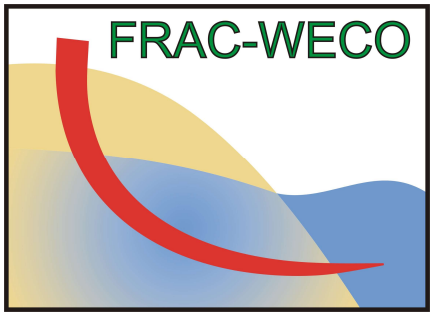
BELGIAN SCIENCE POLICY

Science for a sustainable development

FRAC→WECO



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

S.Brouyère, P.Jamin, D.Caterina, A.Dassargues, C.Hérivaux, S.Crèvecoeur, J.-P.Thomé, I.C.Popescu

Contaminated Site Management in Europe

Gent, October 27th 2009

Université de Liège

ArGEnCo

Aquapôle

Vrije Universiteit Brussel

vito

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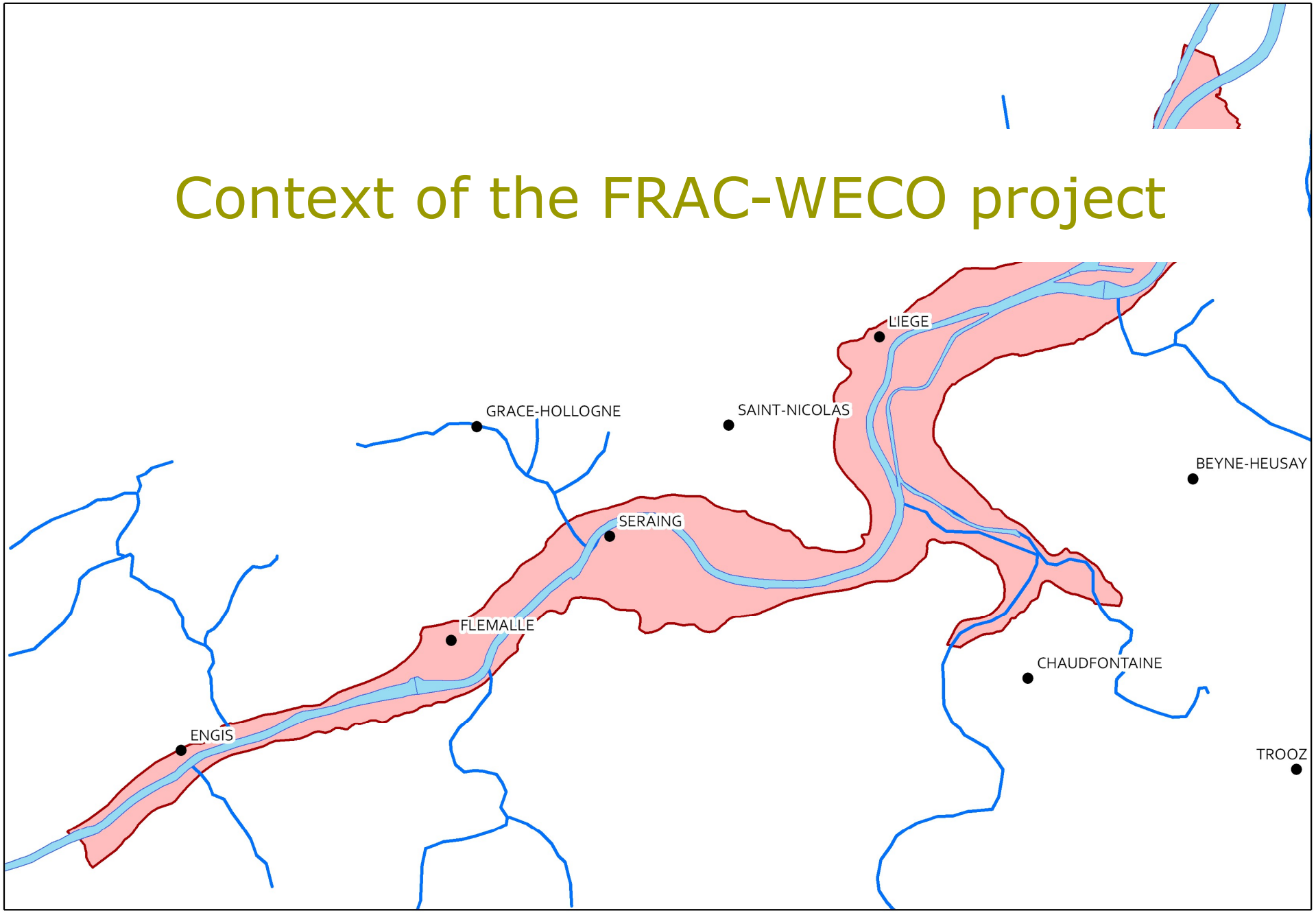
Context of the FRAC-WECO project



Context of the FRAC-WECO project

- Context: EU Water Framework Directive
- Relevance: management of heavily industrialized area with numerous contaminated sites
- Main objectives: risk assessment of contaminated site using mega-site approaches based on criteria able to reflect the risk of water quality degradation
  - In a cumulative way
  - At the water body scale

Context of the FRAC-WECO project

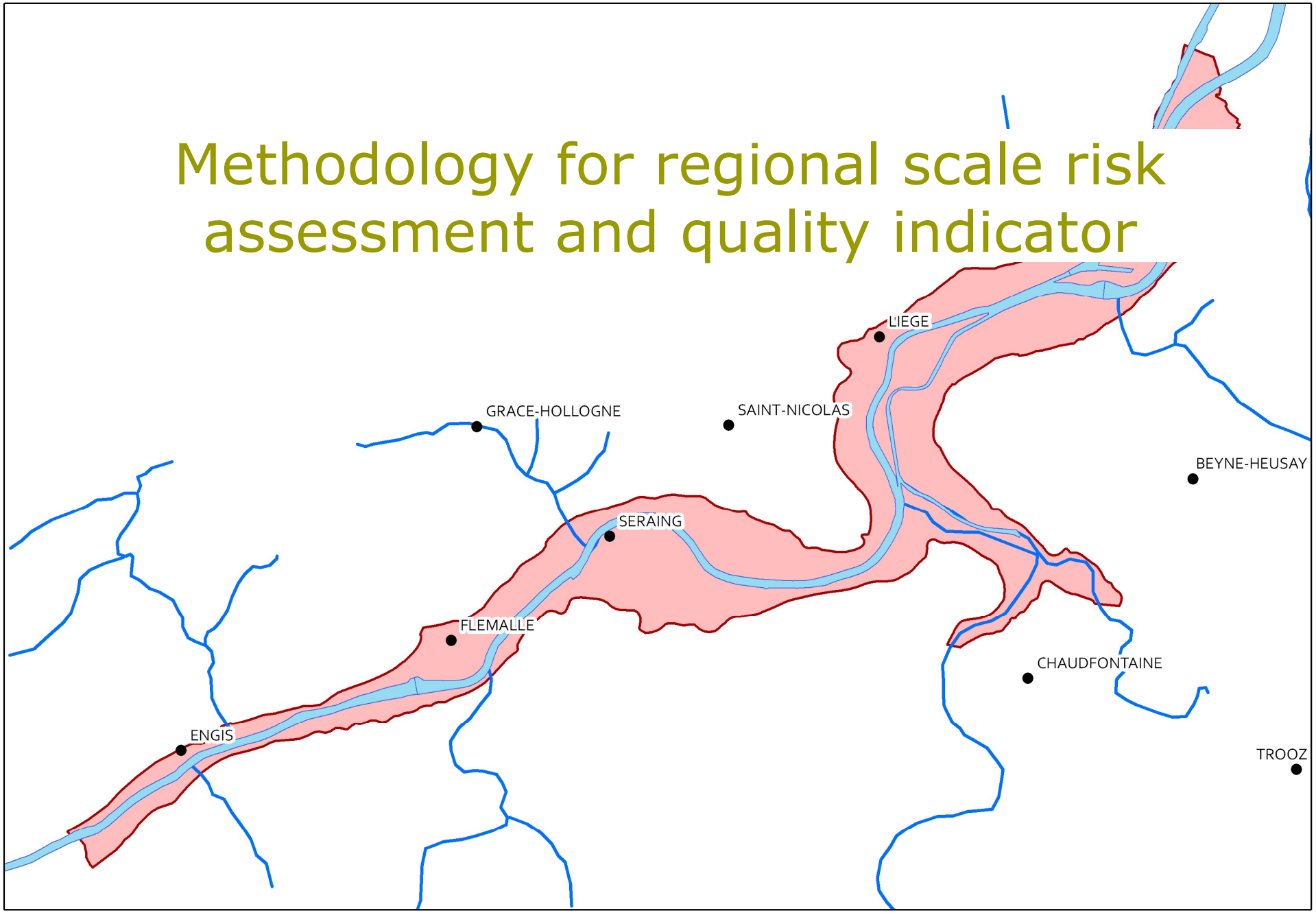
- Flux-based Risk Assessment of Contaminants on Water resources and ECOsystems

- Financed by the Belgian Science Policy 2006-2010, gathering 5 scientific partners from Belgium and France

  - ULg–Aquapôle: Coordinator, hydrogeology
  - ULg–LEAE: Ecotoxicity, TRIAD like approach
  - VUB: Spatially distributed ground water recharge from remote sensing
  - VITO: Behaviour of contaminants
  - BRGM: Socio economical aspects

- Today's presentation focuses on risk assessment methodology and application on groundwater body RWM073

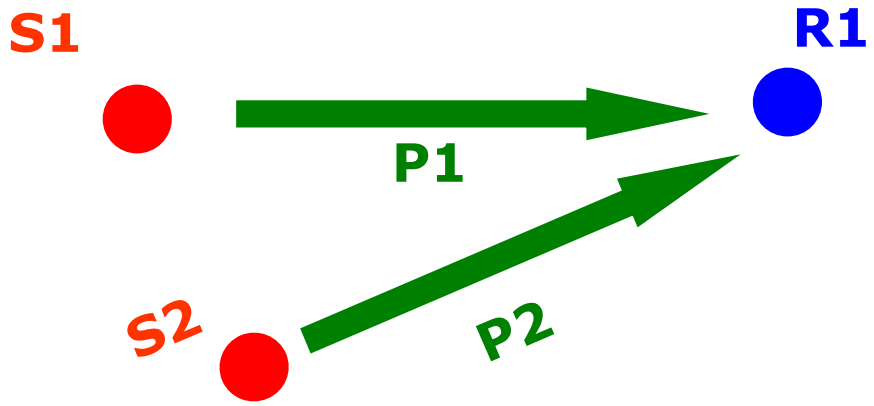
Methodology for regional scale risk assessment and quality indicator

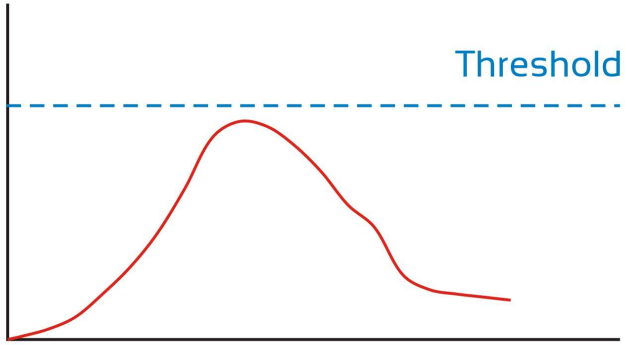


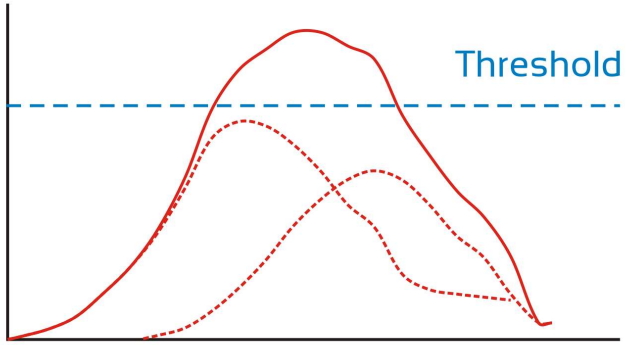
Methodology

Regional risk assessment

- Risk assessment of contaminated site
  - Classical schema: simple S-P-R





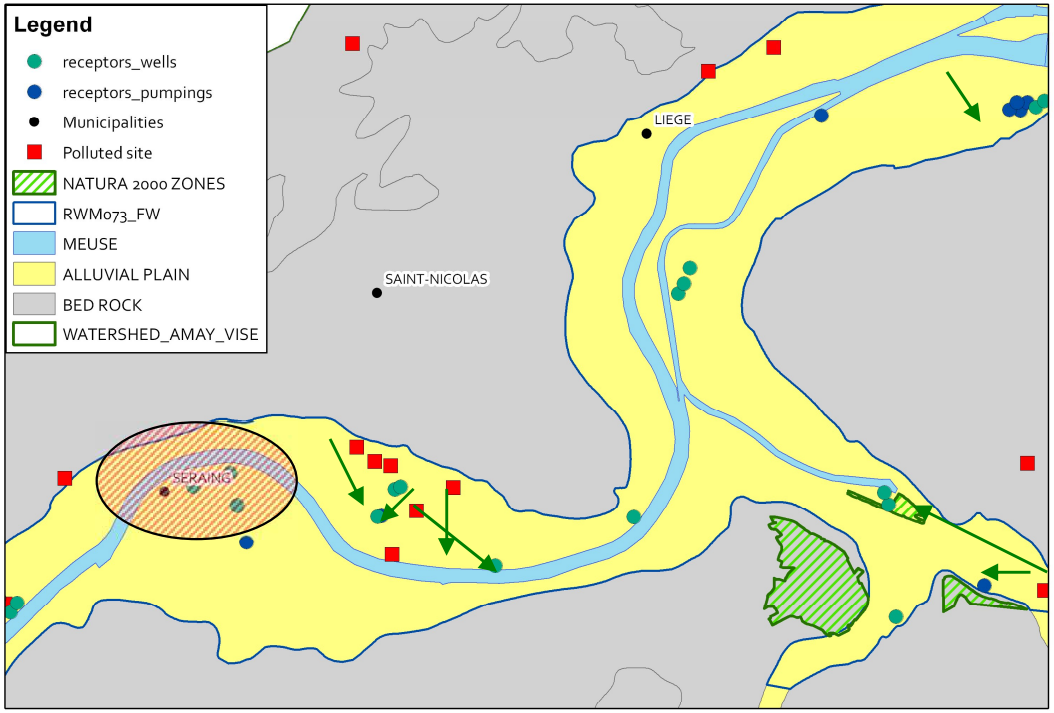


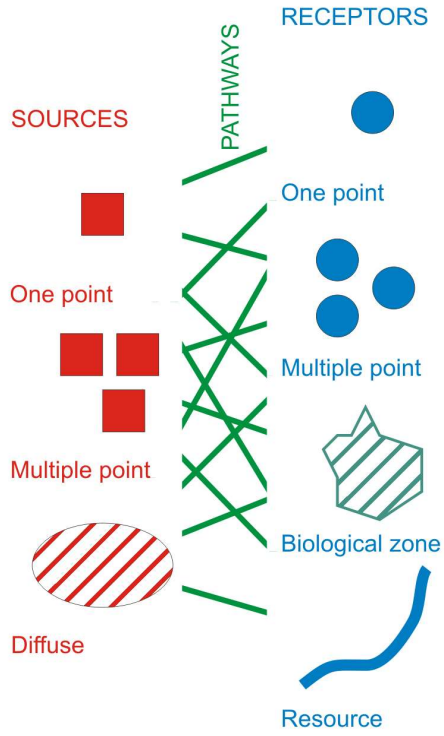
- 1 site means
  - 1 or few sources
  - 1 or few contaminants
  - 1 or few pathways
  - 1 or few well identified receptors
  - Good characterization of context

Methodology

Regional risk assessment

- Risk assessment of multiple contaminations on multiple receptors at regional scale
  - FRAC→WECO: more than point sources and point receptors
  - Need for a lot of information about S, P and R





→Flux based risk assessment in order to consider the additive effect of various sources

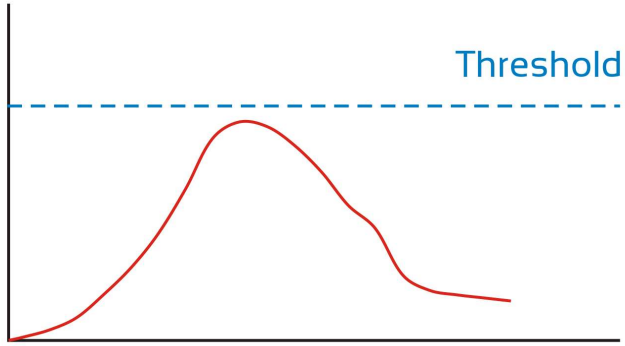
→GIS data base to manage SPR information (Development in progress at ULg)

Methodology

Regional risk assessment

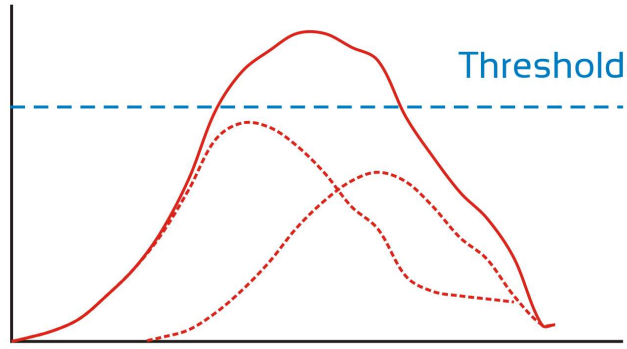
- Local Risk Assessment Criteria
  - 1S → $1R_{point}$: OK with usual concentration-based criteria (referential is a function of the type of receptor)
    - f_M = mass flux
    - Q = amount of contaminated water × t^{-1}

$$C = f_M / Q$$



  - nS → $1R_{point}$: cumulative approach (flux-based) and still usual concentration-based referentials
    - f_M^{cum} = cumulative mass flux
    - Q = amount of contaminated water × t^{-1}

$$C = f^{cum}_M / Q$$

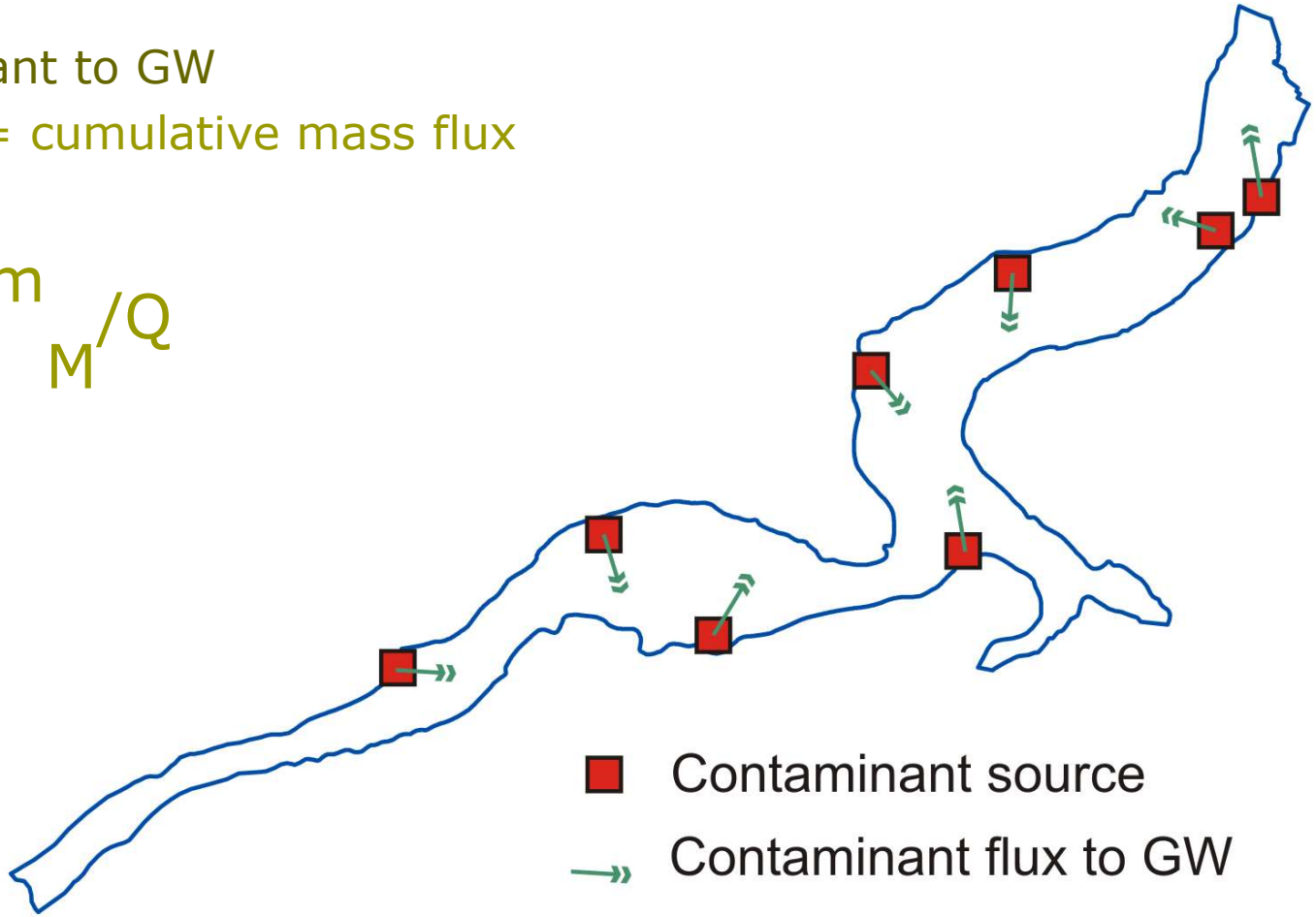


Methodology

Regional risk assessment

- Regional Risk Assessment Criteria
  - nS → 1 $R_{RGW/SW}$: cumulative approach (flux based) but what referential to use?
  - Contaminant to GW
    - f_M^{cum} = cumulative mass flux
    - Q = ?

$$C = f^{cum}_{M} / Q$$



Methodology

Quality indicator

- Contaminant through GW

1. GWB discretization and modelling of contaminant leaching + plume dispersion

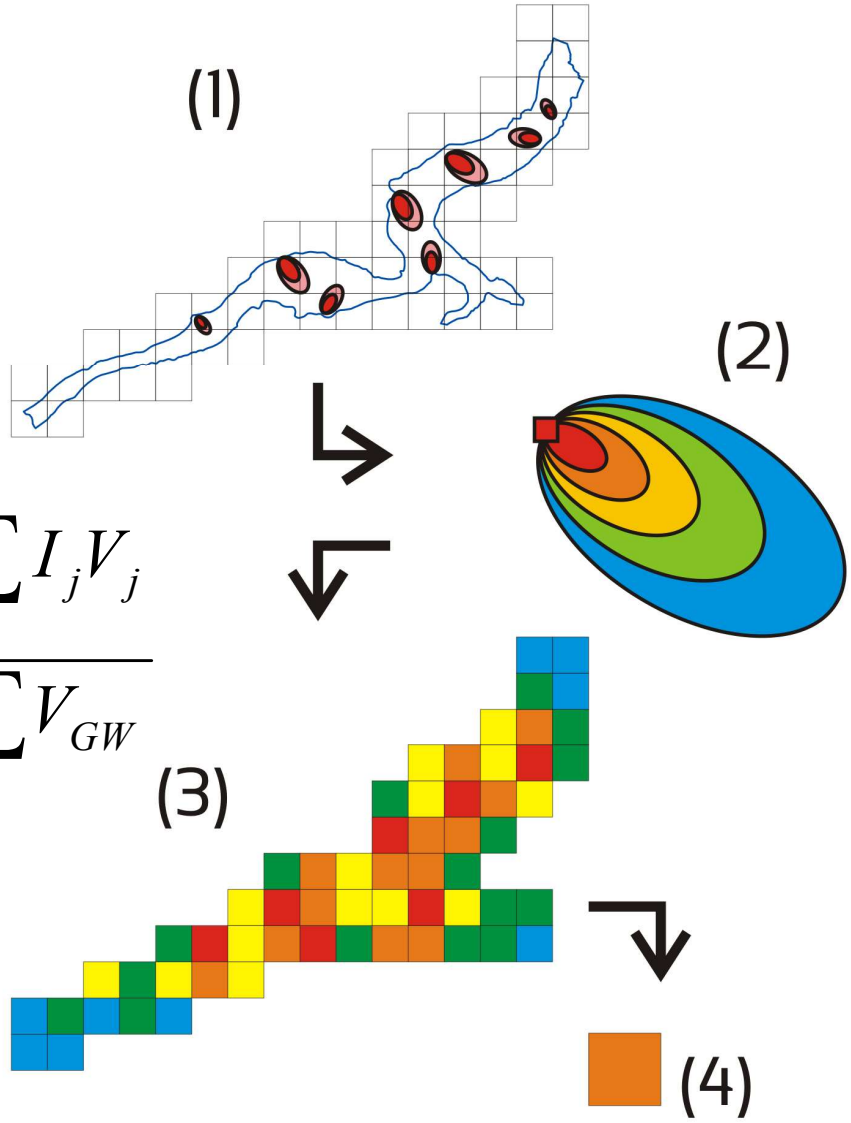
2. For each plume, classification of concentrations according to threshold values of the Walloon region SEQ-ESO

C. Rentier et al., 2006 : A framework for an optimized Groundwater monitoring network and aggregated indicators. Environmental Geology, vol. 50/2, p194-201.

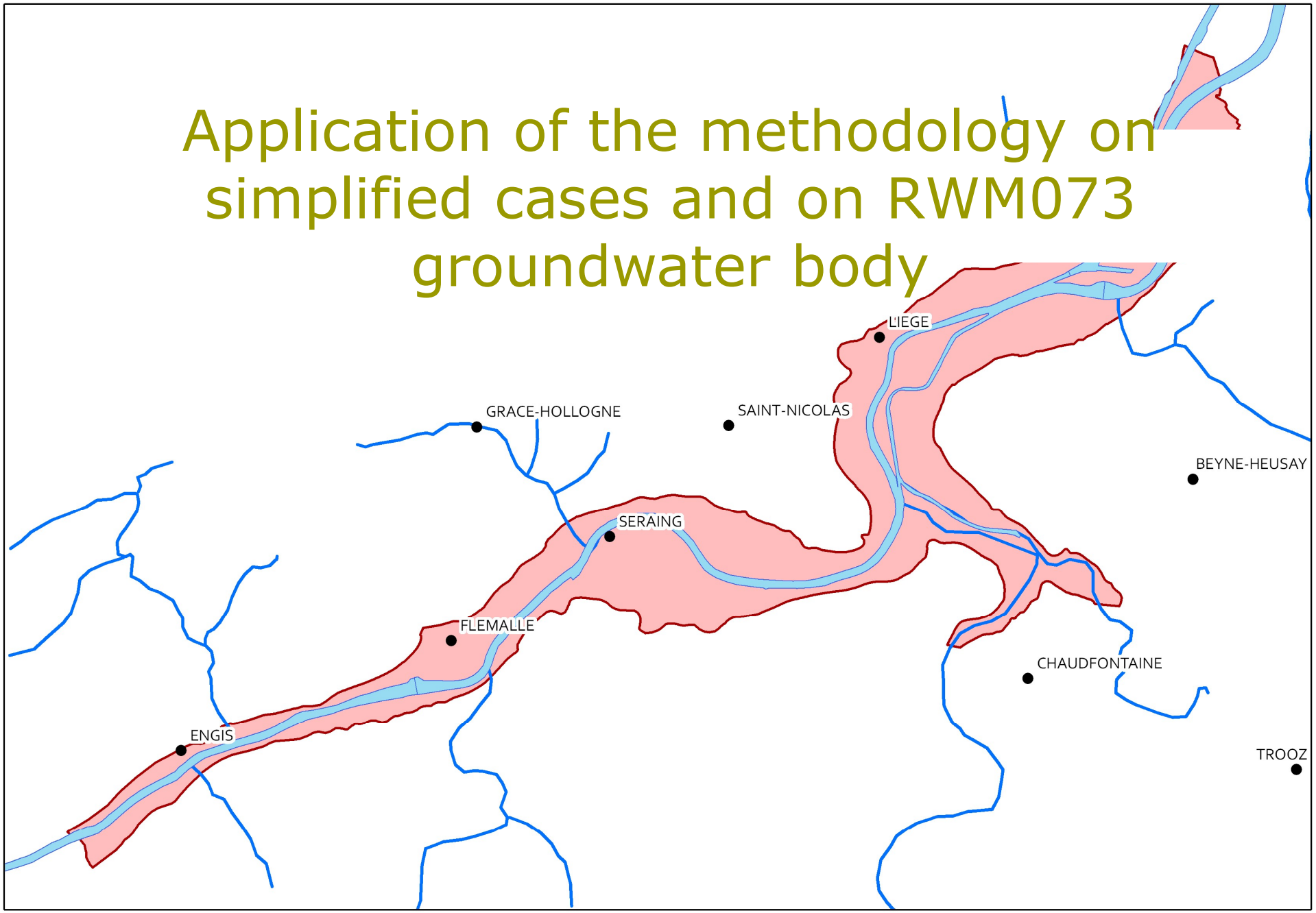
3. In each grid cell: SEQ-ESO indicator taking into account the various contaminants and possible flux cumulative effects

4. Aggregation into a limited number of global SEQ-ESO indicators

$$I_{global} = \frac{\sum_j I_j V_j}{\sum_j V_{GW}}$$



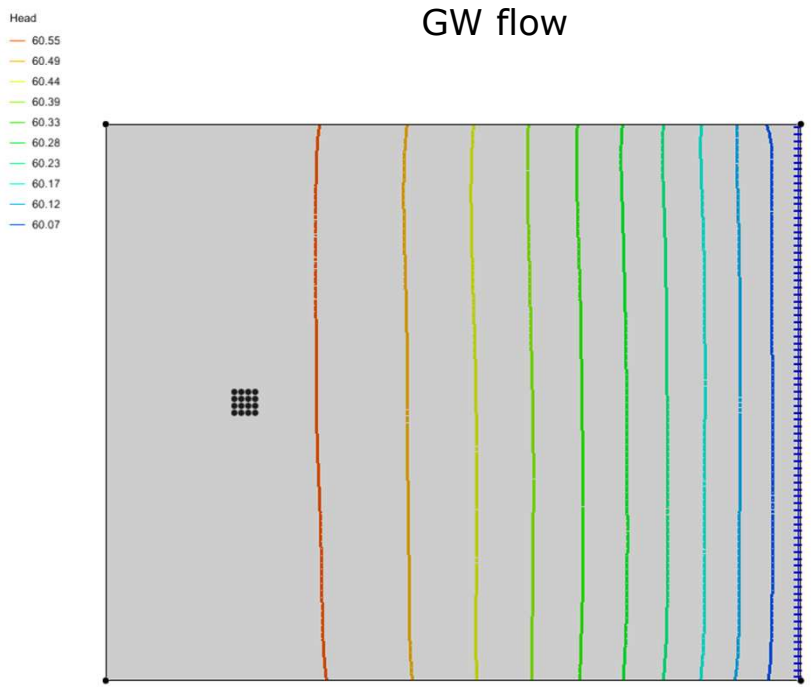
Application of the methodology on simplified cases and on RWM073 groundwater body



Application of methodology — Simplified test cases

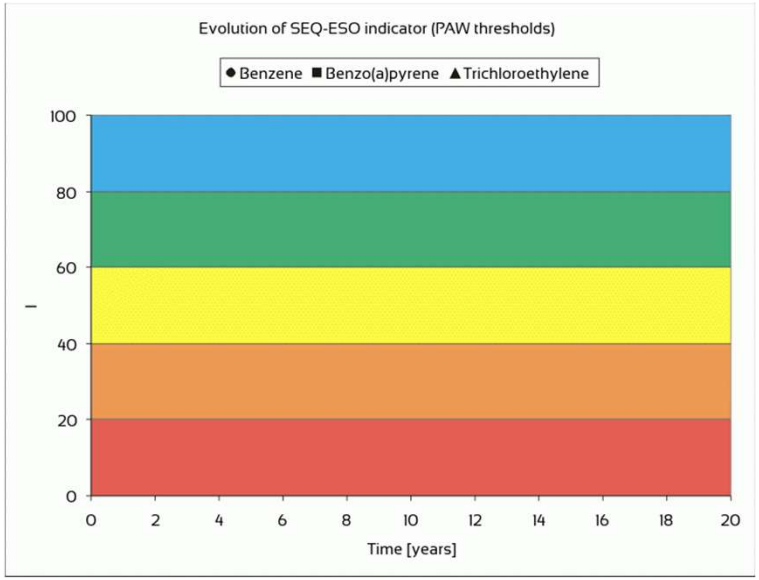
The regional risk assessment methodology using indexes from SEQ-ESO has been tested on simplified cases (in the same time than general model development).

- Simplified model, 500 x 400 x 20 m, with no-fluxes boundary conditions N, S, W and river E.
- Flow and transport parameters coming from former studies on the Meuse alluvial plain.
- Chemical pollutant properties coming from literature.
- Tested for 3 species
  - Benzene: high mobility, high degradation, 1 g/l
  - Benzo(a)pyrene: low mobility, low degradation, 1 µg/l
  - Trichloroethylene: high mobility, low degradation, 1 g/l

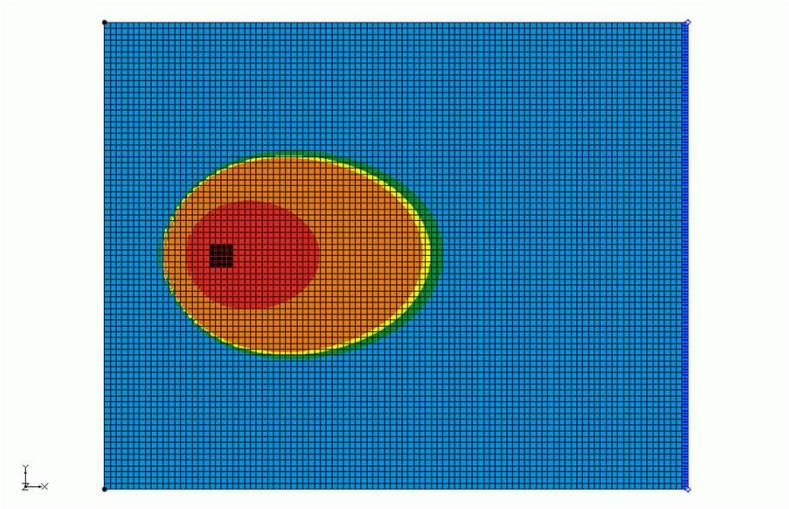


Application of methodology Simplified test cases

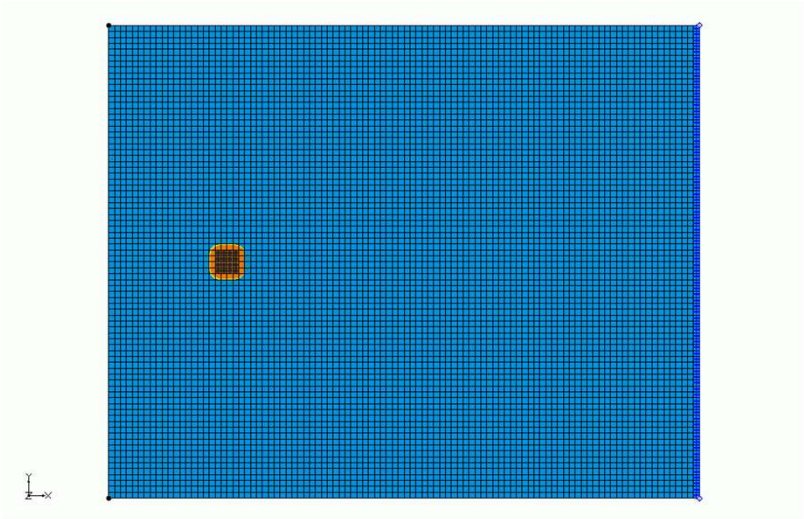
Evolution of SEQ-ESO index during 20 years simulation



Benzene



Benzo(a)pyrene



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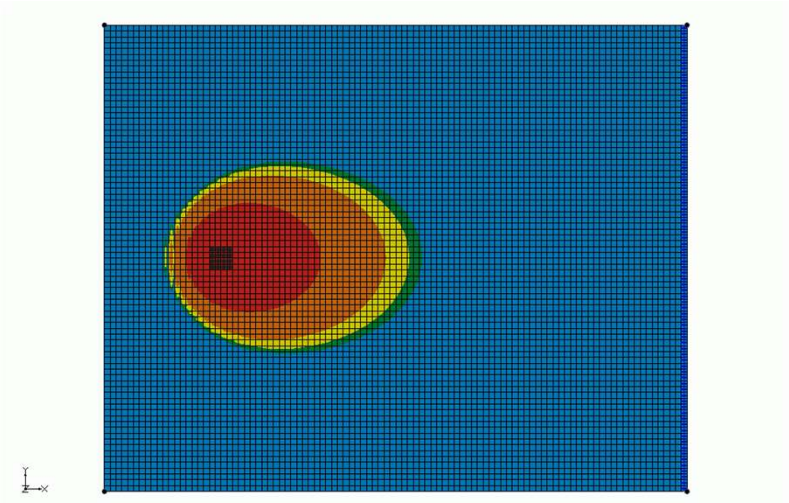
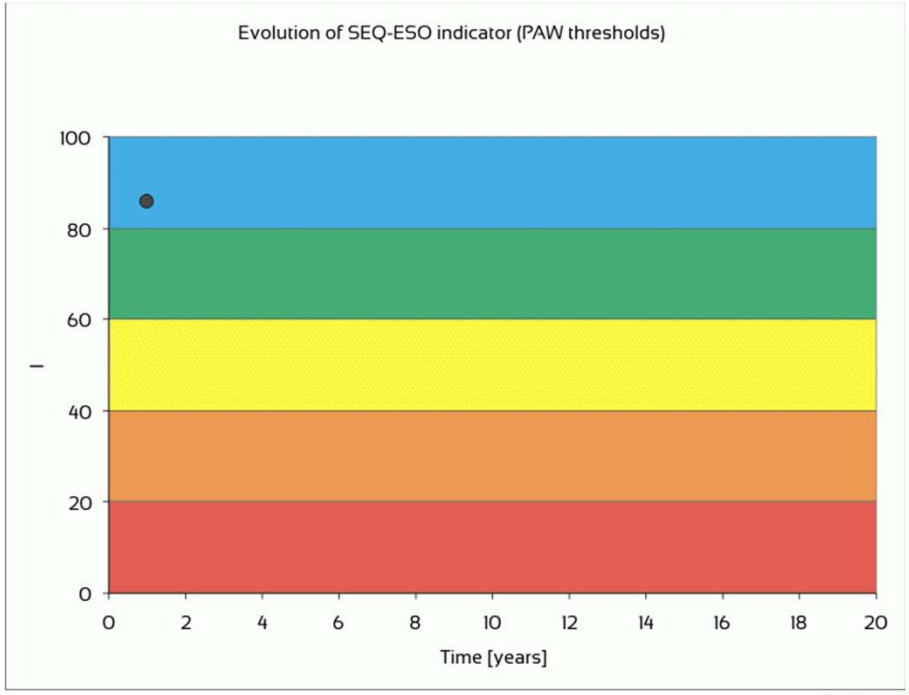
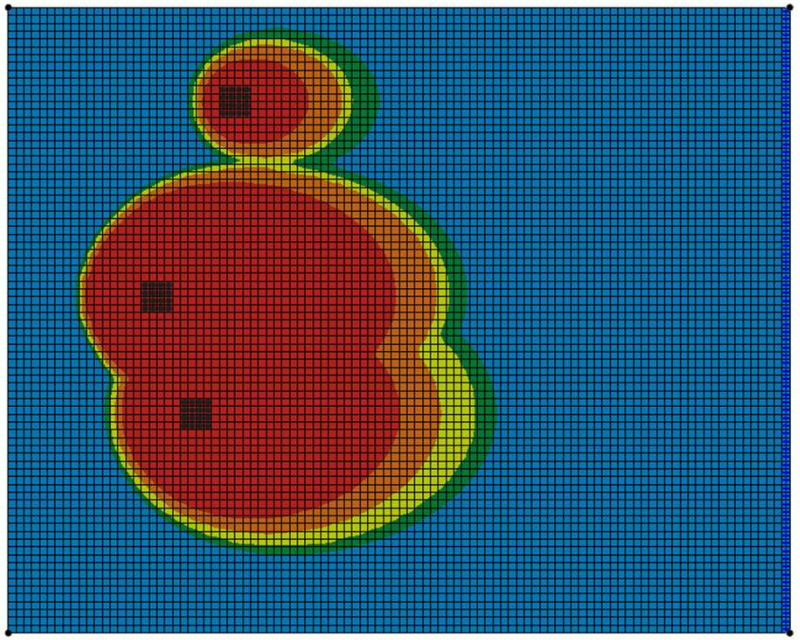


Application of methodology Simplified test cases

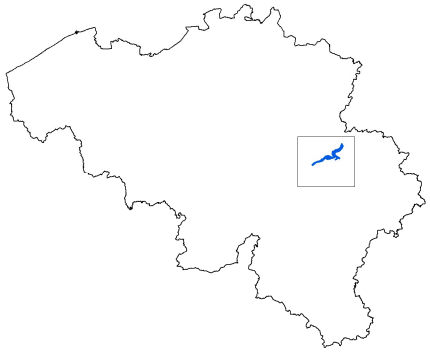
Evolution of SEQ-ESO index during 20 years simulation
Integrating several pollutant species

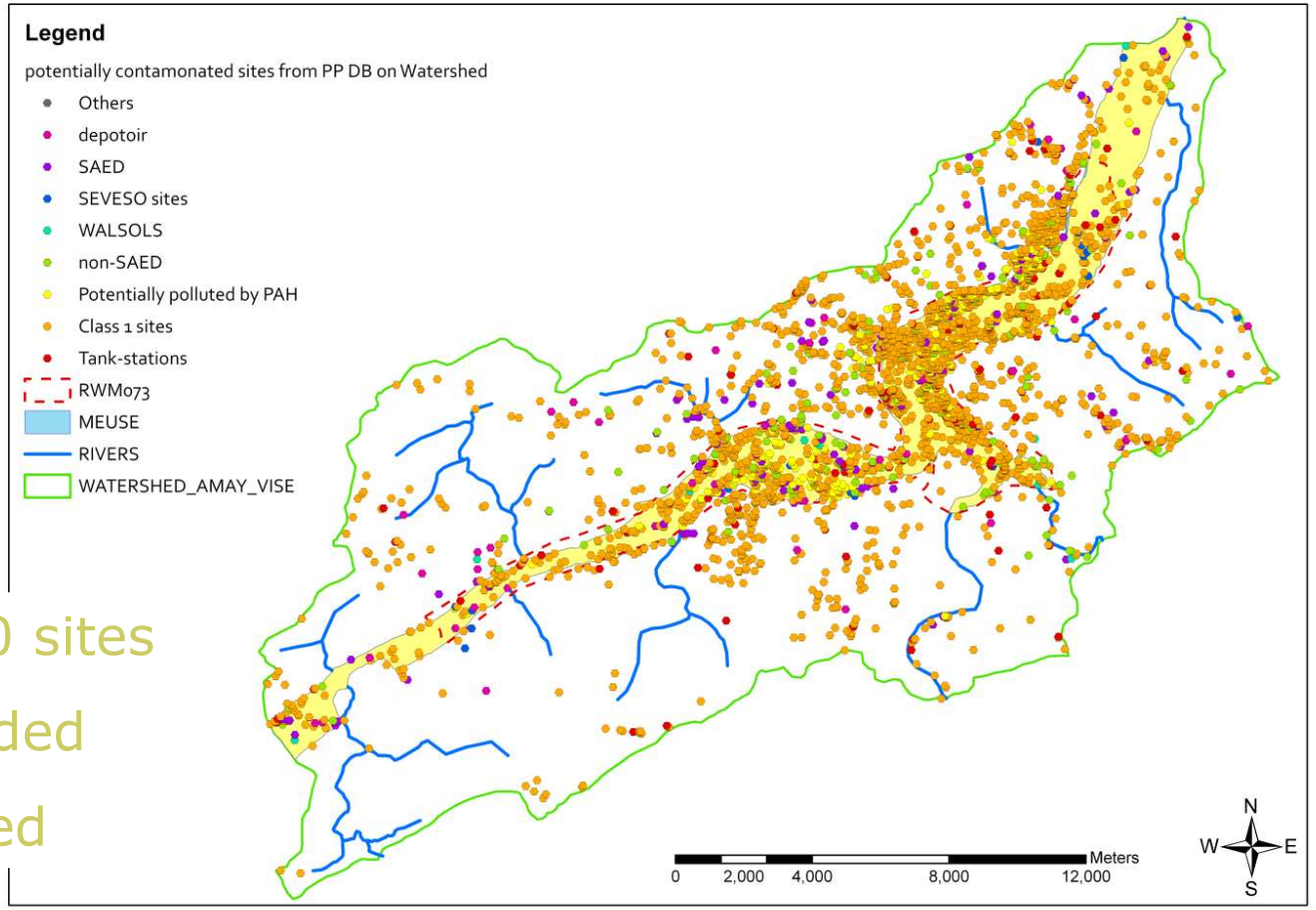




Application of methodology RWM073 case

- RWM073: Alluvial plain of the Meuse River between town of Engis and Herstal
- Heavy industrial past: metallurgy, cokery, mining, urban areas,…





On watershed: 3600 sites

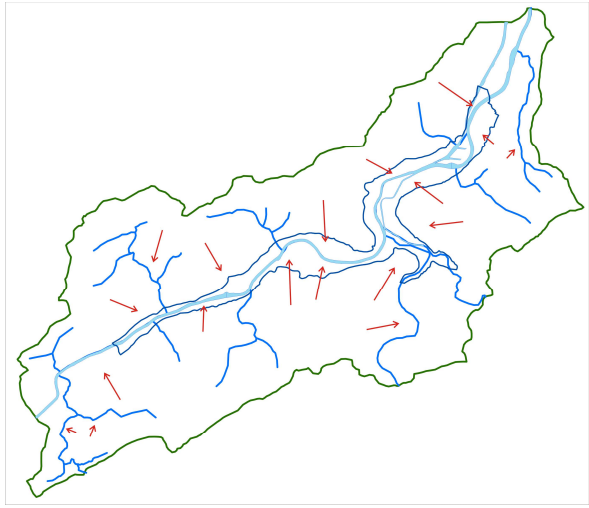
Some can be discarded

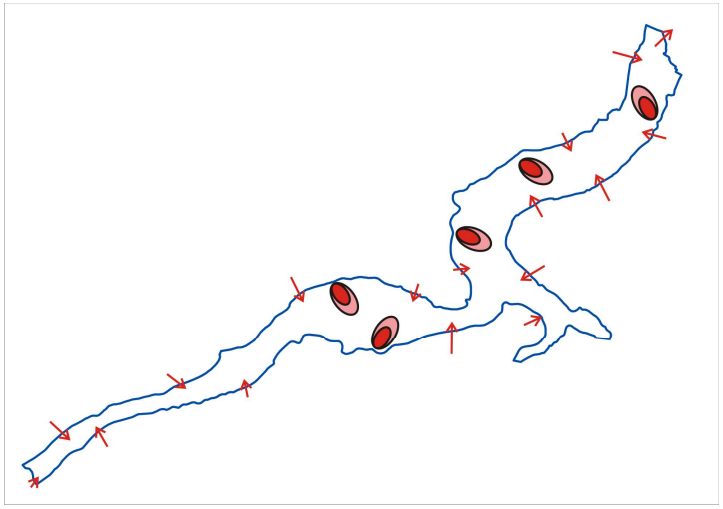
Only 13 characterized

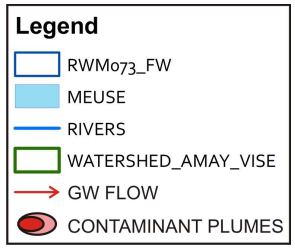
Application of methodology RWM073 case

RWM073 modelling

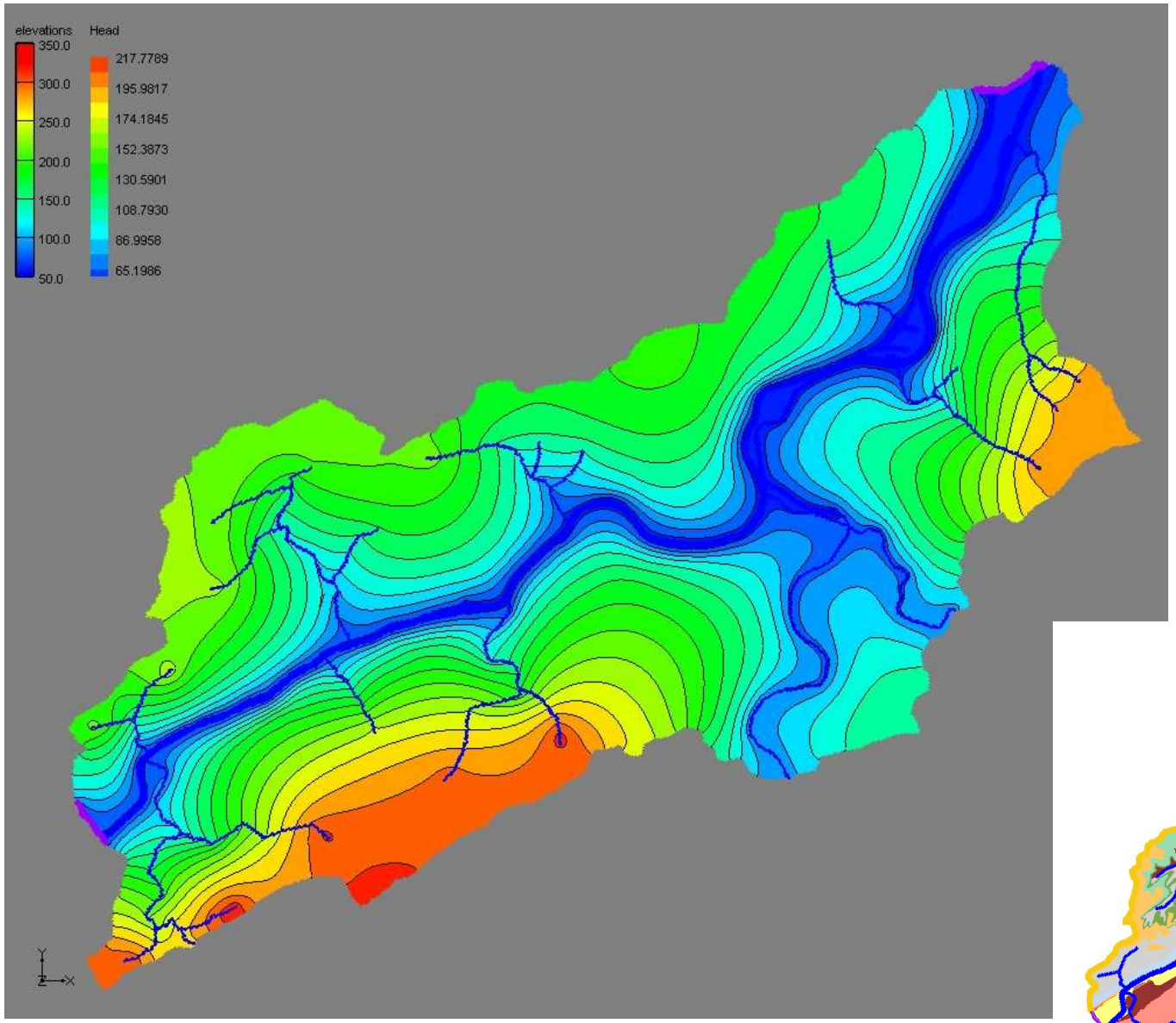
- Local alluvial aquifer fed by rainfall and runoff water from the slop of the watershed, and drained by the Meuse
- Watershed mainly composed by low permeable deposits but a groundwater flow occurs in the shallow altered fringe of those sediments from crest to alluvial plain
- Modelling Steps:
  - → Run GW flow model on the watershed
  - → Extract the results about GW flow and apply them on the alluvial plain boundaries
  - → Run GW transport model on the alluvial plain

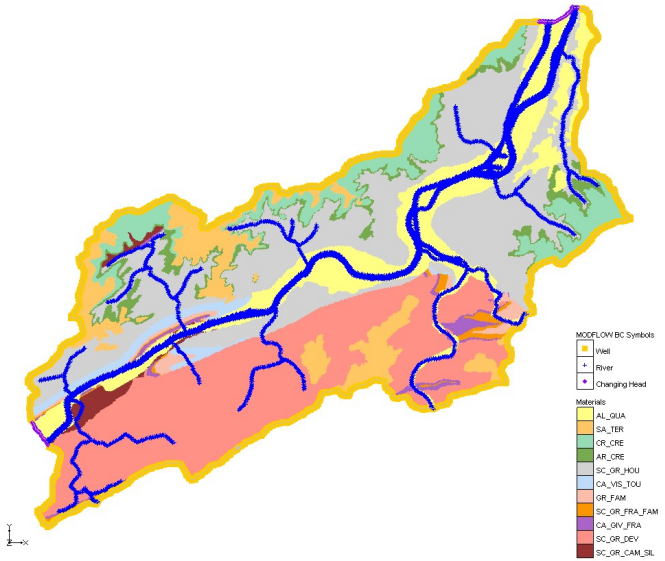




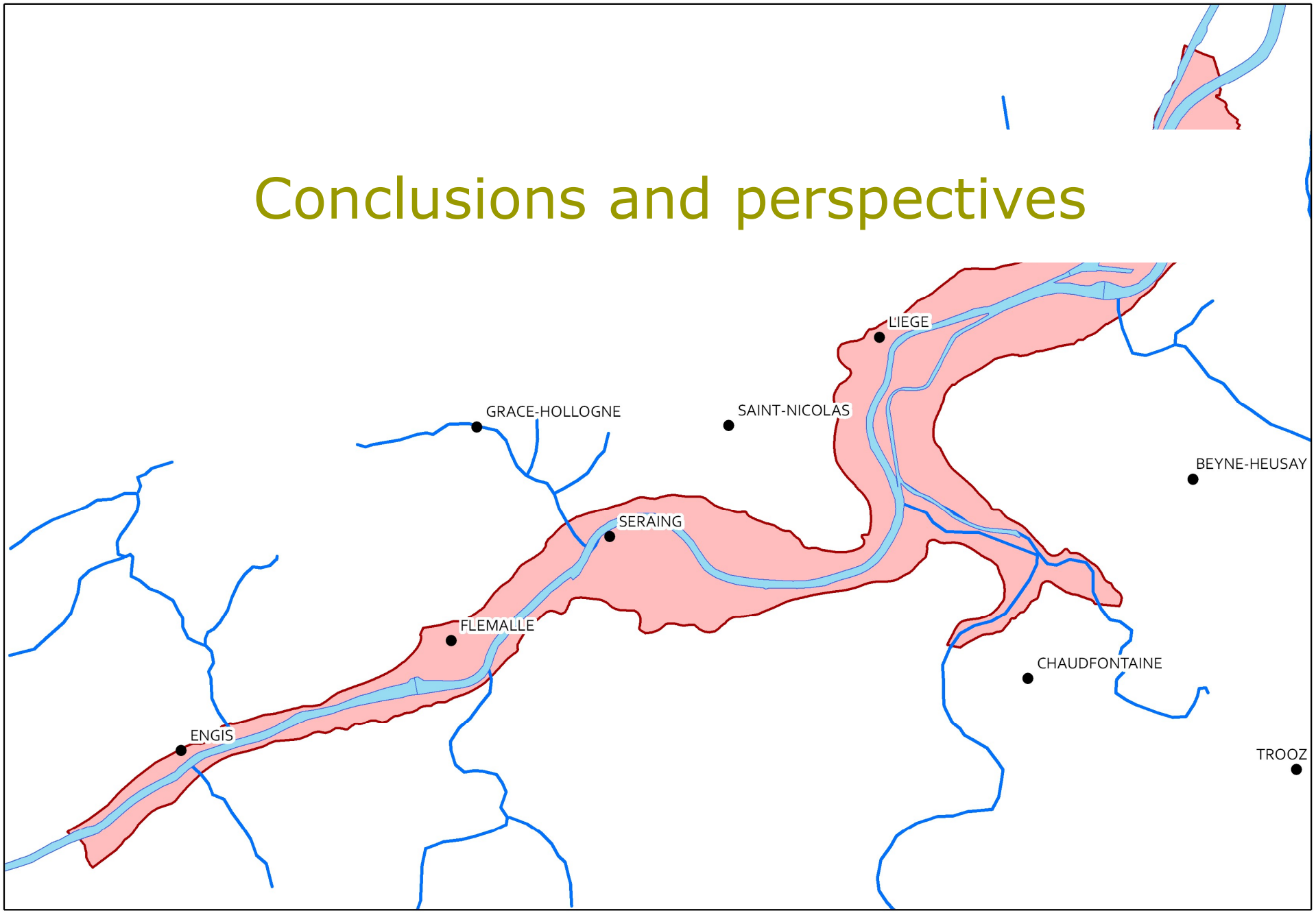


Application of methodology RWM073 case





Conclusions and perspectives



Conclusions and perspectives

- Main outcome if the research:
  - An efficient and flexible methodology of risk assessment for groundwater (or surface water) at the regional scale of the megasite (or groundwater body)
  - A physically based cumulative flux approach giving a global indicator of water quality/degradation
  - The easy usability of this indicator for costs and benefits analyse of management plans
  - The ability to test scenarios and model trends what is Water Framework Directive compliant

- First encouraging results that have to be push further:
  - Complete regional real application on RWM073
  - Complete the development and feed the GIS SPR data base
  - Integrate uncertainties/probabilistic scenarios of pollution sources, pollutants properties, GW flow,…
  - Perform socio-economical analysis (BRGM)
  - Integrate the ecotoxicological indicator of LEAE

Thank you for your attention