A regional flux-based risk assessment approach of contaminated sites on groundwater bodies

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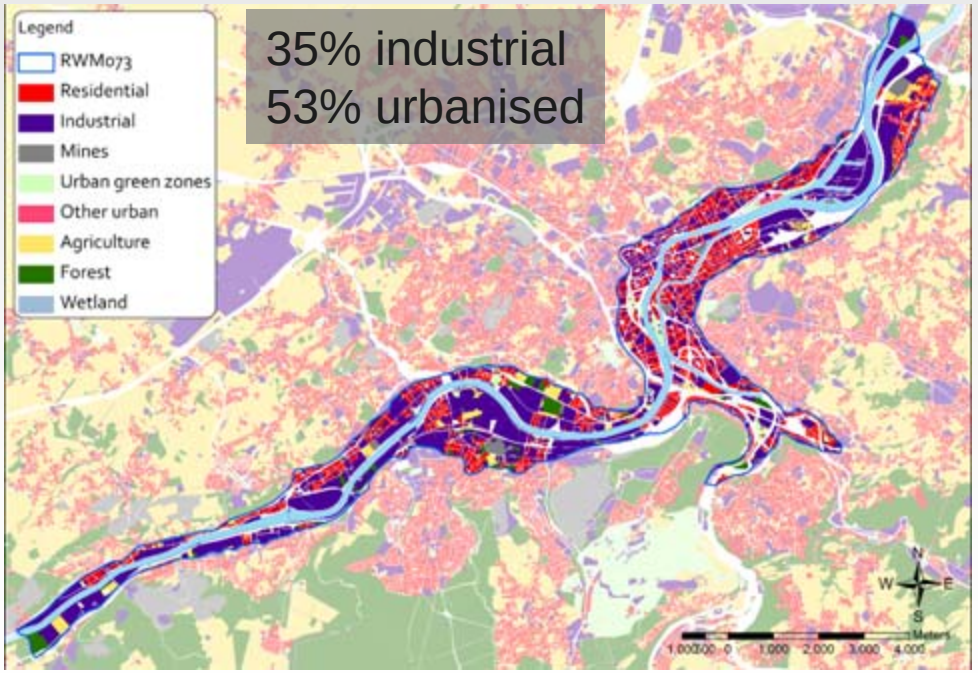
- EU Water Framework Directive and Groundwater Directive require from member states that groundwater bodies (GWB) achieve good quality status by 2015
  - Contaminants < threshold values
  - Trend reversal

- For GWB in industrialised / urbanised areas
  - Many known and potential sources of pollution
  - Many different kinds of pollutants



➔ How to evaluate the GWB quality status in such a context?

- **Pressures**: Discharging contaminant sources within the catchment of the GWB

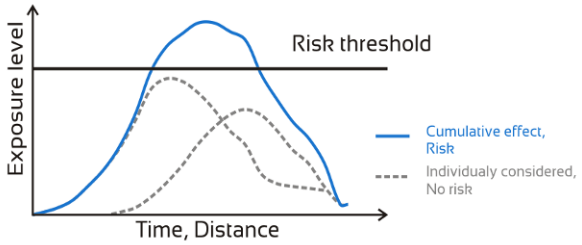
- **GWB status**: Level of contamination of the GWB
  - How much groundwater is contaminated?
  - To which extent and for how long?

- **Impacts**: Damages related to GWB deterioration + costs of remediation to be considered in the programmes of measures for EU reporting?

→ Methodology for Regional Risk Assessment, with focus on the development of a groundwater quality status indicator

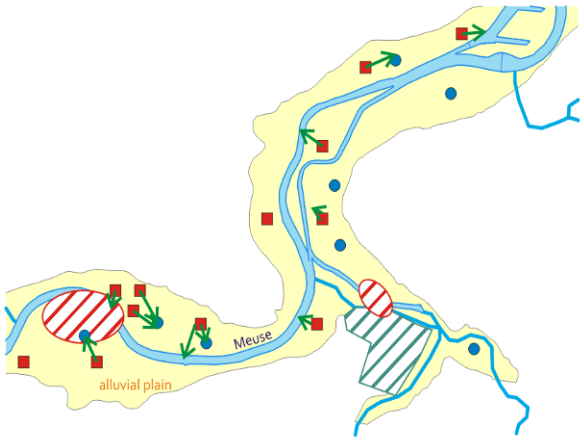
RRA for Groundwater Bodies: Concepts

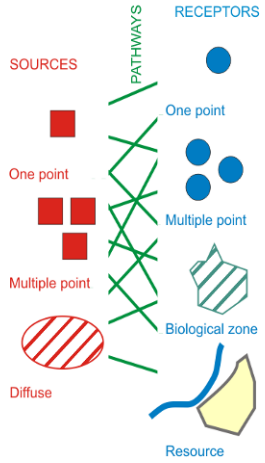
✖ Cumulative effect of several pollutant sources



→ **NEED FOR FLUX-BASED RISK ASSESSMENT**

✖ Spatial distribution of pollutant sources and receptors



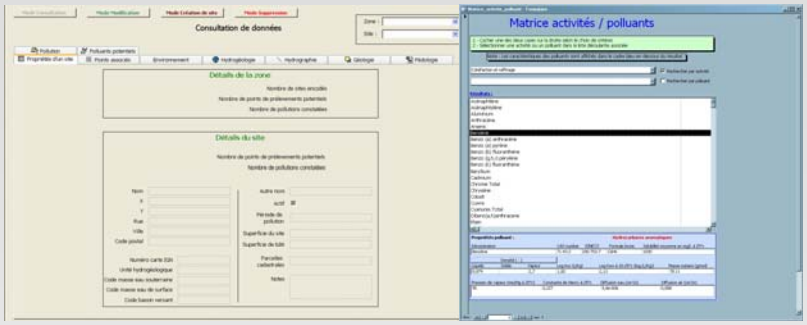


→ **NEED FOR GIS DATABASE FOR S-P-R DATA MANAGEMENT**

Spatial extent of the GWB	→	GIS-based
Cumulative effect of contaminants	→	Flux-based
Contaminant dispersion in GW	→	Process-based

RRA for Groundwater Bodies: Methodology

(1)



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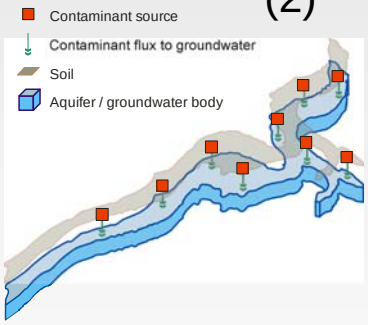

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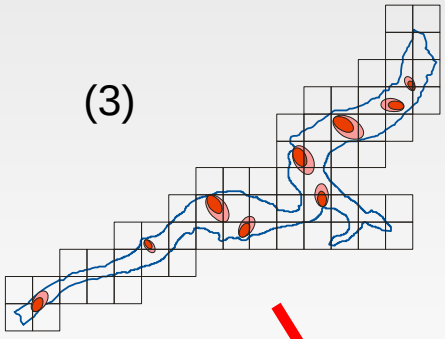

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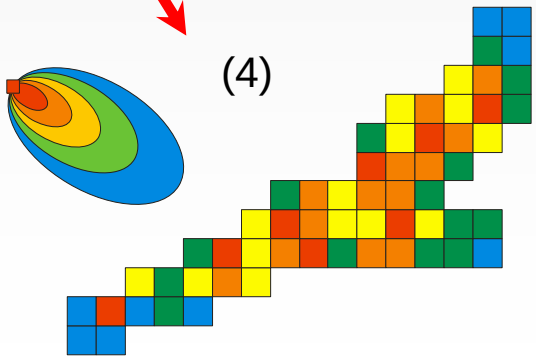


$$I_{global} = \frac{\sum_i I_i V_i}{V_{GW}}$$

(1) GIS geodatabase with information on soil, land use, geology, hydrogeology, contaminated sites, contaminant properties …

(2) Distribution of contaminant sources for GW flow and transport model at GWB scale

(3) Modelling of contaminant dispersion in GWB
→ plumes of deteriorated GW

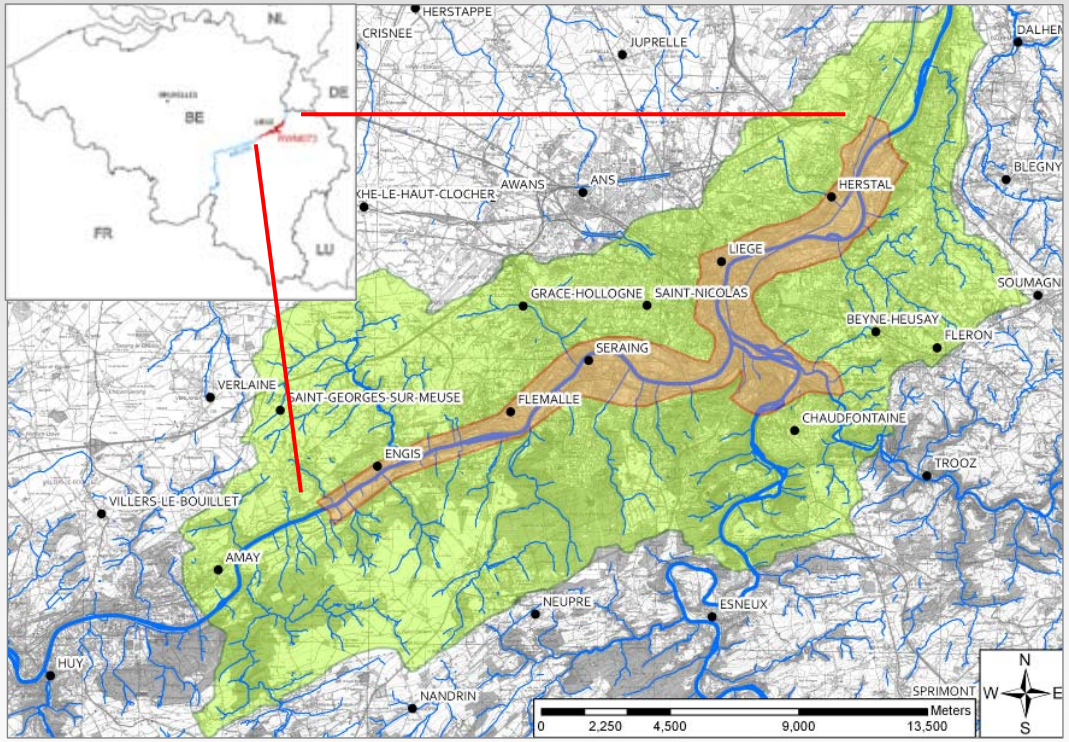
(4) Plumes classification according to Walloon Region Groundwater Quality Index (SEQ-ESO)
→ Map of GWQ indicators

(5) Aggregation of GWQ indicators into a global GWB quality index

Case study: alluvial aquifer of the Meuse river in the region of Liège, Walloon region of Belgium

- Alluvial gravel deposits
- 46 km²

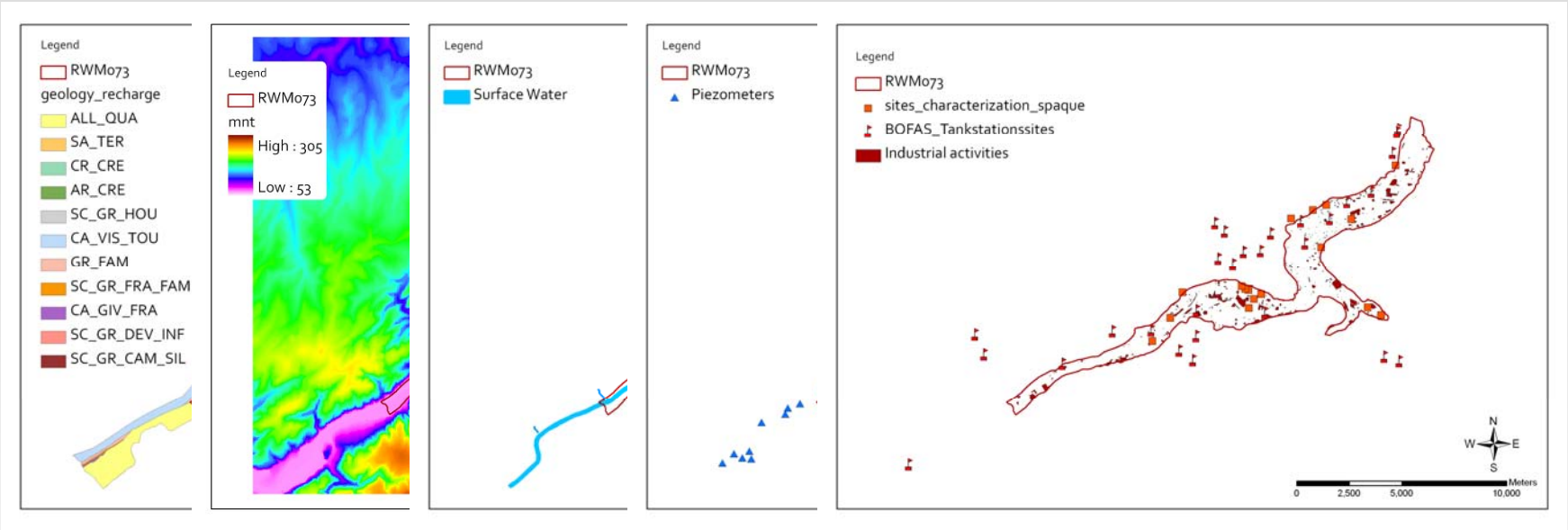
- Many past and ongoing industrial activities (metallurgy, coal mining, chemistry …)
- Evidences of GW quality degradation
- GWB classified at risk of not achieving good chemical status for 2015

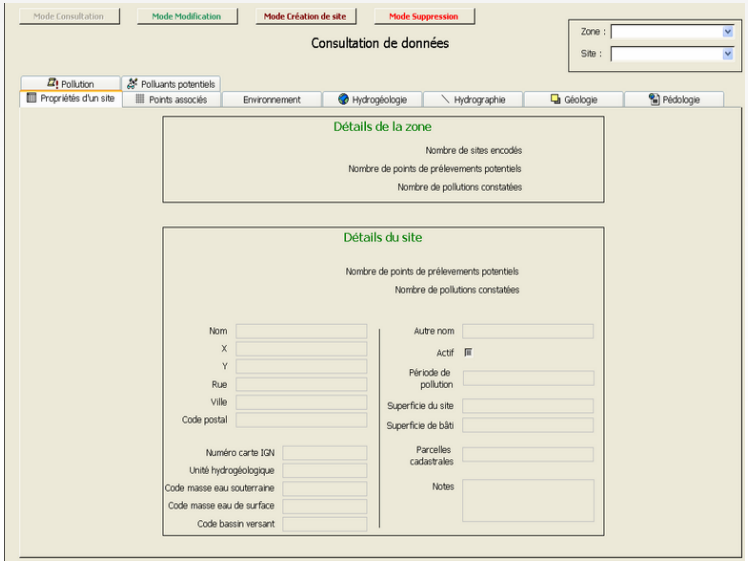


First tests of concepts and tools

- Potential contamination sources ← 2000 cadastral frame + known polluted sites + tank stations
- Three contrasted contaminants selected: TCE, Benzene and Benzo(a)pyrene
- Major assumption: all potential contaminant sources are leaking …

Case study: Data and Geodatabase

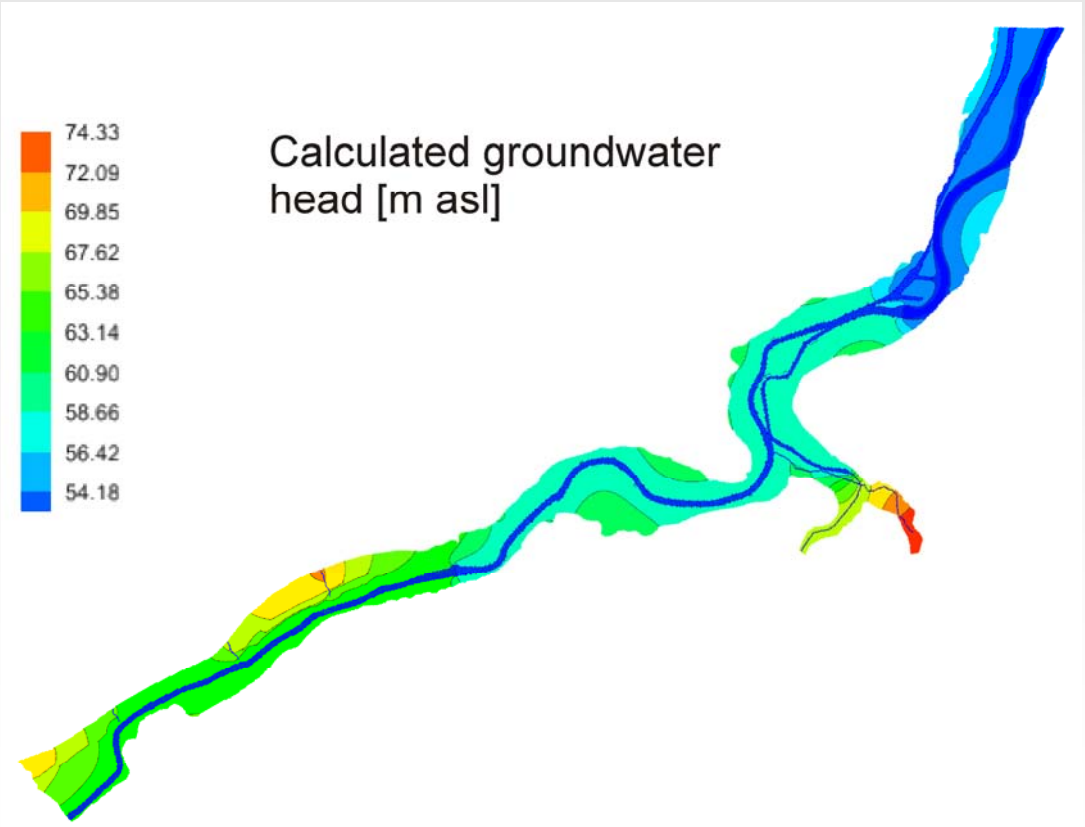


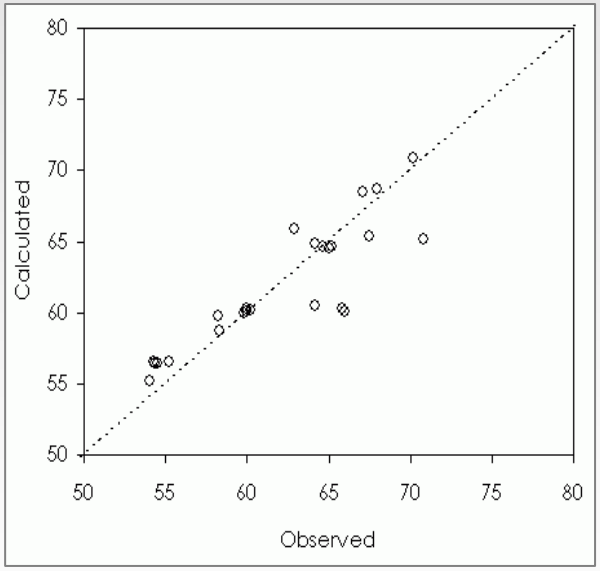


GIS-Based Geodatabase under ArcGIS environnement

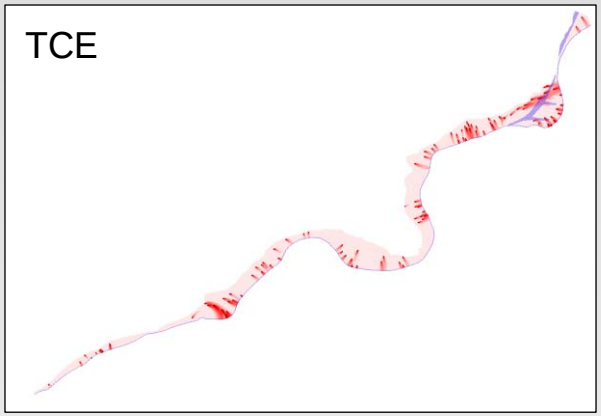
Case study: Groundwater flow and transport modelling

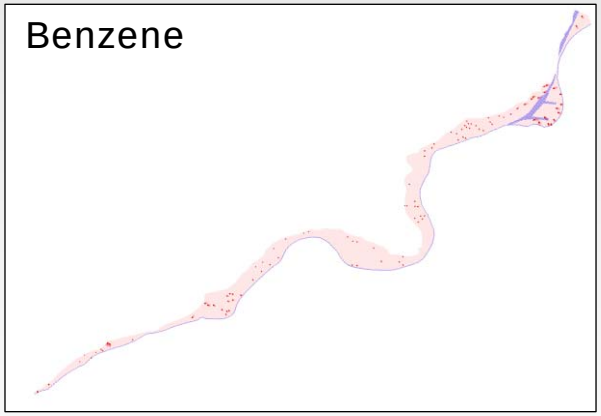
Modelling application under GMS environment, using Modflow2000 + MT3D
- GW flow model: steady state
- Contaminant transport model: transient over 20 year

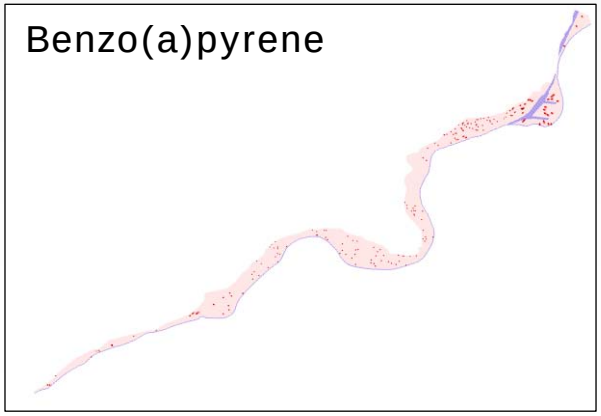




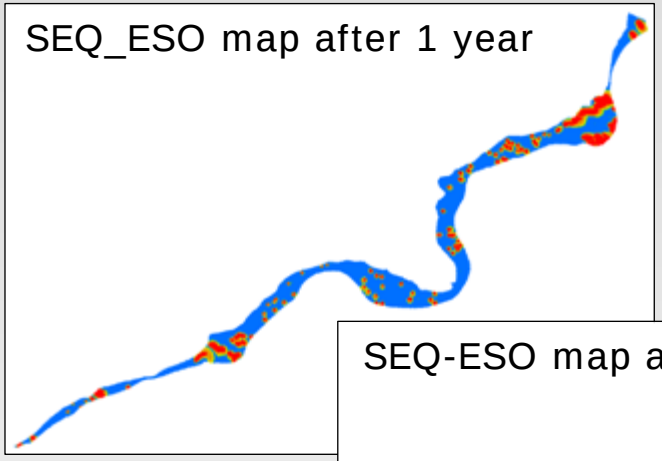
Case study: SEQ-ESO indicator

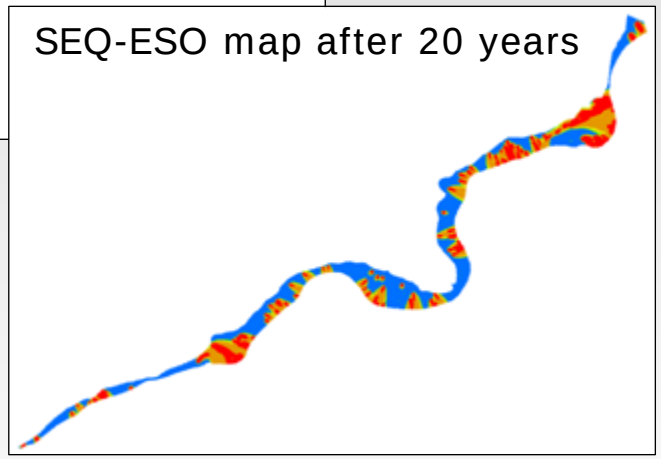


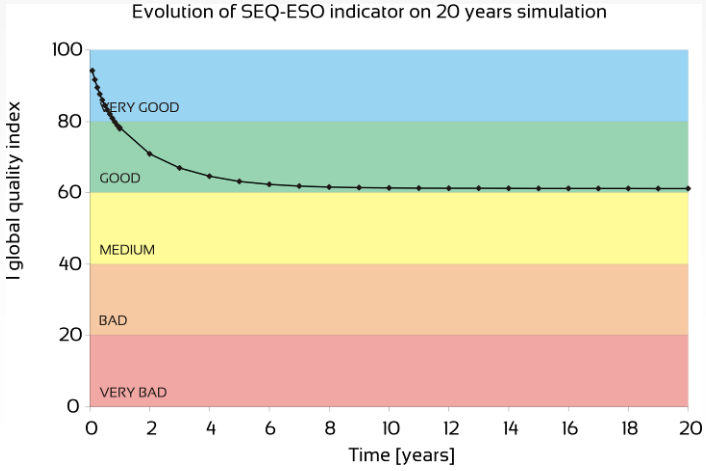




SEQ-ESO classification of contaminated plumes







Conclusions & Perspectives

Regional Risk Assessment Approach for GW Bodies

Compliant with EU WFD and GWD (GWB status and indicator, trend and trend reversal, and with Walloon Region regulations (SEQ-ESO)

Further work required on definition of landuse maps

Inventory of former and present polluting activities
!!! Statistics on contaminant emitted quantities and properties

→ Statistical / probabilistic approach of the problem

Ongoing socio-economic analysis (BRGM)

Groundwater damage costs assessment
Groundwater market and non-market valuation

Costs of programmes of measures

Acknowledgement

Research performed in the scope of the BELSPO Project FRAC-WECO (Project Nb SD/TE/02B), financed by the Belgian Federal Government

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- Aquapôle University of Liège

SEQ-ESO Concepts (1/3)

GW quality contaminants grouped into consistent classes (alterations)

-mineralisation and salinity (pH, hardness, Cl, SO4...)

-organic matter and nutrients (N, P, TOC, ...)

-filterable elements and particles (NTU, Fe, Mn, Al ...)

-mineral micro-pollutants (Cu, Zn, As, B, Cn, Cd, ...)

-Pesticides

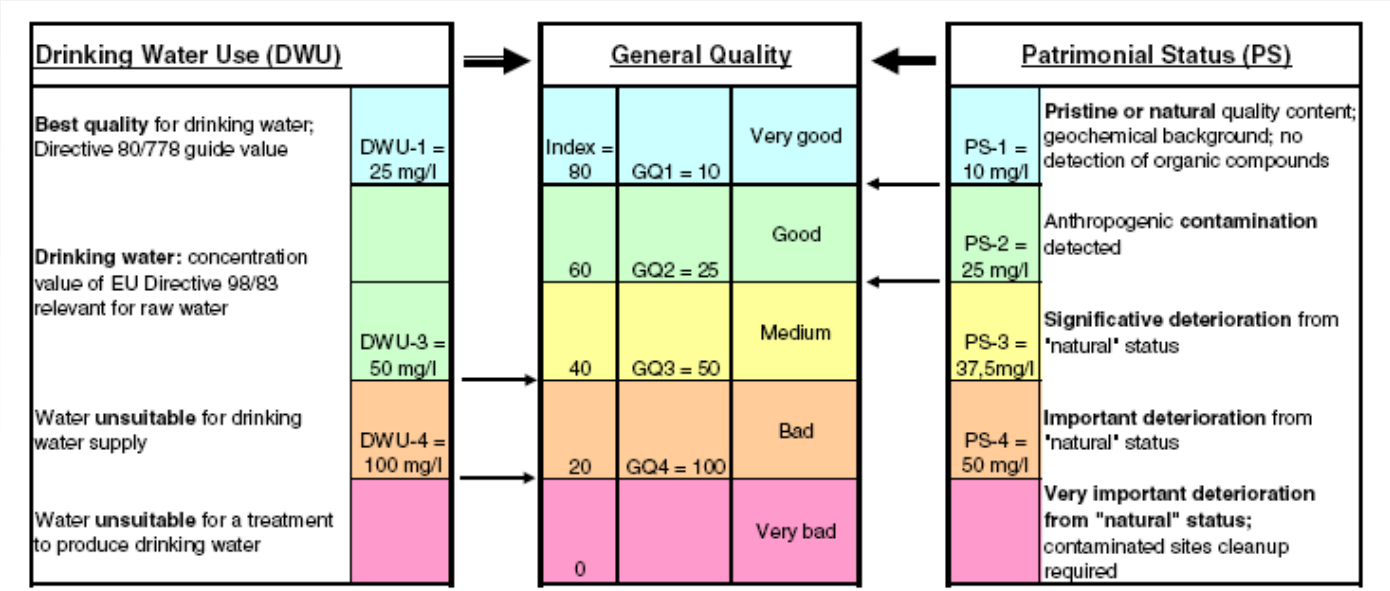
-PAH (Polycyclic Aromatic Hydrocarbons) and other organic pollutants (PCE, TCE ...).

SEQ-ESO Concepts (2/3)

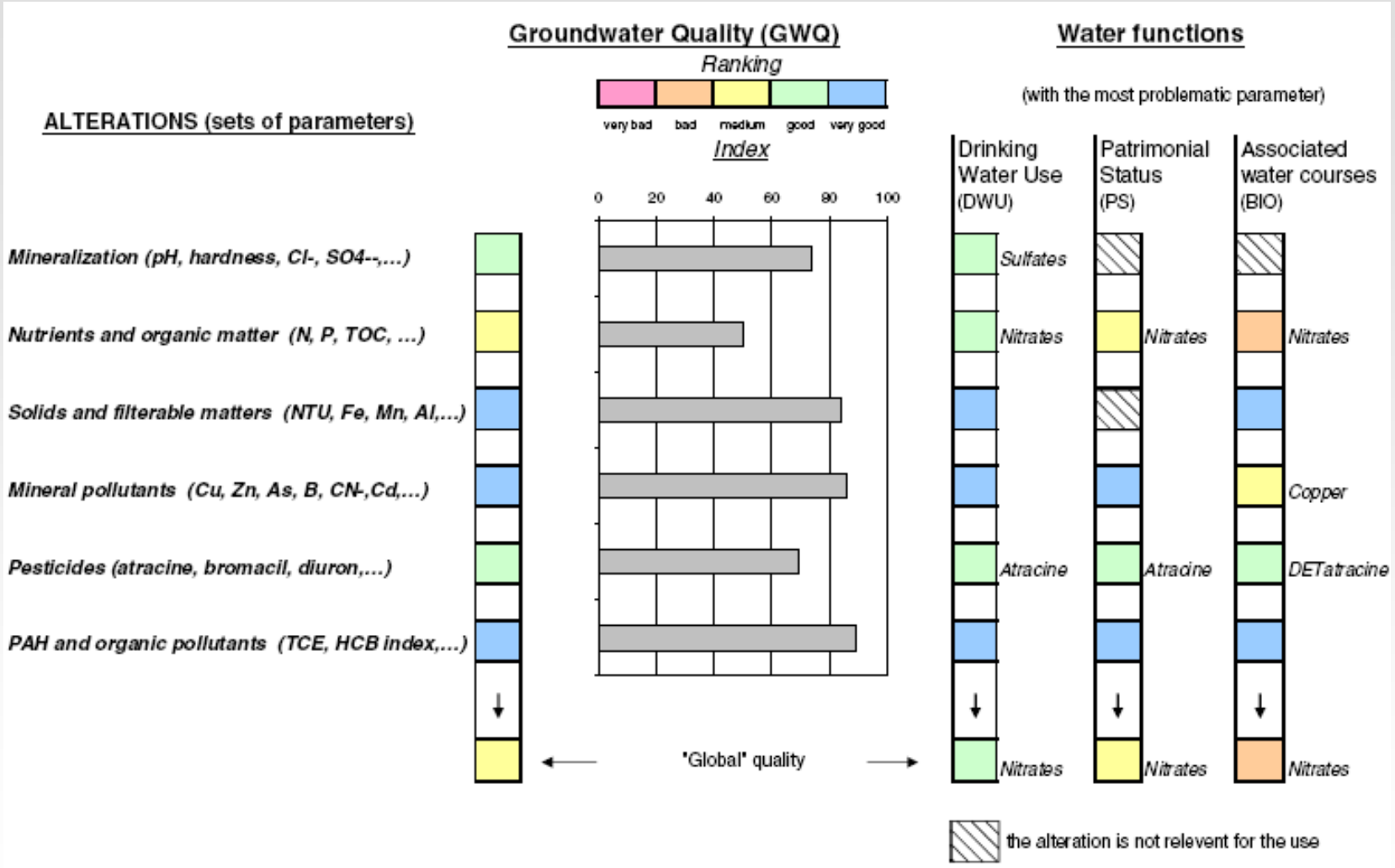
For each parameter, 4 or 5 quality classes defined, depending on GW functions:

- Water use (DWS, industrial …)
- Patrimonial status
- Ability to sustain ecology in surface water courses (groundwater dependent ecosystems)

Scaling of GW quality classes to a scale from 0 (very bad) to 100 (very good)



SEQ-ESO Concepts (3/3)



Details: Rentier, C., F. Delloye, S. Brouyère, A. Dassargues, A Framework for an optimised groundwater monitoring network and aggregated indicators, Environmental Geology, 50(2), 194-201, 2006