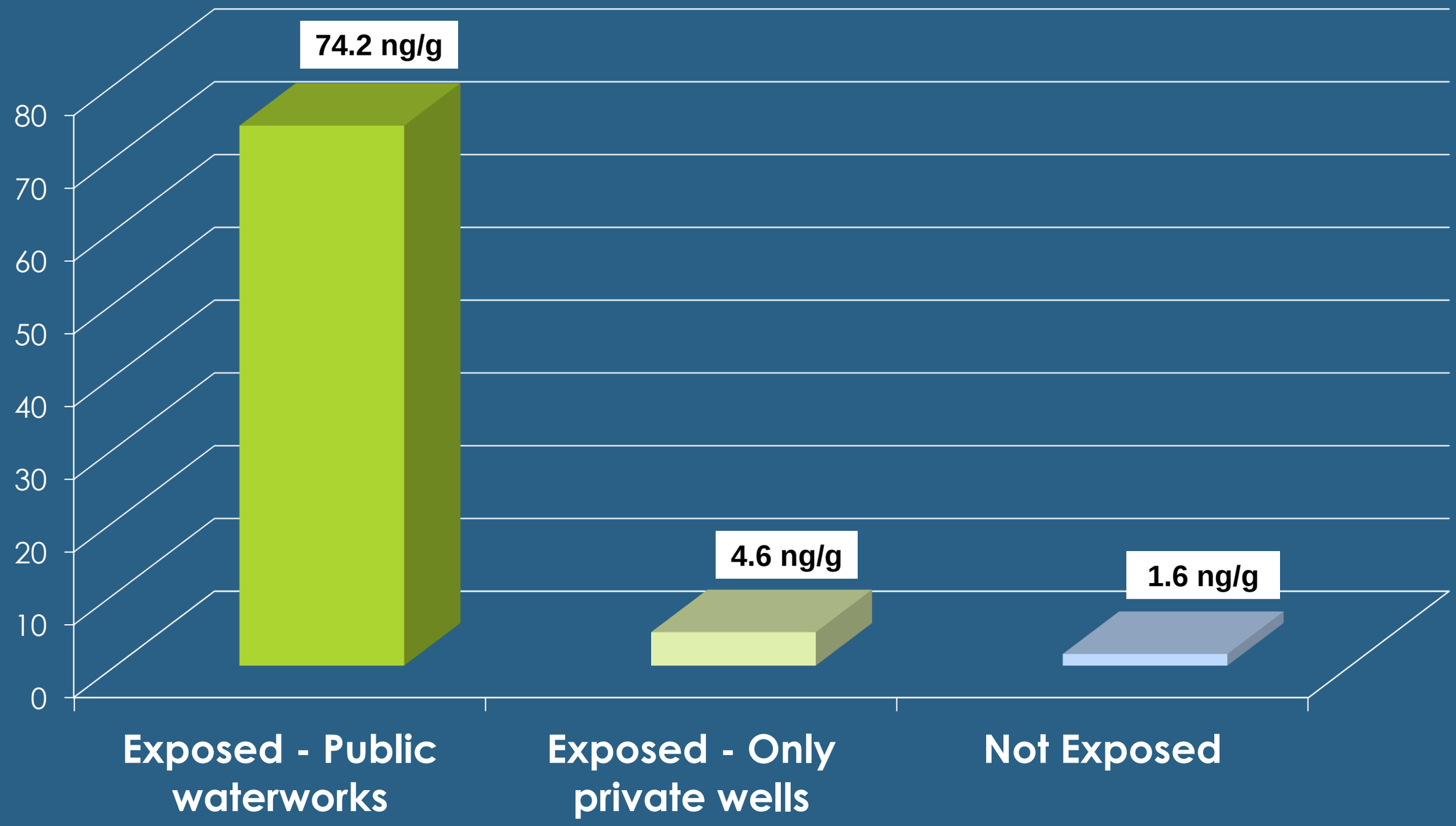
- **Exposed residents** (n=257): municipalities affected by the contamination of drinking water (public waterworks + private wells)
- **Not Exposed residents** (n=250): municipalities not affected by the contamination of drinking water

THE IMPACT ON PUBLIC HEALTH
the Biomonitoring Survey (2015-2016)

VIACQUA RIVE RISORSE IDRICHE VENETE

REGIONE DEL VENETO

Median serum PFOA concentrations



PFAS contamination to aquifers of central Veneto Region: assessing the risk and acting for solutions

RISK ASSESSMENT
the Health Surveillance Program

- Population-based, free of charge screening program provided by the Regional Healthcare Service
- Target population: residents in the Red Area, cohorts of people born between 1951-2014 (n=105,000)
- Started in January 2017 and currently ongoing (94,000 people invited)
- The program includes:
  - Structured interview on medical history and lifestyle habits
  - Measurement of blood pressure
  - Non-fasting blood and urine samples (lipid profile, renal and liver function, glicated haemoglobin, thyroid function, urine albumine excretion)
  - Serum measurement of 12 PFAS
- **AIMS:**
  - Characterization of PFAS exposure and evaluation of the health effects
  - Identification of unhealthy behaviors and promotion of lifestyle modification
  - Early detection and treatment of health problems in exposed individuals

RISK ASSESSMENT

the Health Surveillance Program

VIACQUA RIVE RISORSE IDRICHE VENETE

REGIONE DEL VENETO

Outcomes of the Analyses on ~18,000 individuals born 1978-2002

Key results:

- Main predictors of PFAS serum levels were gender, municipality, duration of residence in the Red Area, and number of previous deliveries
- Log-linear relationship of serum PFAS with cholesterol and blood pressure levels

PFAS (ng/L)	GM	Median	min-max
PFOA	38.4	44.4	LOQ-1400
PFOS	3.9	3.9	LOQ-142
PFHxS	3.7	3.9	LOQ-127

Pitter *et al. Environmental Health* (2020) 19:102
https://doi.org/10.1186/s12940-020-00656-0

Environmental Health

RESEARCH Open Access

Check for updates

Perfluoroalkyl substances are associated with elevated blood pressure and hypertension in highly exposed young adults

Gisella Pitter[1], Maryam Zare Jeddi[2], Giulia Barbieri[2], Massimo Gion[3], Aline S. C. Fabricio[3], Francesca Daprà[4], Francesca Russo[5], Tony Fletcher[6] and Cristina Canova[2*]

Research

A Section 508–conformant HTML version of this article is available at https://doi.org/10.1289/EHP5337.

Serum Levels of Perfluoroalkyl Substances (PFAS) in Adolescents and Young Adults Exposed to Contaminated Drinking Water in the Veneto Region, Italy: A Cross-Sectional Study Based on a Health Surveillance Program

Gisella Pitter,[1] Filippo Da Re,[2] Cristina Canova,[3] Giulia Barbieri,[3] Maryam Zare Jeddi,[3] Francesca Daprà,[4] Flavio Manea,[4] Rinaldo Zolin,[5] Anna Maria Bettega,[5] Giampaolo Stopazzolo,[5] Silvia Vittorii,[5] Lorena Zambelli,[6] Marco Martuzzi,[7] Domenico Mantoan,[8] and Francesca Russo[2]

Environmental Health Perspectives 027007-1 128(2) February 2020

Environment International 145 (2020) 106117

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

ELSEVIER

Associations between perfluoroalkyl substances and lipid profile in a highly exposed young adult population in the Veneto Region

Cristina Canova[a,*], Giulia Barbieri[a], Maryam Zare Jeddi[a], Massimo Gion[b], Aline Fabricio[b], Francesca Daprà[c], Francesca Russo[d], Tony Fletcher[e], Gisella Pitter[f]

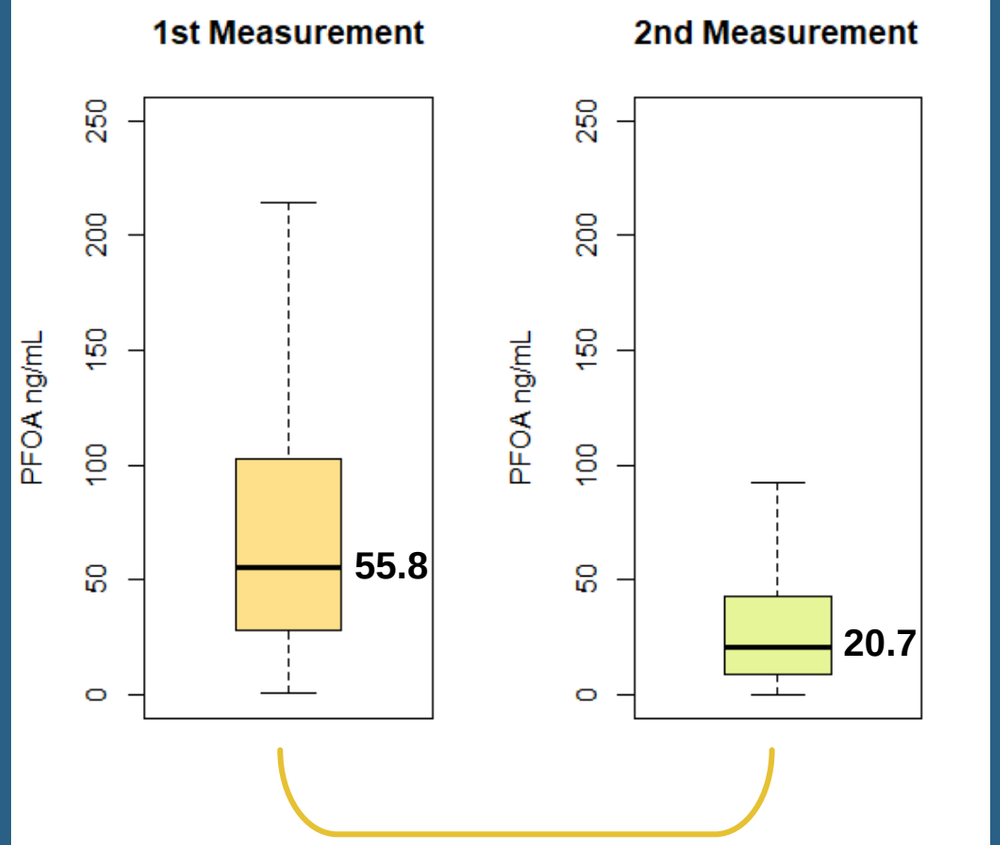
Assessing the risk and acting for solutions

4 years later

RISK ASSESSMENT
the Health Surveillance Program

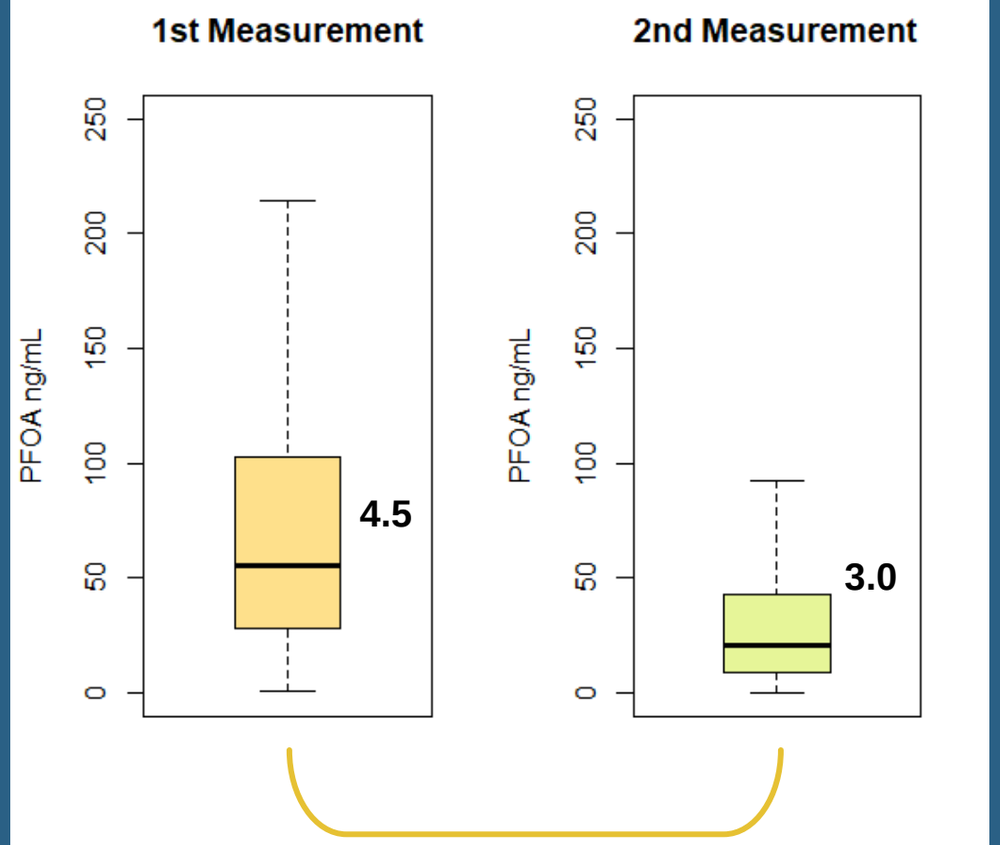
- About 4200 individuals repeated the determination on serum PFAS after a median of 46.7 months since the first determination.
- A marked decrease of serum PFAS (especially PFOA) was observed, as a consequence of the measures undertaken to reduce exposure through drinking water.

PFOA



Median reduction: 62.9%

PFOS



Median reduction: 33.3%

PFAS contamination to aquifers of central Veneto Region: assessing the risk and acting for solutions

RISK ASSESSMENT
the Health Surveillance Program

Exposure to PFAS and COVID_19 mortality (2021):

- observed a higher mortality risk for COVID-19 in a population heavily exposed to PFAS, which was possibly explained by PFAS immunosuppression, bioaccumulation in lung tissue, or pre-existing disease being related to PFAS

International Journal of *Environmental Research and Public Health*

MDPI

Article

Exposure to Perfluoroalkyl Substances and Mortality for COVID-19: A Spatial Ecological Analysis in the Veneto Region (Italy)

Dolores Catelan [1], Annibale Biggeri [1], Francesca Russo [2], Dario Gregori [3], Gisella Pitter [4], Filippo Da Re [2], Tony Fletcher [5] and Cristina Canova [3,*]

1 Department of Statistics, Computer Science, Applications 'G. Parenti' (DiSIA), University of Florence, 50134 Firenze, Italy; dolores.catelan@unifi.it (D.C.); abiggeri@ds.unifi.it (A.B.)
2 Regional Directorate of Prevention, Food Safety, Veterinary Public Health, Regione del Veneto, 30123 Venice, Italy; francesca.russo@regione.veneto.it (F.R.); filippo.dare@regione.veneto.it (F.D.R.)
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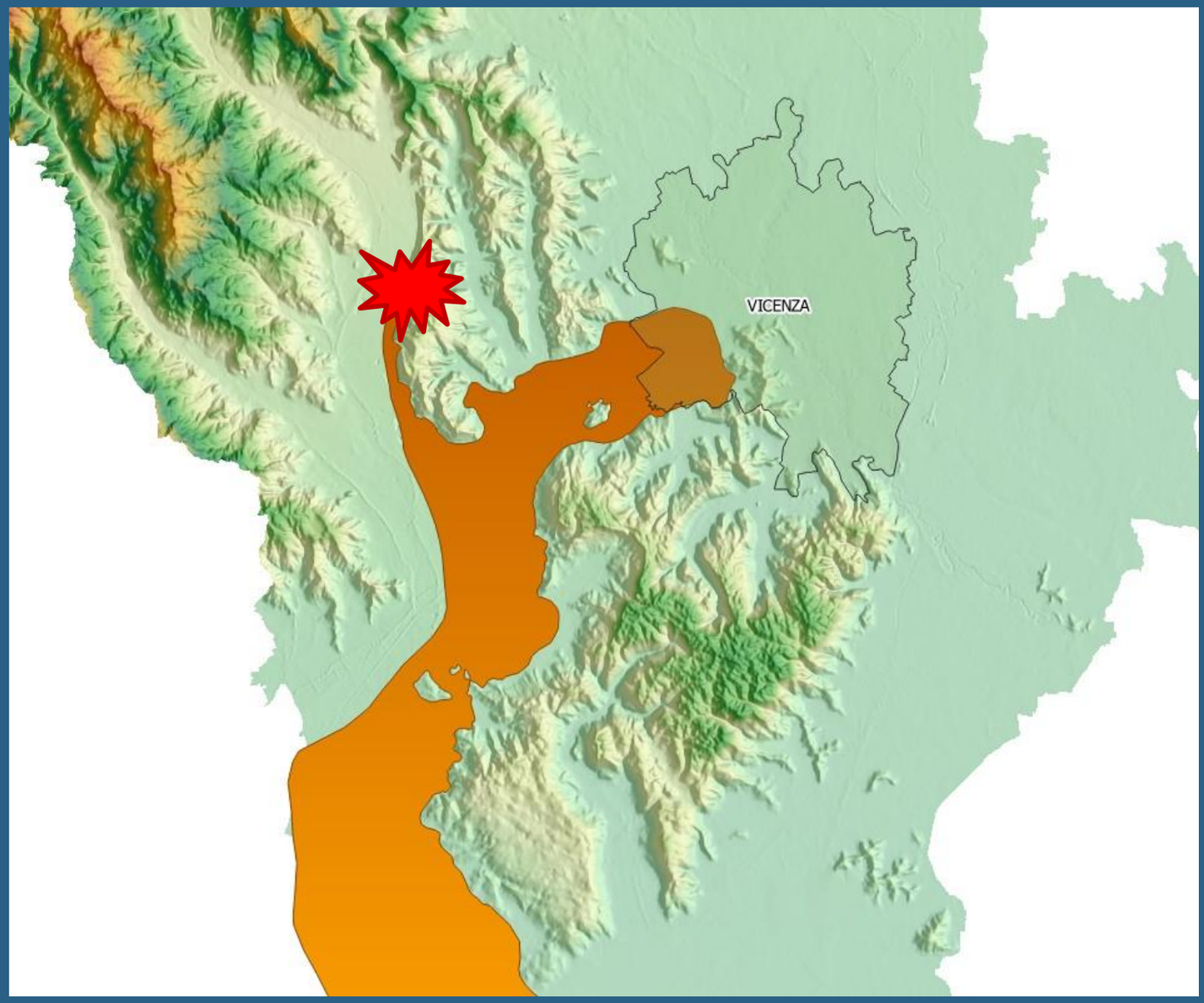
4 Screening and Health Impact Assessment Unit, Azienda Zero, Regione del Veneto, 35131 Padova, Italy; gisella.pitter@azero.veneto.it
5 Department of Public Health, Environments and Society, London School of Hygiene & Tropical Medicine, London WC1H 9SH, UK; tony.fletcher@lshtm.ac.uk
* Correspondence: cristina.canova@unipd.it

RISK MITIGATION MEASURES

short- and long- term

At the source of contamination site

- Plug-in of the Pump&Treat system
- Removal of contaminated industrial waste at the river's banks (2016)



Drinking water supplies

- Closure of contaminated boreholes (if alternatives are available)
- Set up of new GAC filtration units
- Set of new concentration limits to industrial discharges

RISK MITIGATION MEASURES

short- and long- term

Installation of CA filters at one large pumping site

7 boreholes
Max 550 L/s

Tank
1.000 m³

5
pressurized
sand filters

10
pressurized
GAC filters

10
pressurized
GAC filters

Max 500 L/s

- 4 water supply networks served (1.350 km)
- 140.000 population served
- 11.000.000 m³ of water produced per year
- 1.000.000 Euro/year for GAC replacement (very site specific)

8 Pumps

Tank
4.000 m³

sodium
hypochlorite

RISK MITIGATION MEASURES
short- and long- term

OBJECTIVE: identify and assess ALL risks, also associated with PFAS contamination and plan for effective risk reduction, mitigation or elimination

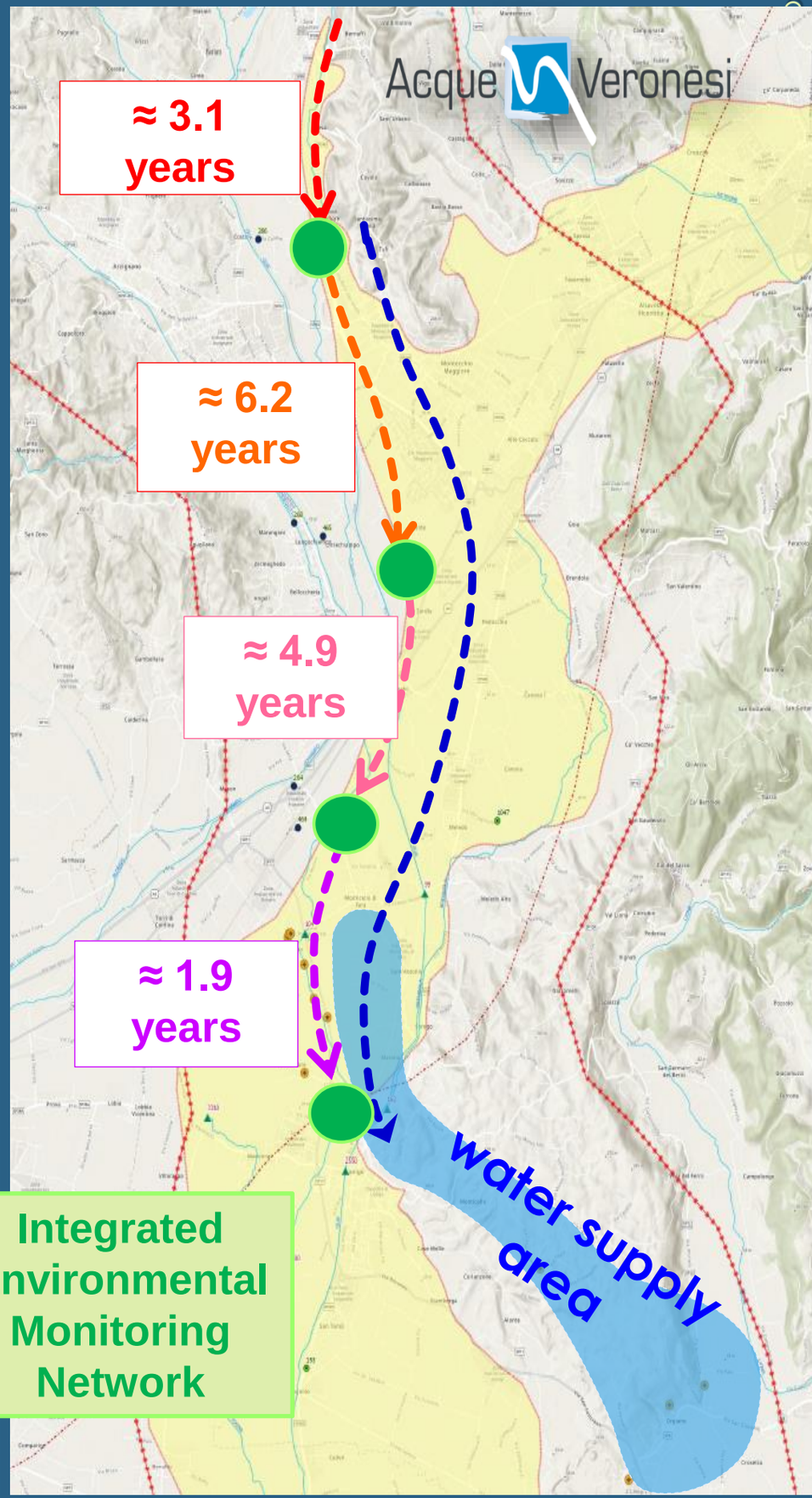
I. 316 risks have been identified in the system in question, system weaknesses identified

II. Monitoring procedures for PFAS and other emerging pollutants improved and shared

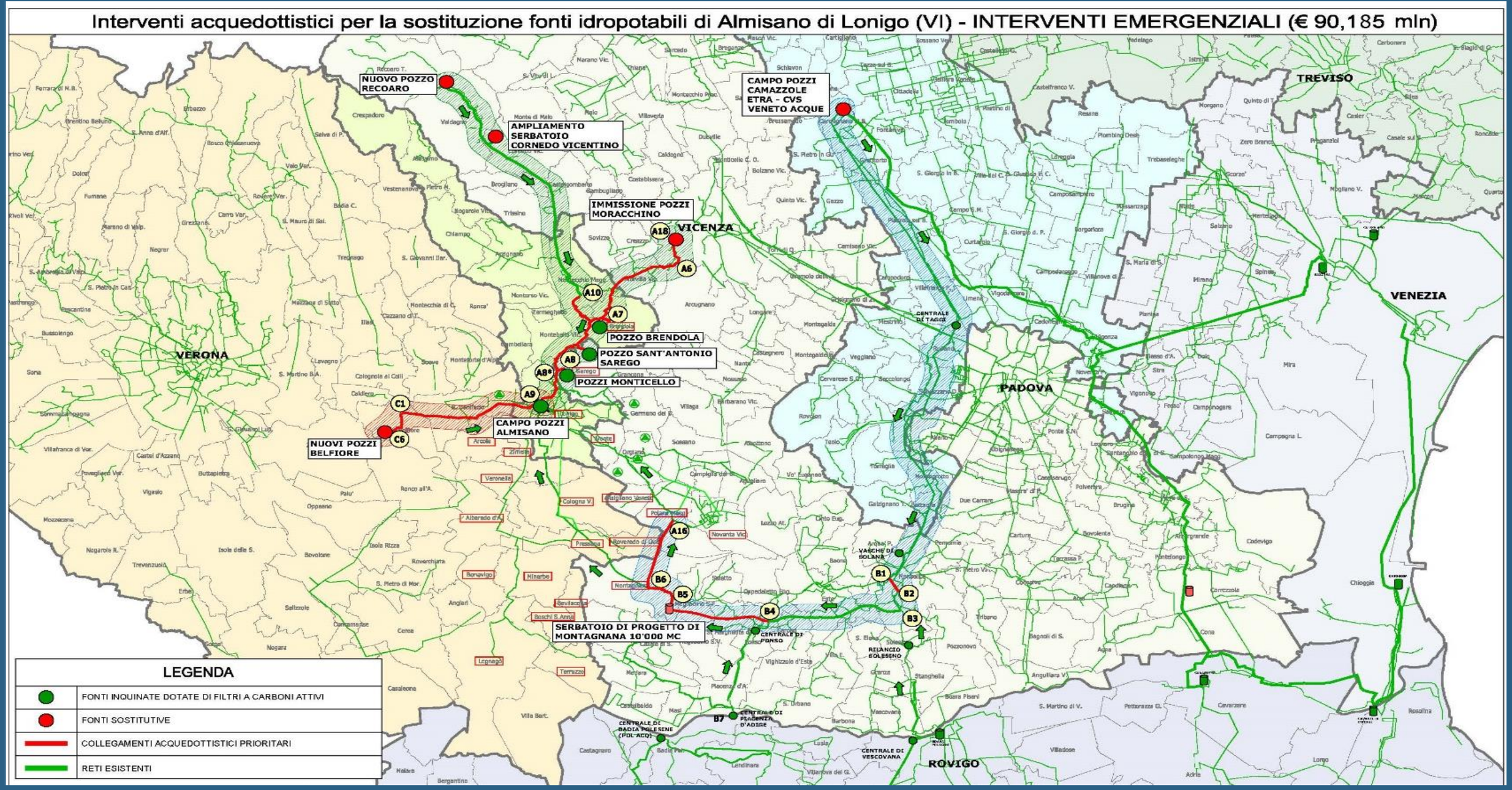
III. Definition of future Investments:

- Improve existing plants and Technology (filtration)
- integrated environmental monitoring network
- alternative sources and distribution network of water supply (around 90M€)

IV. Communication of the WSP to the population



RISK MITIGATION MEASURES
short- and long- term



Drinking water supplies (total cost: 103 M €)

- Interconnections with other distribution networks
- Implementation of new water production sites(boreholes) and storage

PFAS contamination to aquifers of central Veneto Region: assessing the risk and acting for solutions

RISK MITIGATION MEASURES
short- and long- term

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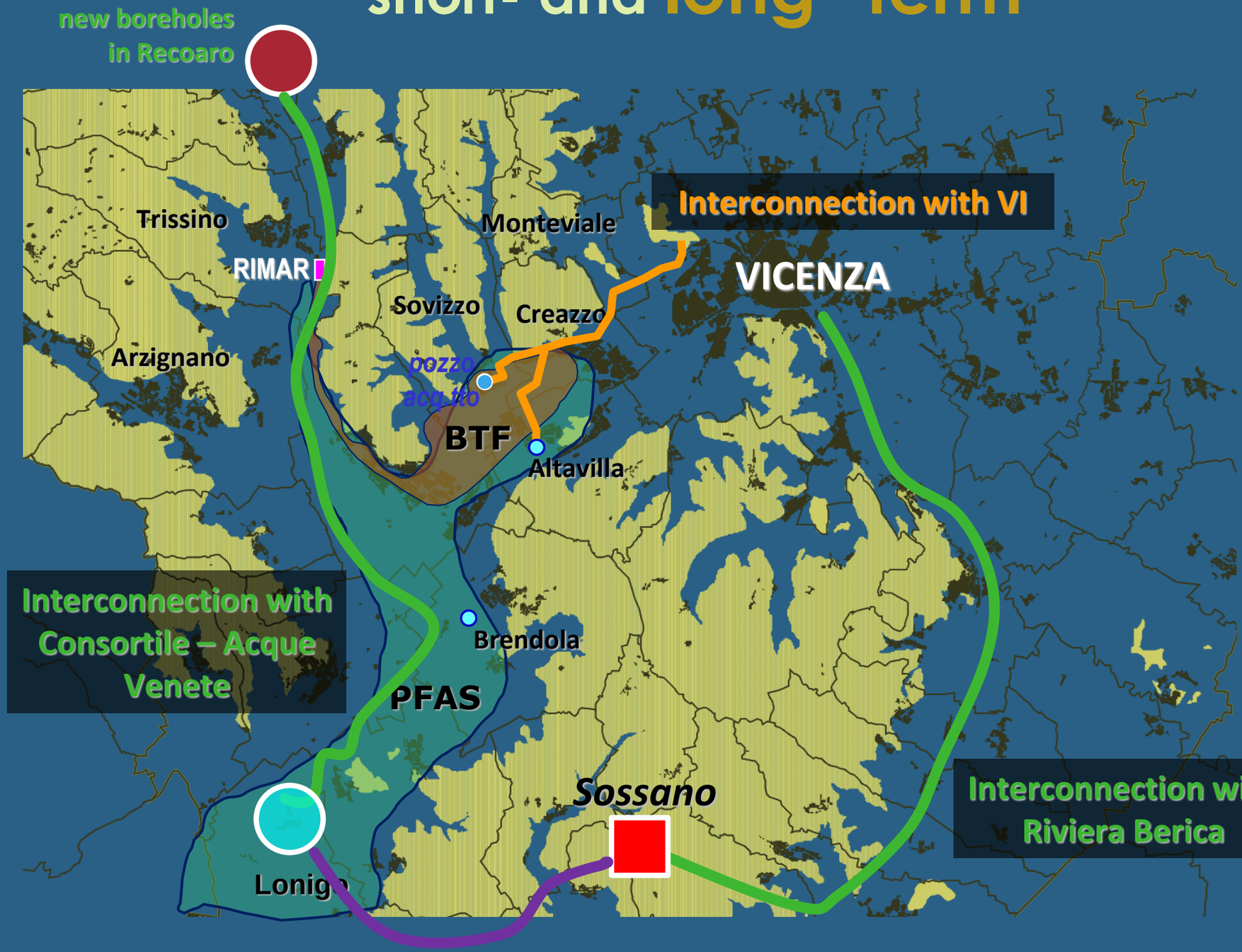


1977
Contamination by benzotrifluoride (BFT)

2013-21
Contamination by PFAS

Drinking water supplies (total cost: 103 M €)

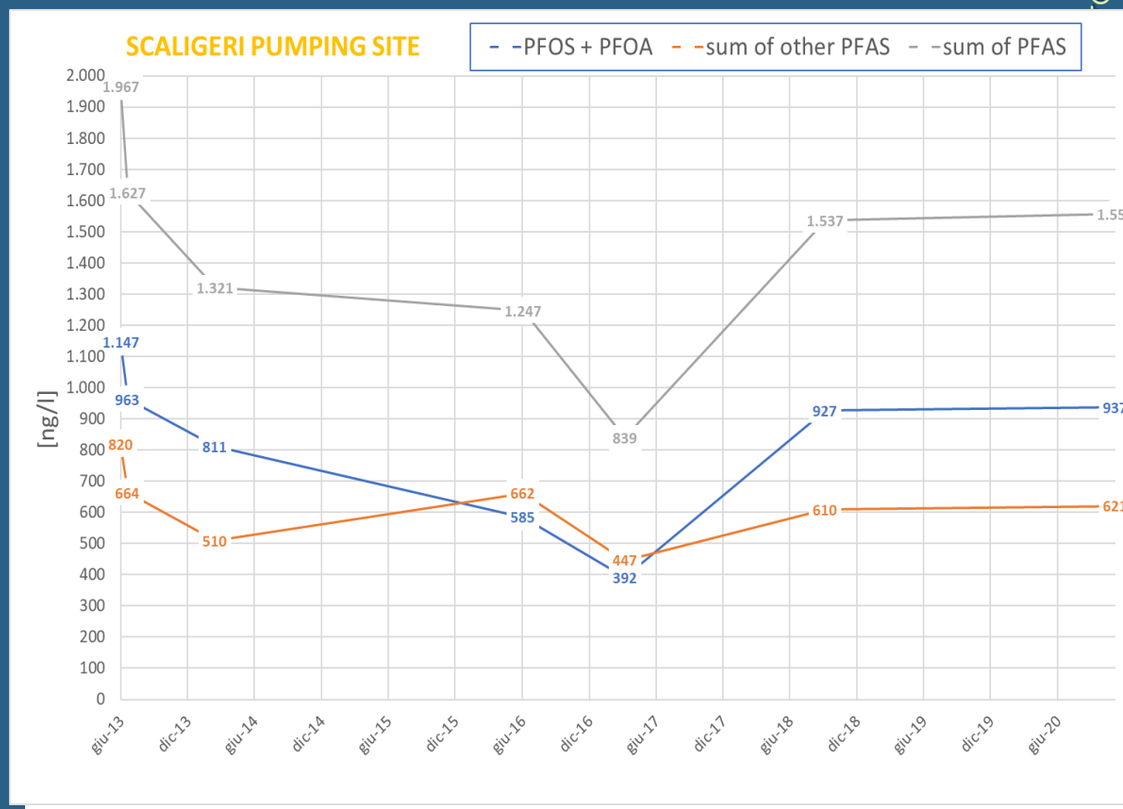
- Interconnections with other distribution networks
- Implementation of new water production sites(boreholes) and storage

PFAS contamination to aquifers of central Veneto Region: assessing the risk and acting for solutions

The LIFE CAPTURE Project

- **General Objective:**
  - Combining novel analytical protocols for PFAS contamination with technologies for sustainable remediation.
- **Specific Objectives:**
  1. Development of robust protocol for the analysis of PFAS. The intention is to enlarge the spectrum of the PFAS family that can be identified and analysed;
  2. Development of methods to monitor the transport of PFAS from soil, through groundwater, to receptors
  3. Identification, testing and validation in real (field) conditions of remediation technologies
     - **AOP for VIACQUA and RIVE**
  4. Development of risk assessment methods for mixtures of different known or unknown PFAS and methods for assessing risk reductions achieved by remediation

- **Duration:** 2022 – 2027 (5 years)
- **Partners:**
  1. ABO NV, Belgium
  2. GreenSoil International B.V., Netherlands
  3. Politecnico di Milano, Italy
  4. Universita' degli Studi di Milano-Bicocca, Italy
  5. iFLUX BVBA, Belgium
  6. VIACQUA spa, Italy
  7. SVERIGES LANTBRUKSUNIVERSITET, Sweden
  8. SGS Belgium nv, Belgium



Region: assessing the risk and acting for solutions

Conclusions:

- PFAS Contamination in Veneto Region is an extensive and massive event, with lots of consequences for the environment, the public health, the socio-economy, and the regulation

- The environmental monitoring and modelling exercise allowed to identify and characterize the sources of contamination, the fate&transport of the PFAS plume, while developing innovative approaches for forecasting PFAS distribution also due to low concentration source of pollution, and correlation with past events

- The Health Surveillance Program allowed to take care of the exposed population and to collect a considerable amount of health data that is increasing our knowledge on health effects of PFAS. A second assessment 4 years apart has shown a significant decrease of serum PFAS concentrations, particularly PFOA, proving the effectiveness of exposure reduction measures.

- The regulatory approach has been cautelative and conservative. It anticipated the EU definition of limits for PFAS in drinking water (see the recast of the DWD) and expanded the focus of PFAS national environmental monitoring

- The water supply risk assessment (WSP) allowed to better characterize the risk and identify and implement mitigation and reduction strategies at different time scales (short-medium-long term), anticipating the implementation of the holistic risk analysis model as required by the Directive (EU) 2020/2184

- Overall, while the technical-regulatory management of the contamination has been archived trough an integrated and inter-institutional approach, more has to be done to COMMUNICATE and ENGAGE with the local communities (the risk culture)