INTEGRATED RIVER-BASIN MODELLING AS A TOOL for WATER MANAGEMENT in the SCOPE of the WFD

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EURO INBO 2005, Namur, 29 – 30 SEPTEMBER 2005

Models & the implementation of the WFD

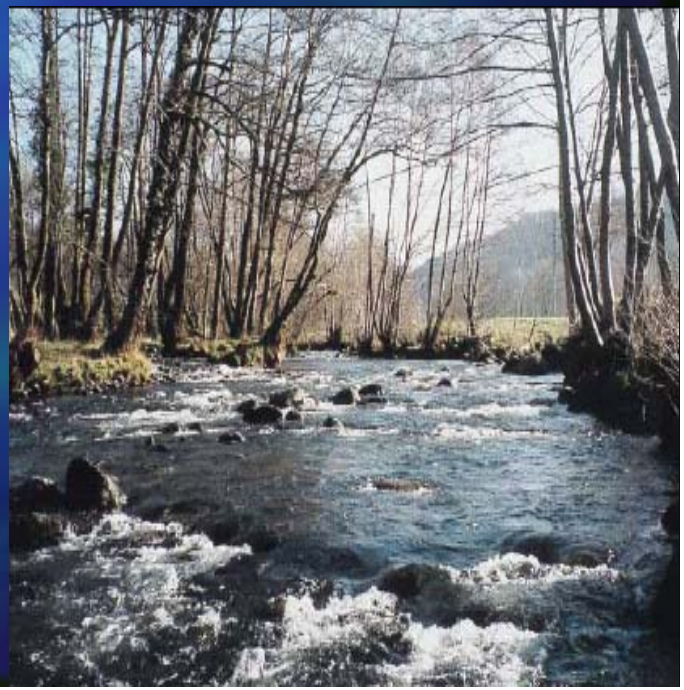
WFD :

- What are the effects of driving forces and pressures ?
- What is the impact ?
- What is the risk of not achieving the good status ?

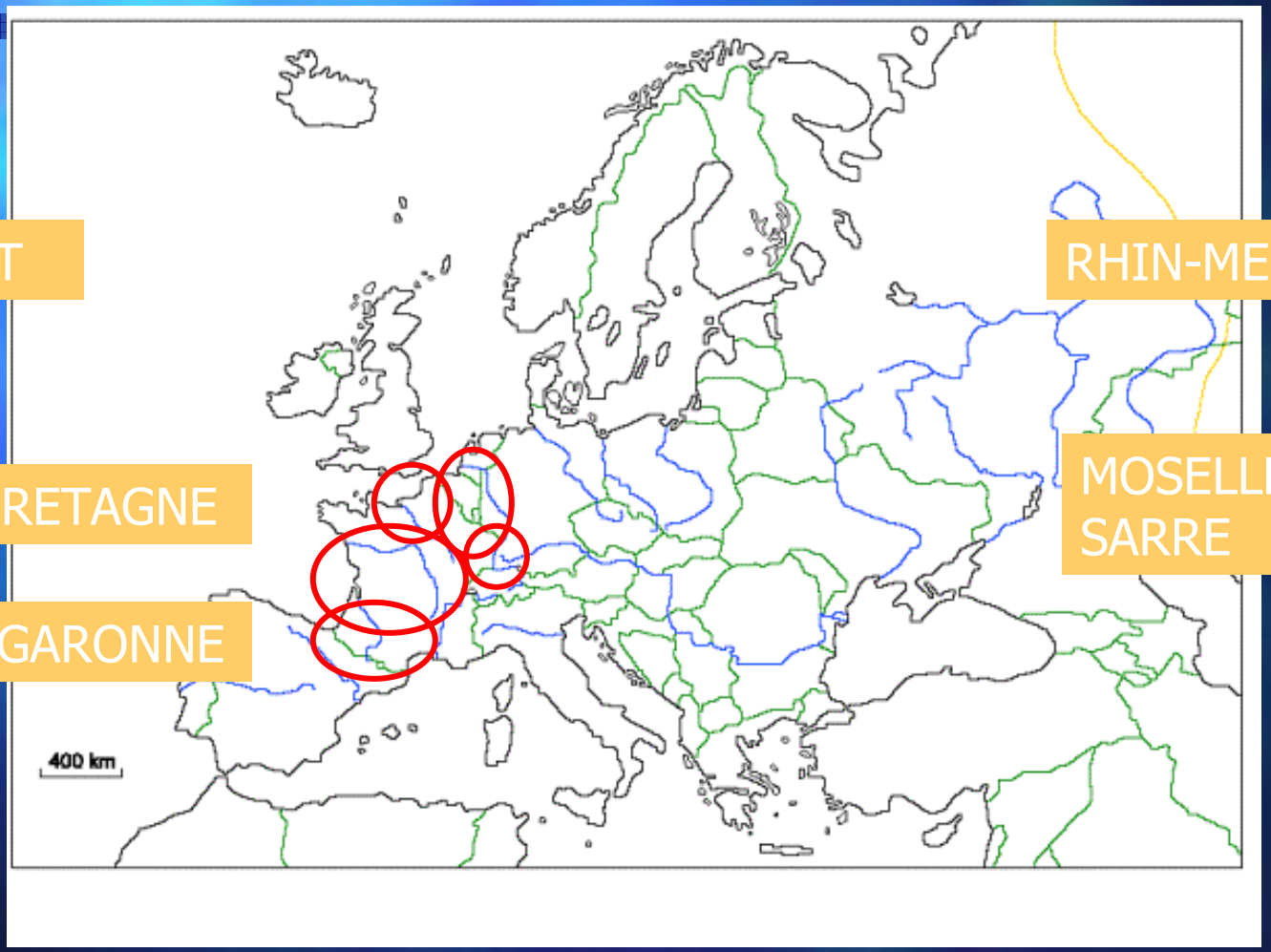
Some utilisations of the PEGASE model in the scope of the implementation of the WFD

realized by / in collaboration with > 8 Water Agencies

- Ministry of Environment, Région wallonne, Belgium
- Flanders Environment Agency, Belgium
- Rhin-Meuse Water Agency, France
- Artois-Picardie Water Agency, France
- Loire-Bretagne Water Agency, France
- Adour-Garonne Water Agency, France
- Water Administration, Luxemburg
- Saarland & Rhine-Palatine Environment Agencies, Germany
- several local Water Authorities



Some utilisations of the PEGASE model in the scope of the implementation of the WFD

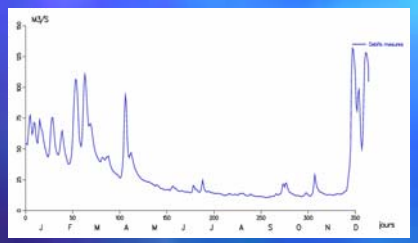


The PEGASE model

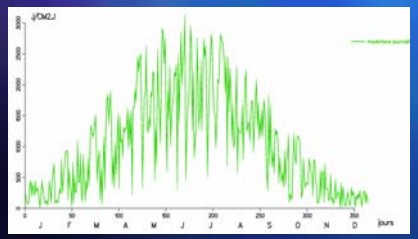
PEGASE = Planification Et Gestion de l'ASsainissement des Eaux

Inputs

Basins
Land use



Hydrographic network



Hydro-meteo

Driving forces / Pressures

PEGASE model

Outputs / results

Pollutant loads to the river network

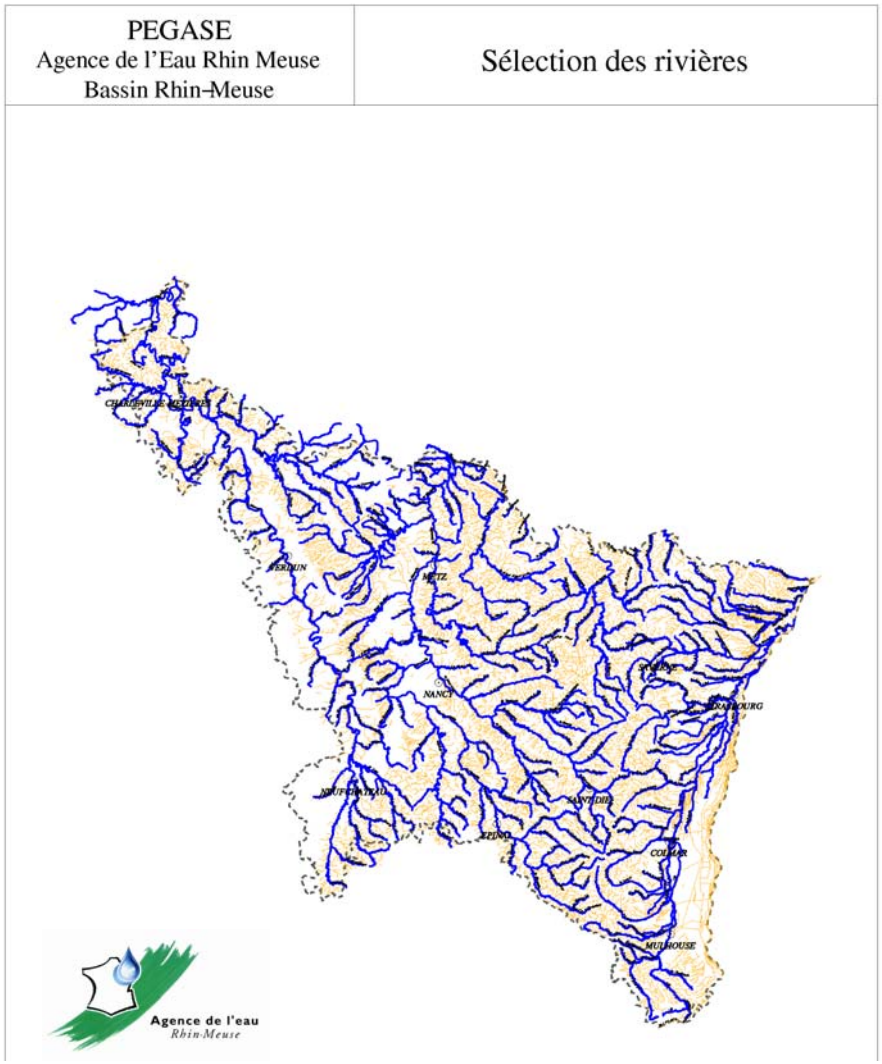
River flow & veloc.
Water temperature

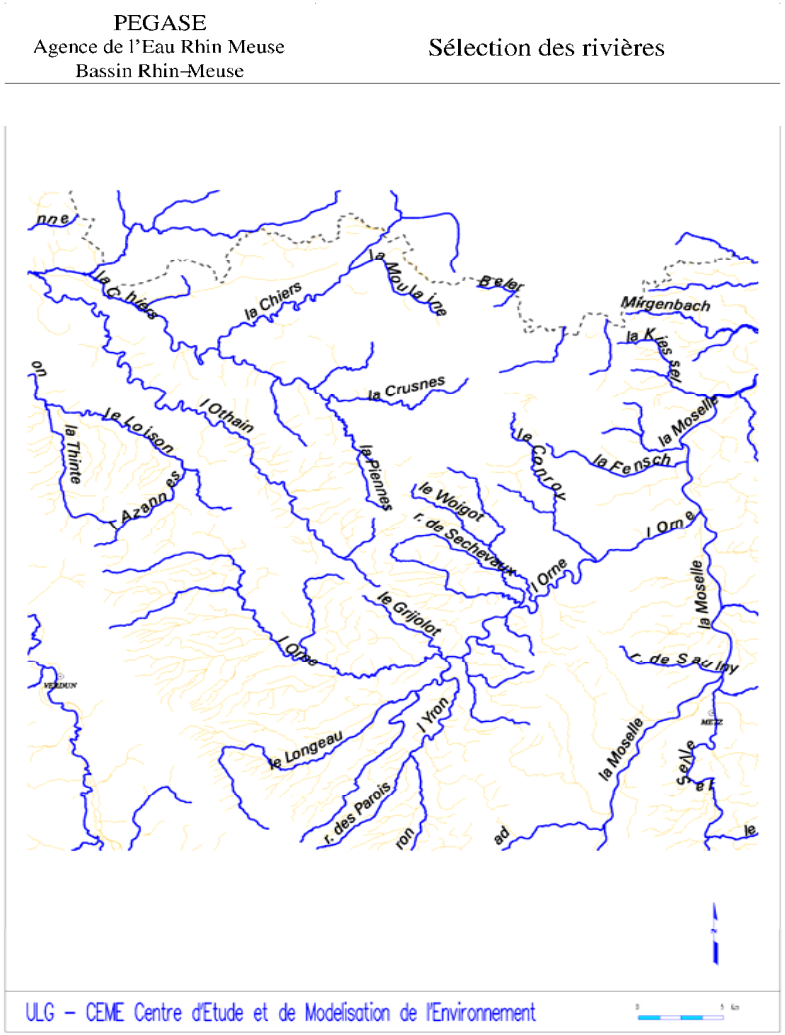
Biomasses
Ecosystem activity

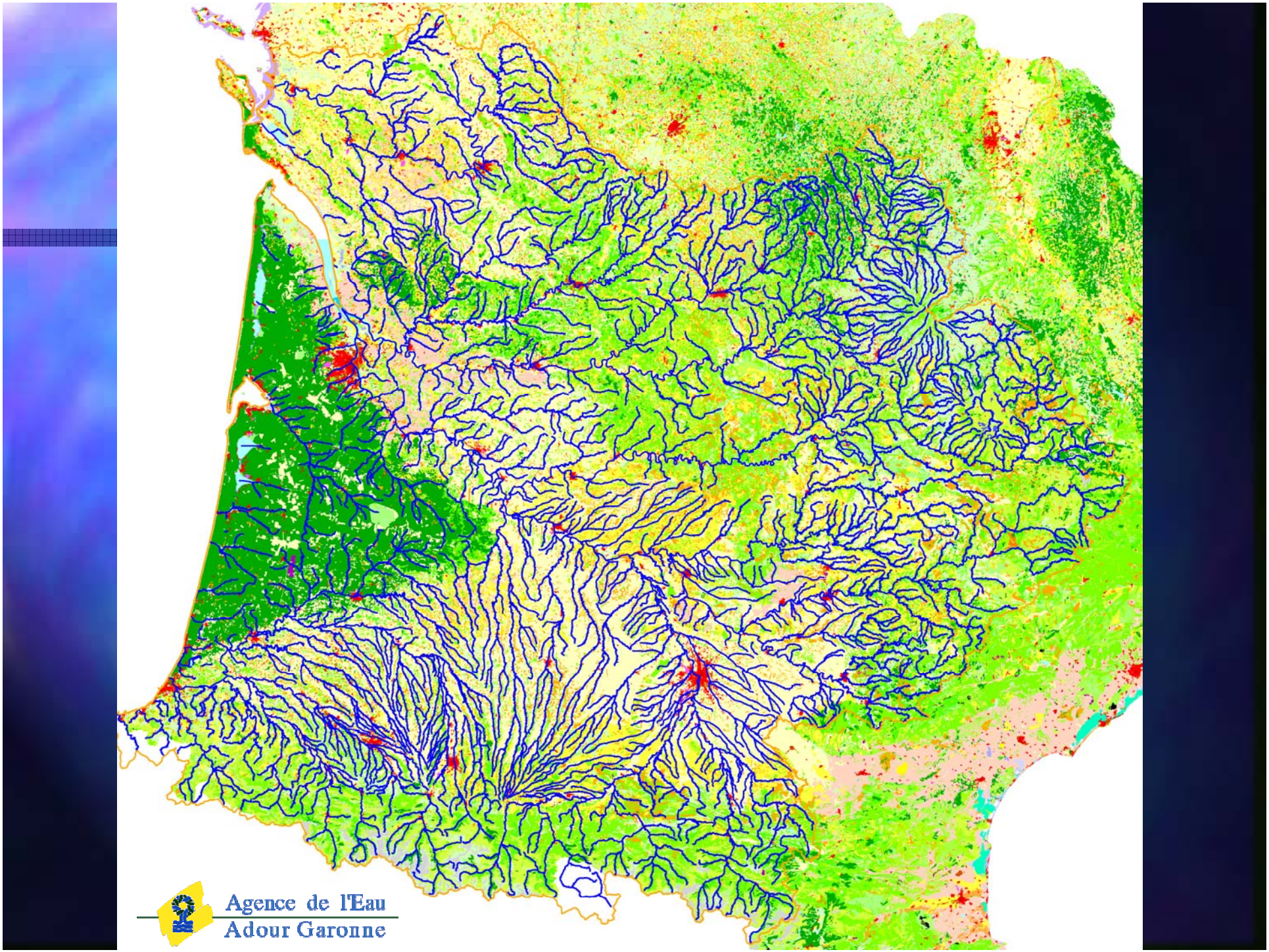
Water quality
Fluxes

Input data : geo- & hydrological referential

- DTM, land use, river network
- Selection of rivers that are included explicitely in the model





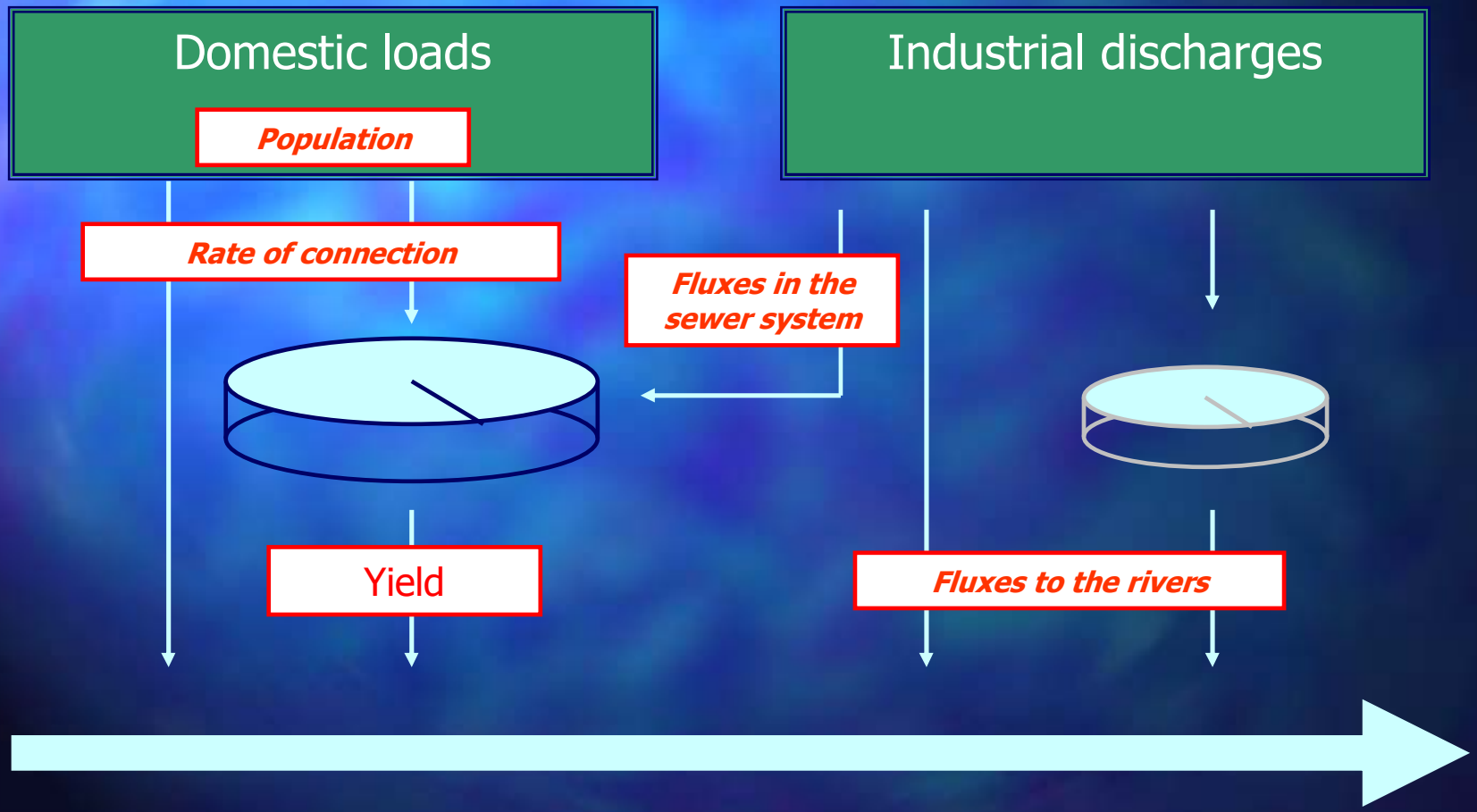

Agence de l'Eau
Adour Garonne

LE BASSIN LOIRE-BRETAGNE

Délimitation des principaux bassins hydrographiques

Input data : point discharges

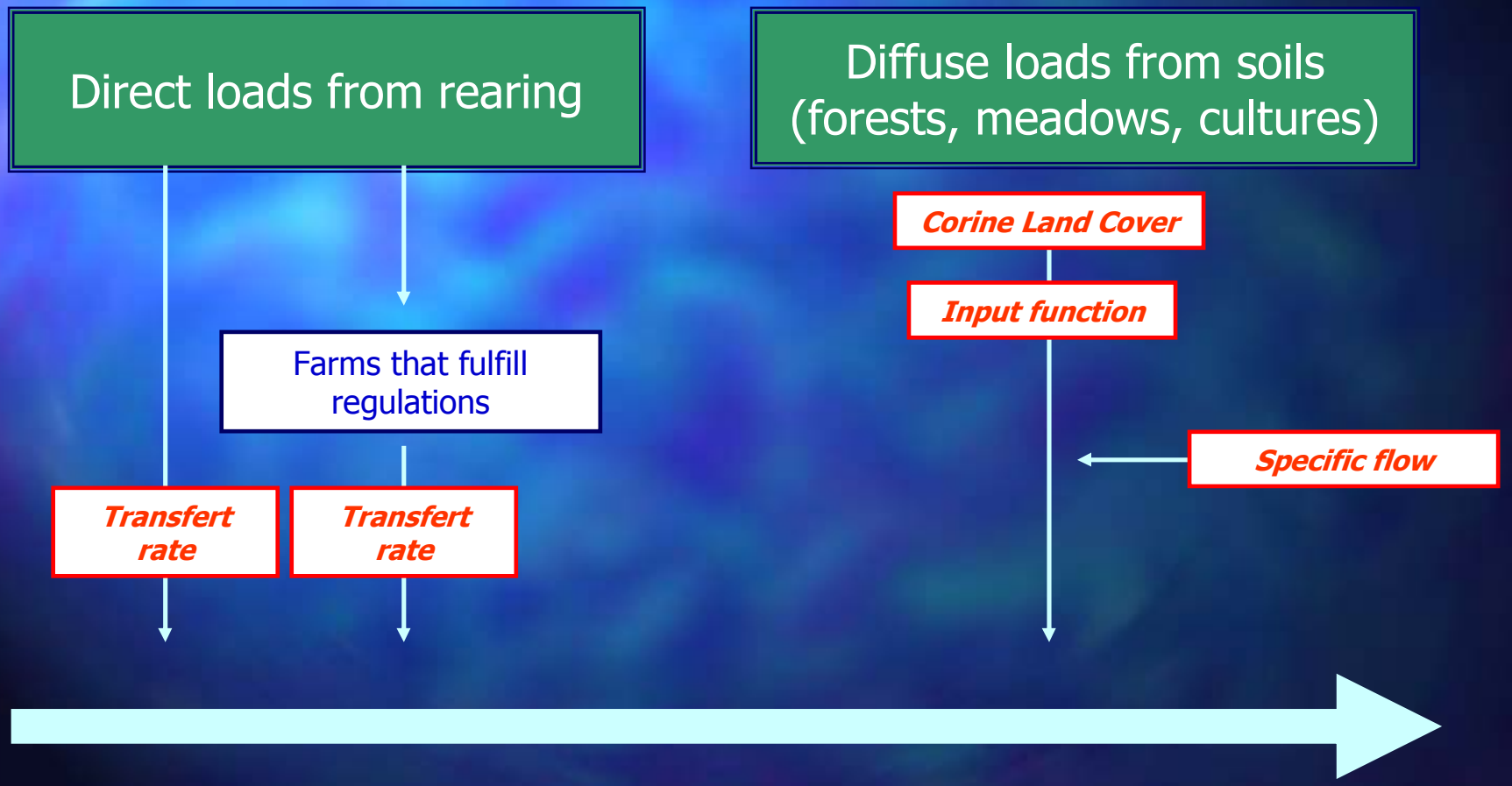
- Domestic loads (population) + industrial discharges
- Connections to sewer systems and purification plants



Source : Agence de l'Eau Rhin-Meuse

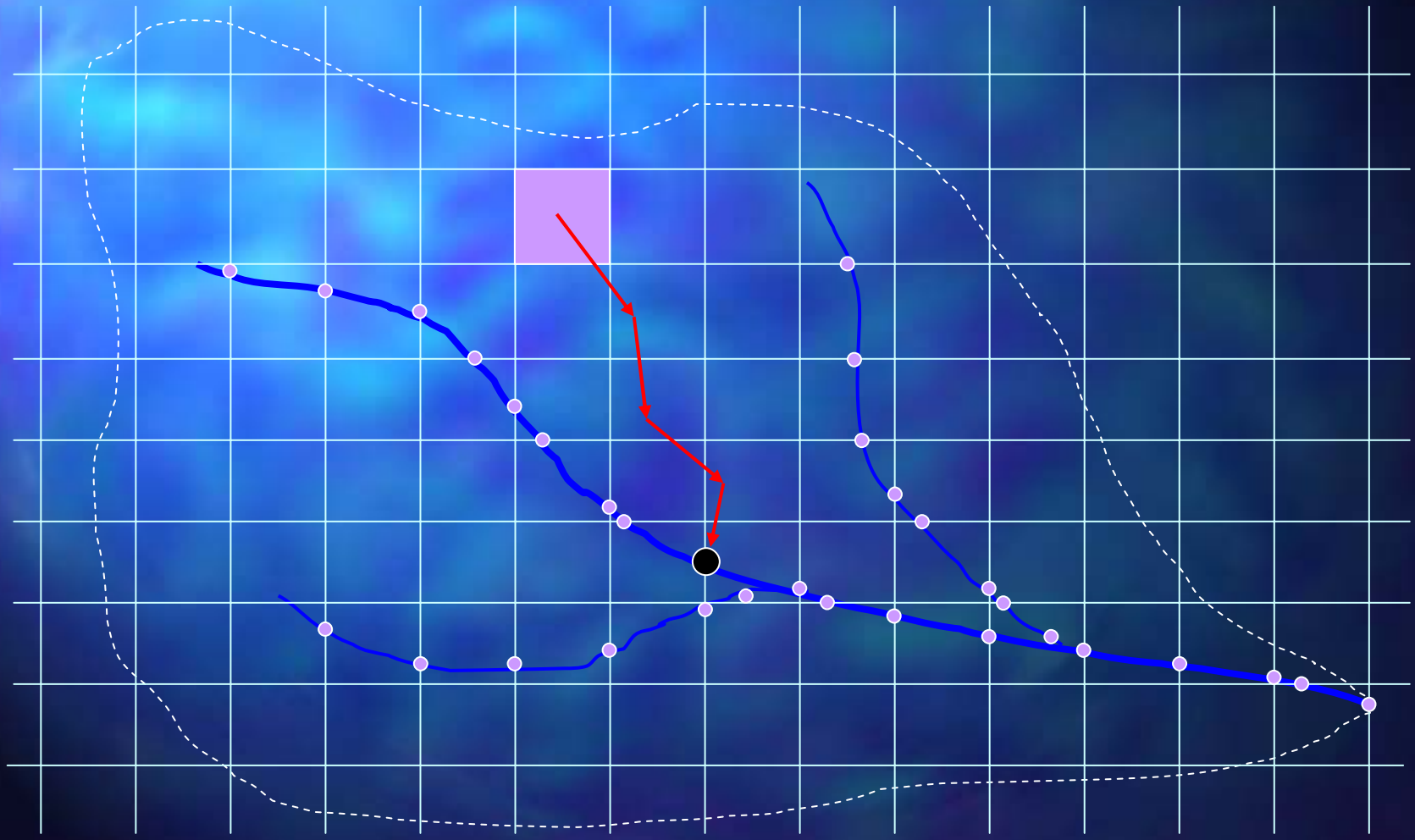
Diffuse loads : calculation of :

- Diffuse loads from soils : statistical functions (emission factors) depending on soil type and land use (forest, meadow, culture)
- Direct loads from rearing (bovine, porcine, … populations)



Source : Agence de l'Eau Rhin-Meuse

Diffuse loads



Source : AERM

PEGASE : calculations

- Calculation of the loads and discharges
  to the river network
- Calculation of the hydrological / hydraulic variables
- Calculation of ecosystem and water quality variables :
  The processes that are included are :
  . Physico-chemical processes
  . Primary production : phytoplancton, phytobenthos
  . Grazing : zooplancton
  . Organic matter degradation by bacteria
  (planctonic, biofilm, benthic)
  . Nitrification, denitrification
  . Oxygen productions and consumptions
  . Nutrient cycling processes

PEGASE : results

Non-stationnary (dynamic) simulation of :

- Flows, depths, velocities, … in the river network ($\Delta x \sim 300$ m)
- Ecosystem and water quality variables (daily / hourly) :
  - . Biomasses
  - . Concentrations (BOD, COD, DOC, POC, N, P, D.Oxygen, …)
  - . Fluxes
- Quality indexes (*Seq-Eau*) : scale 1 - 100
  5 levels

- Results : profiles (in space), evolutions (in time), maps, tables

The results can be calculated for each of the surface water bodies

PEGASE : utilisation in the scope of the WFD

THE SUCCESSIVE STEPS :

1) IMPLEMENTATION of the model in a basin (district)

Main characteristic of PEGASE : input = 'classical' data

2) VALIDATION of the model : simulation of past/present situations

Main characteristic of PEGASE :
very few or NO calibration needed (all processes are already calibrated)
calibration needed only for emission functions of diffuse loads

3) PRESSURE / IMPACT ANALYSIS (Art. 5 analysis)

Assessment of the impacts of domestic, industrial, diffuse loads

4) SIMULATION OF SCENARIO'S (2015 scenario's)

Assessment of the **RISK** of failing to meet the GOOD STATUS

5) SIMULATION OF ADDITIONAL MEASURES

=> preparation of the River Basin Management Plans (2009)
=> support for the public participation / consultation

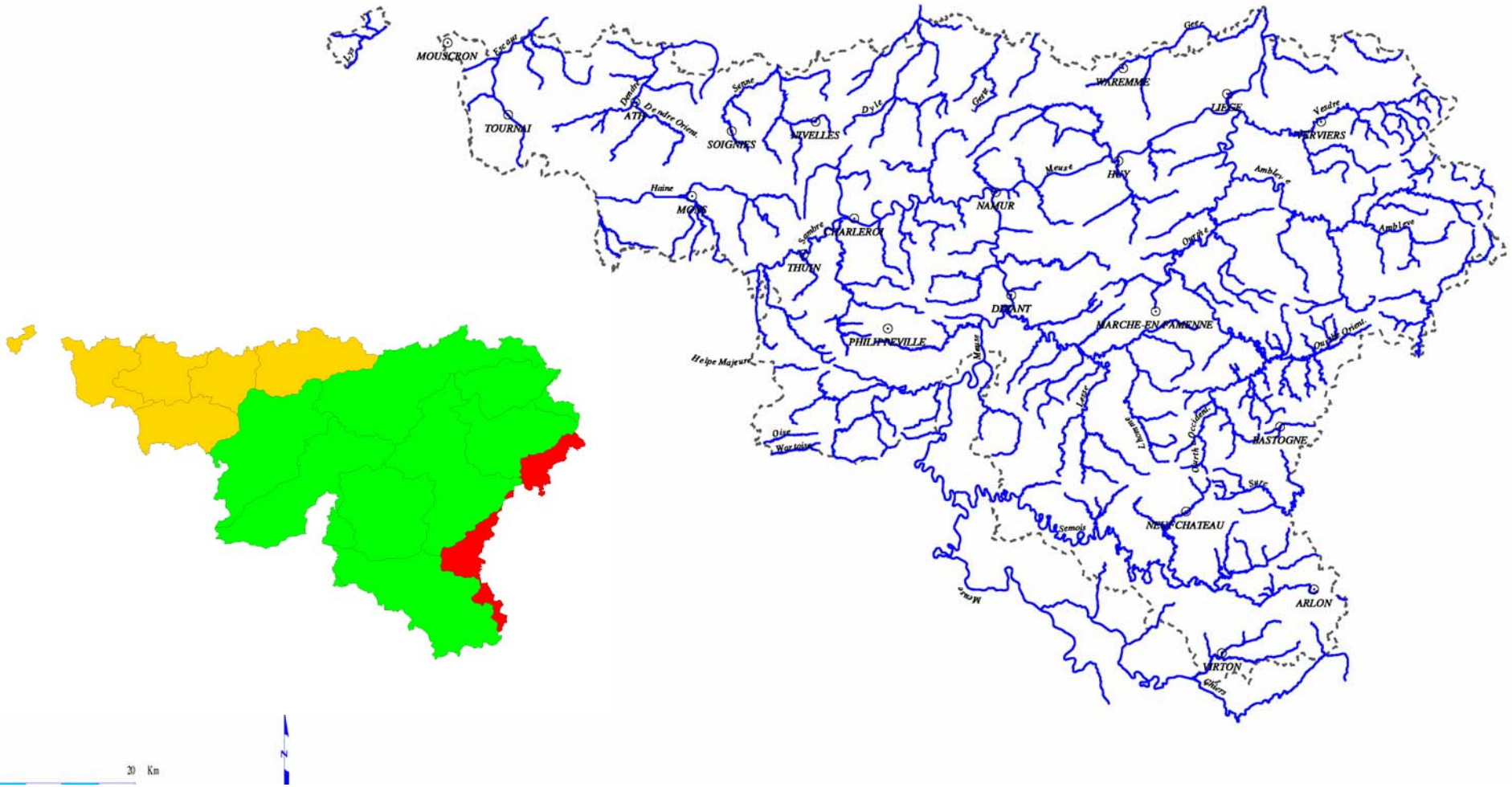
6) SUPPORT for the DESIGN of the MONITORING NETWORKS

PEGASE : Région wallonne

VALIDATION : SIMULATION OF PAST / PRESENT SITUATIONS

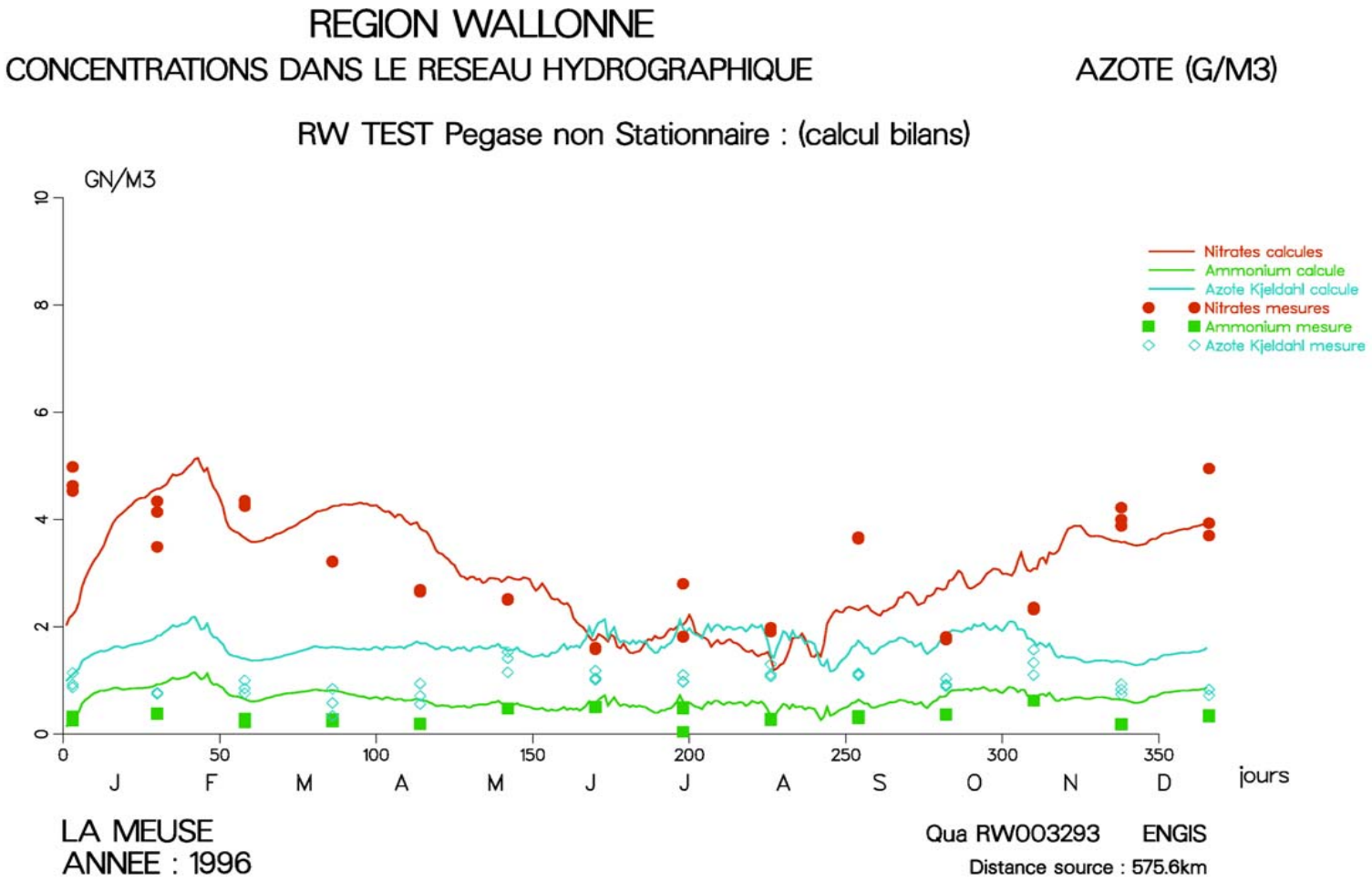
PEGASE River Model
Région Wallonne

Sélection des rivières



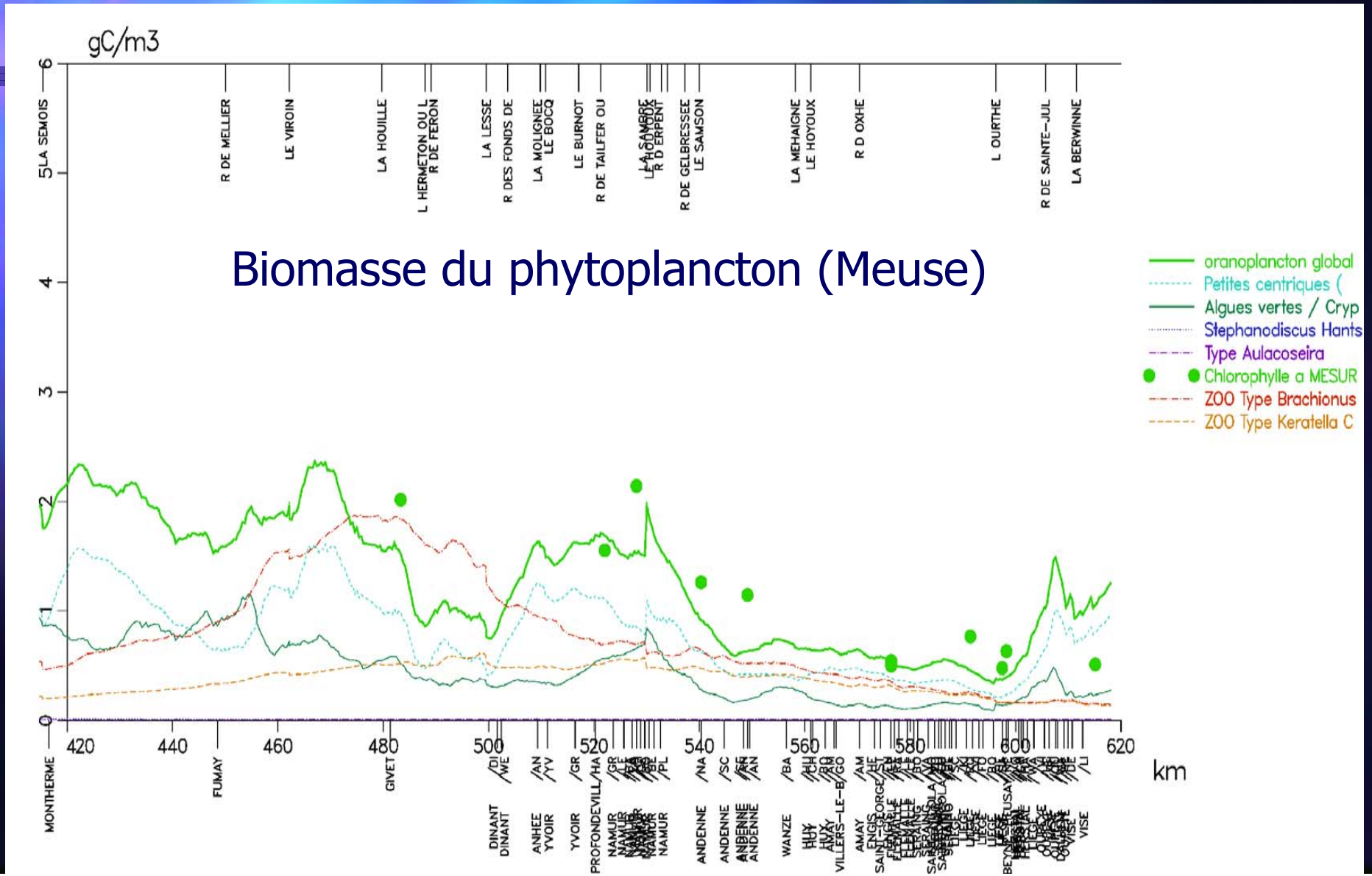
PEGASE : Région wallonne

VALIDATION : SIMULATION OF PAST / PRESENT SITUATIONS



PEGASE : Région wallonne

VALIDATION : SIMULATION OF PAST / PRESENT SITUATIONS



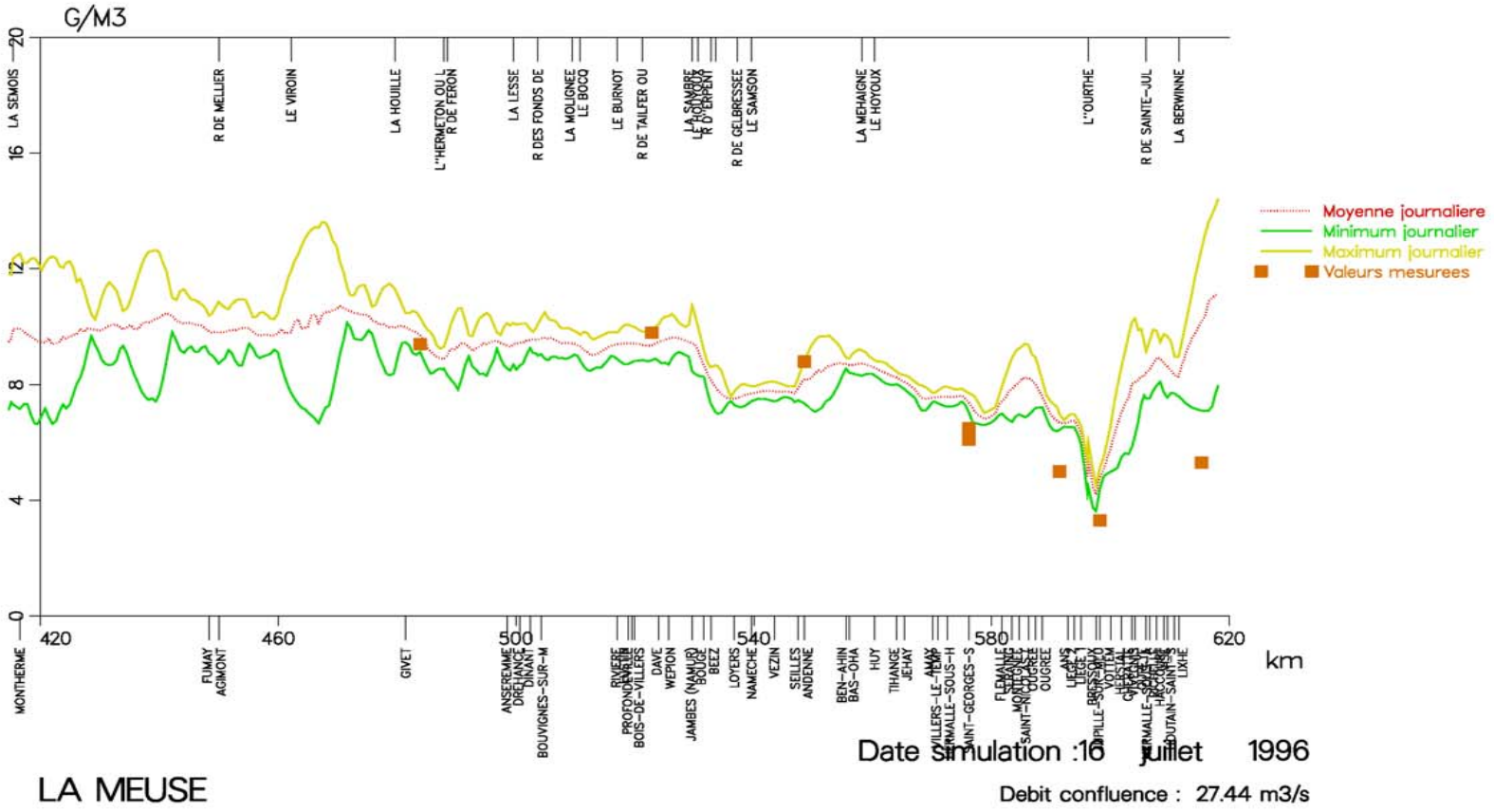
PEGASE : Région wallonne

VALIDATION : SIMULATION OF PAST / PRESENT SITUATIONS

REGION WALLONNE

CONCENTRATIONS DANS LE RESEAU HYDROGRAPHIQUE OXYGENE (G/M3)

RW TEST Pegase non Stationnaire : (calcul bilans)



Date simulation :16 juillet 1996

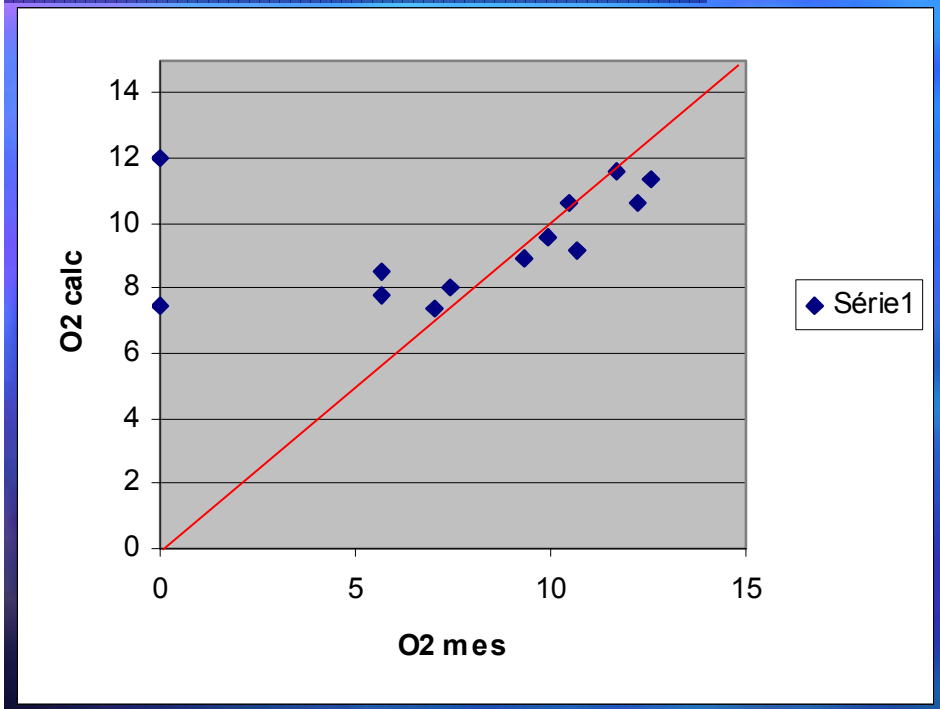
LA MEUSE

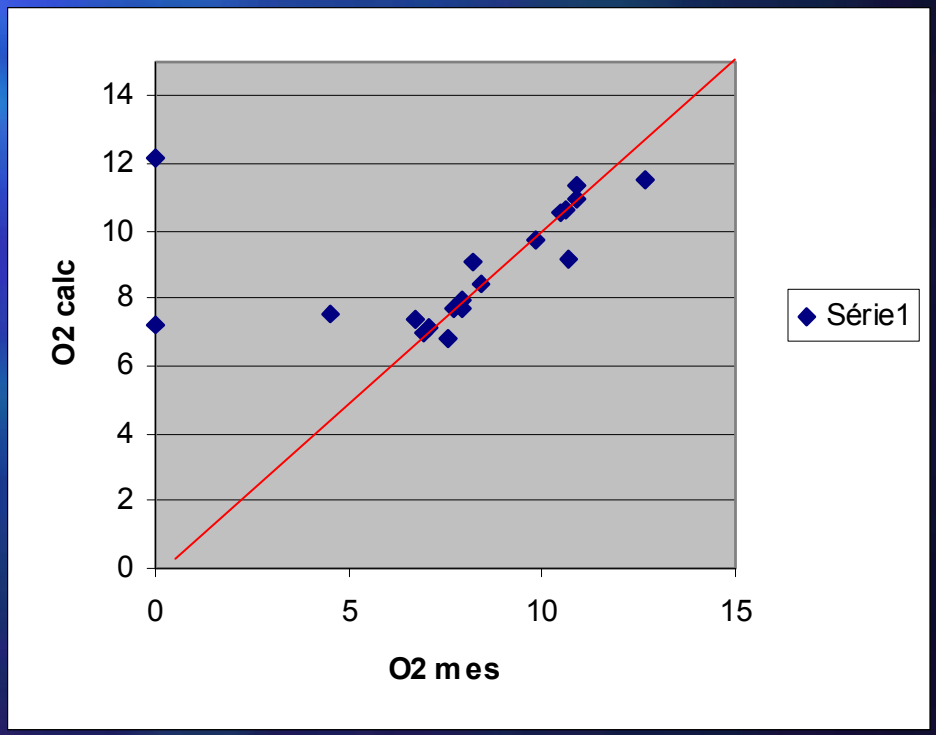
Debit confluence : 27.44 m3/s

PEGASE : Région wallonne

VALIDATION : SIMULATION OF PAST / PRESENT SITUATIONS

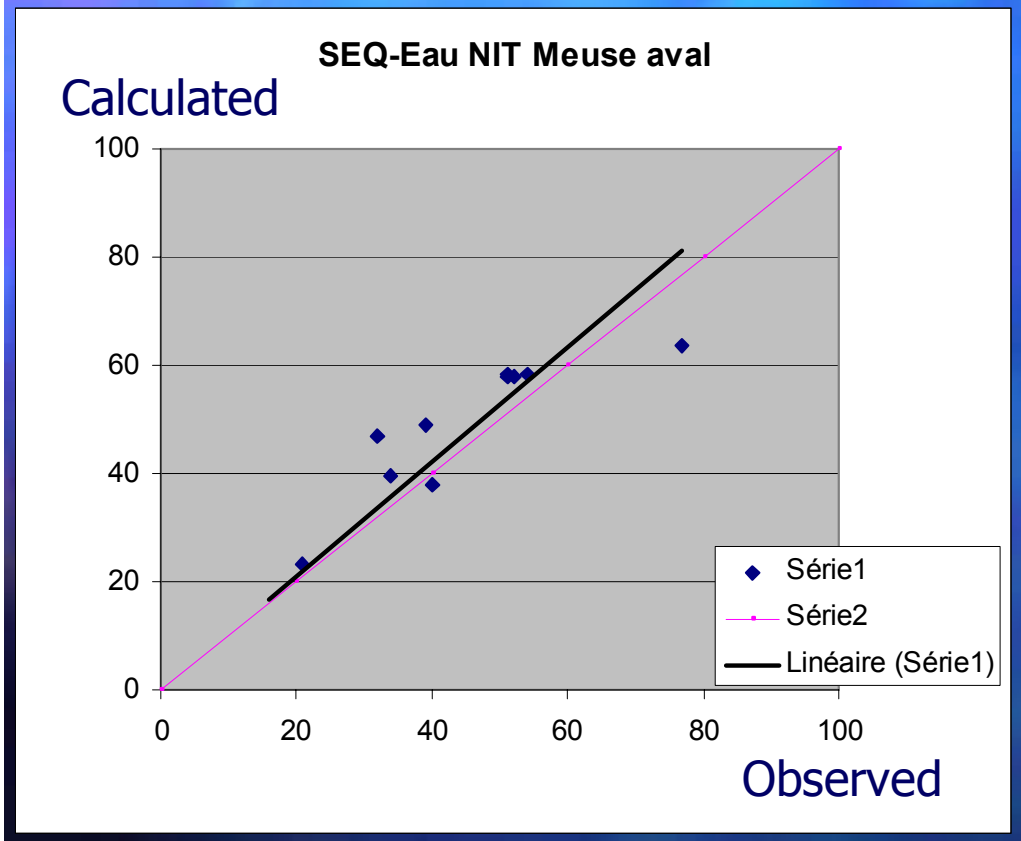
MEUSE Liege & Vise – Year 2002 : Comparison
OBSERVED vs CALCULATED values of Dissolved Oxygen concentrations (mg O2 / l)





PEGASE : Région wallonne

VALIDATION : SIMULATION OF PAST / PRESENT SITUATIONS

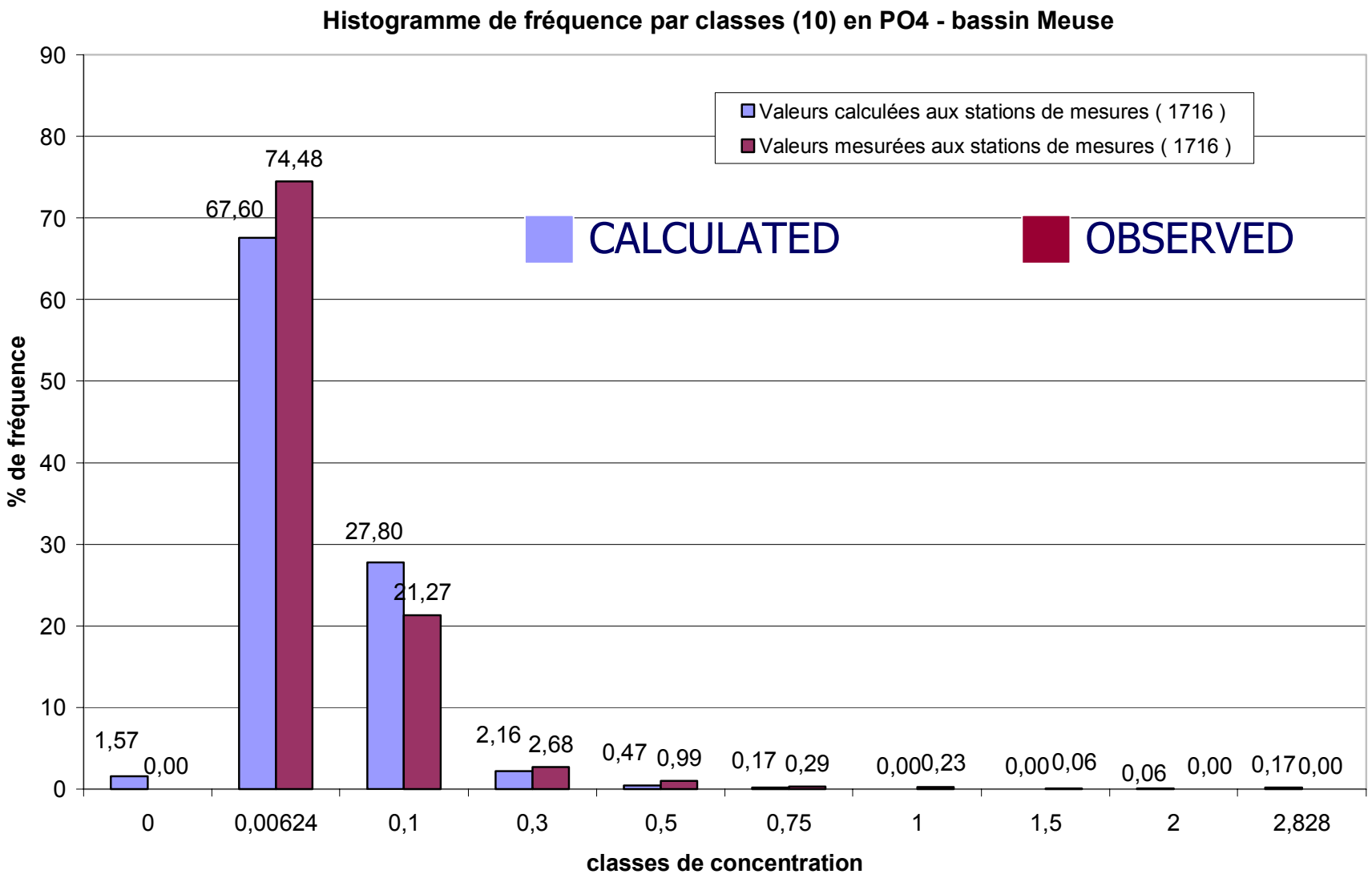


MEUSE Liege – Year 2002 :
Comparison
OBSERVED vs CALCULATED values
SEQ-EAU INDEXES

PEGASE : Région wallonne

VALIDATION : SIMULATION OF PAST / PRESENT SITUATIONS

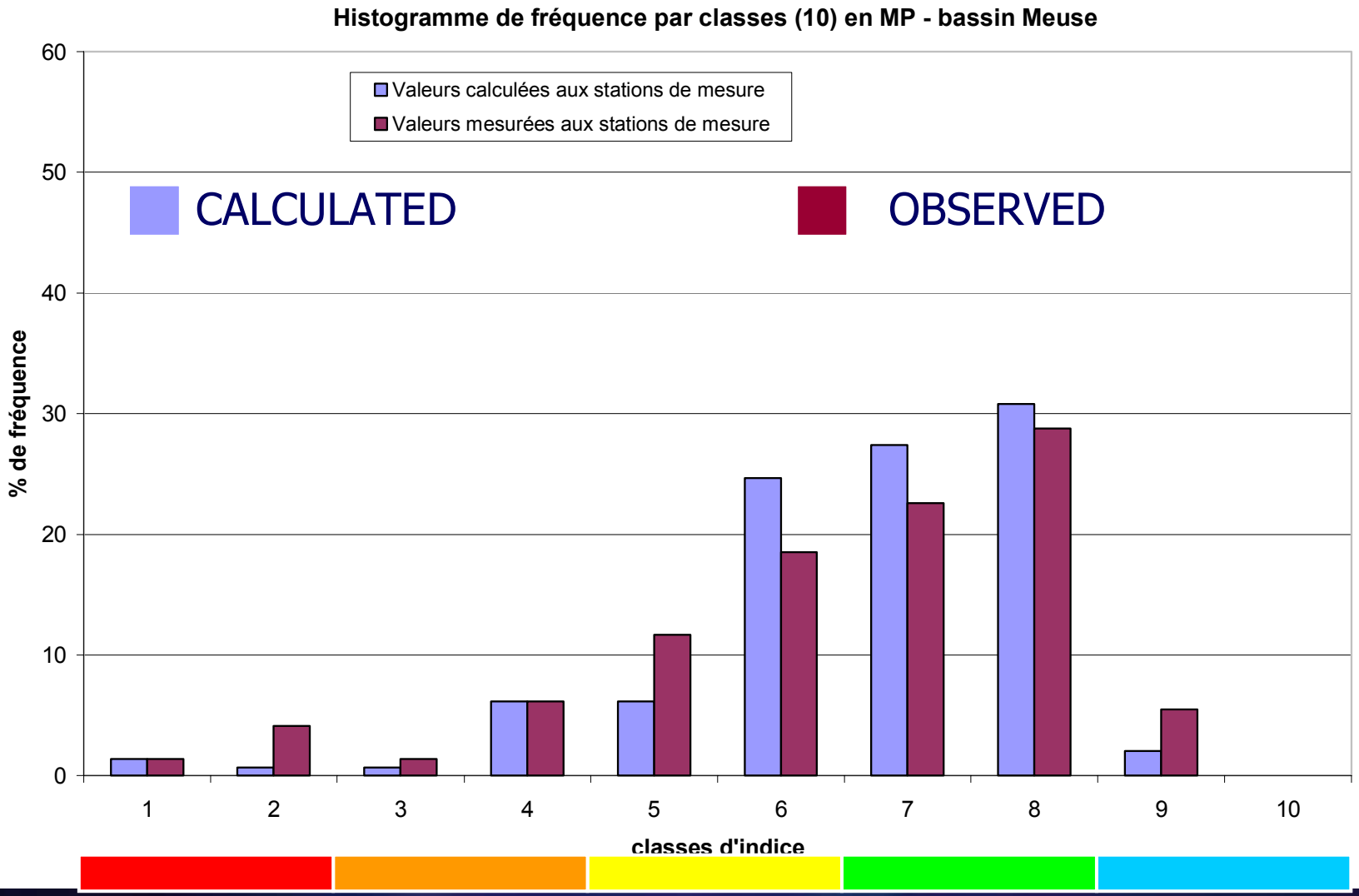
MEUSE basin in Wallonia : PO4 concentrations - Year 2002



PEGASE : Région wallonne

VALIDATION : SIMULATION OF PAST / PRESENT SITUATIONS

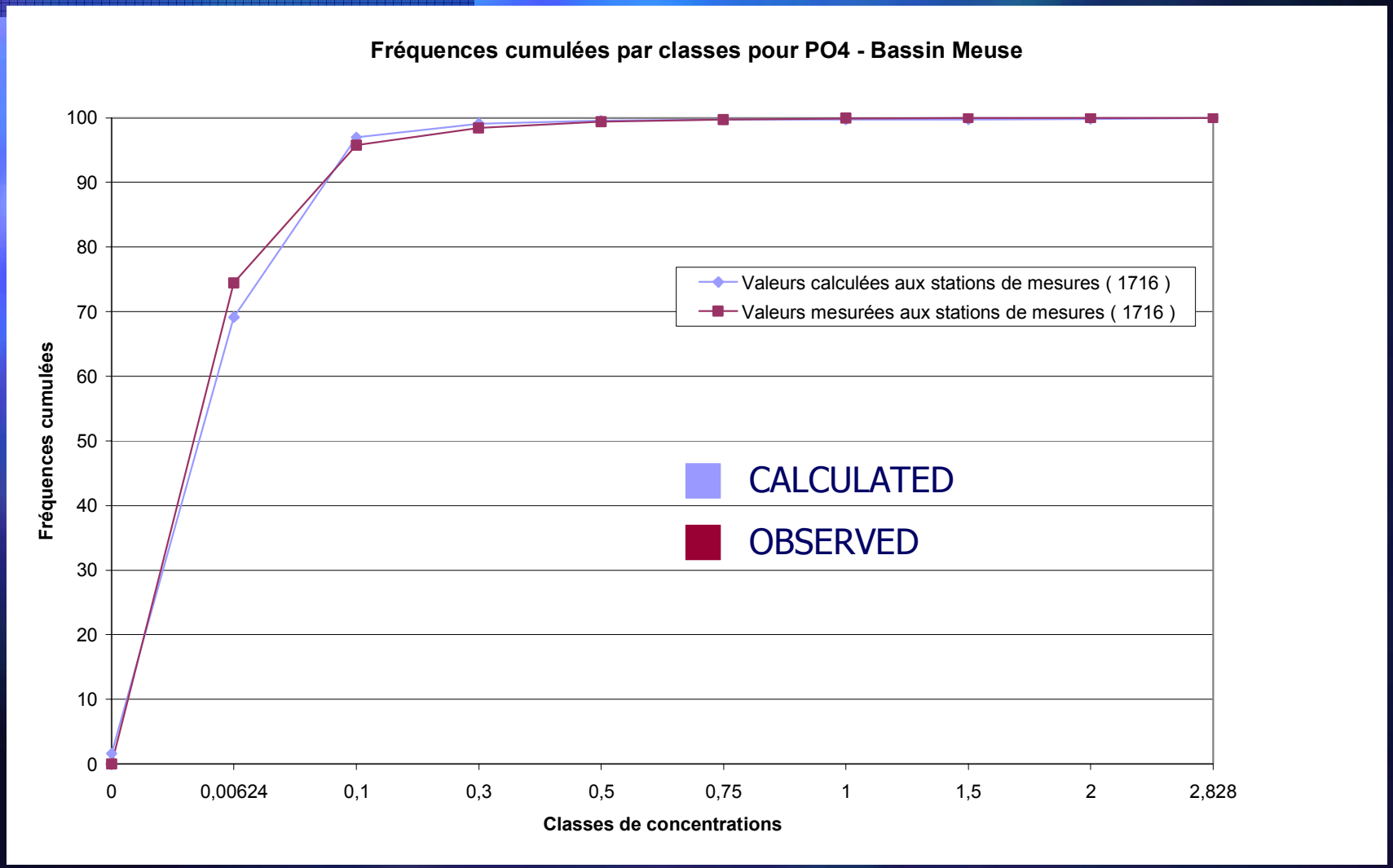
MEUSE basin in Wallonia : PHOSPHORUS quality index - Year 2002



PEGASE : Région wallonne

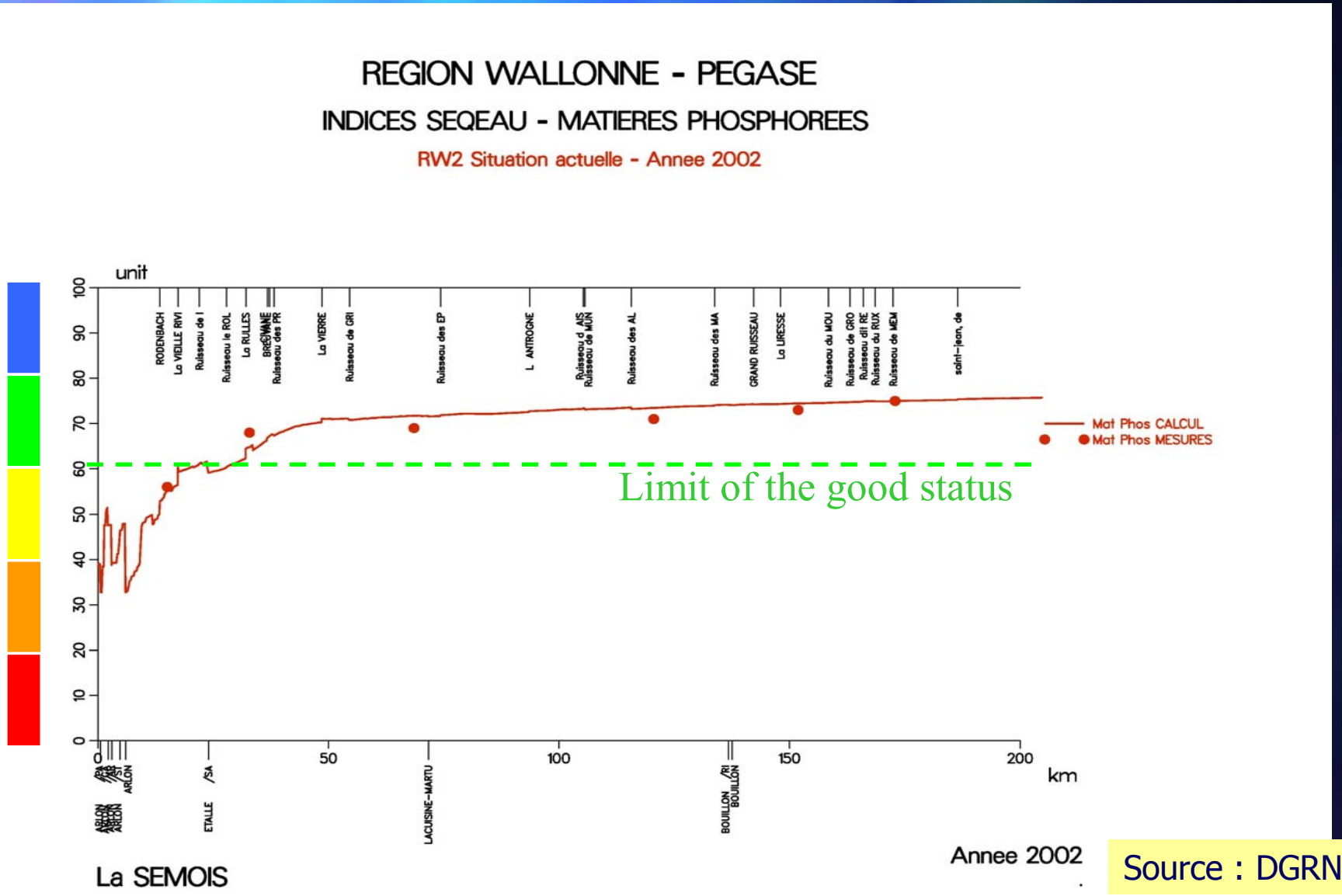
VALIDATION : SIMULATION OF PAST / PRESENT SITUATIONS

MEUSE basin in Wallonia : cumulative distribution of PO4 concentrations (calculated + observed) - Year 2002



PEGASE : utilisation in the scope of the WFD

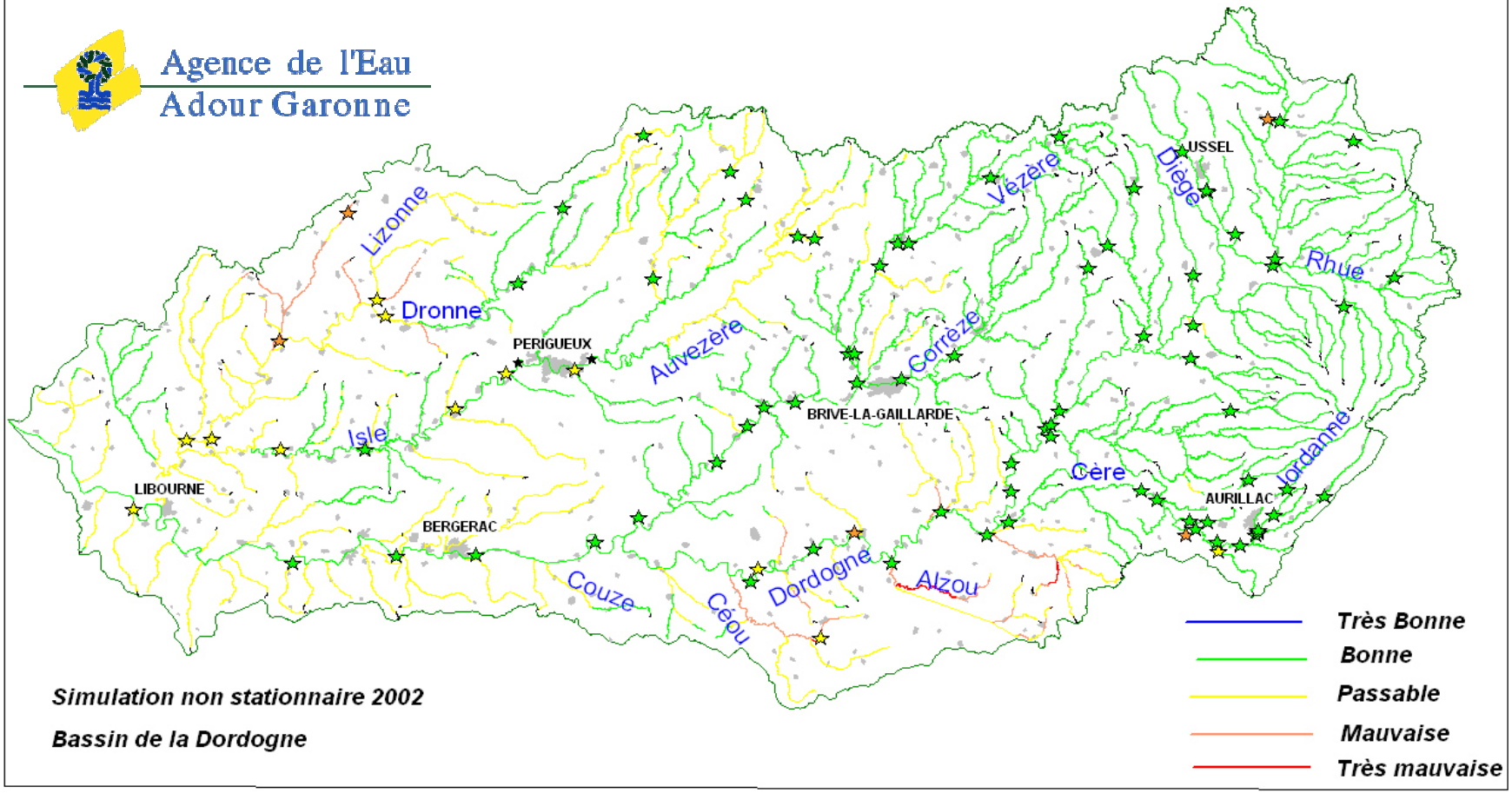
VALIDATION : SIMULATION OF PAST / PRESENT SITUATIONS



Source : DGRNE

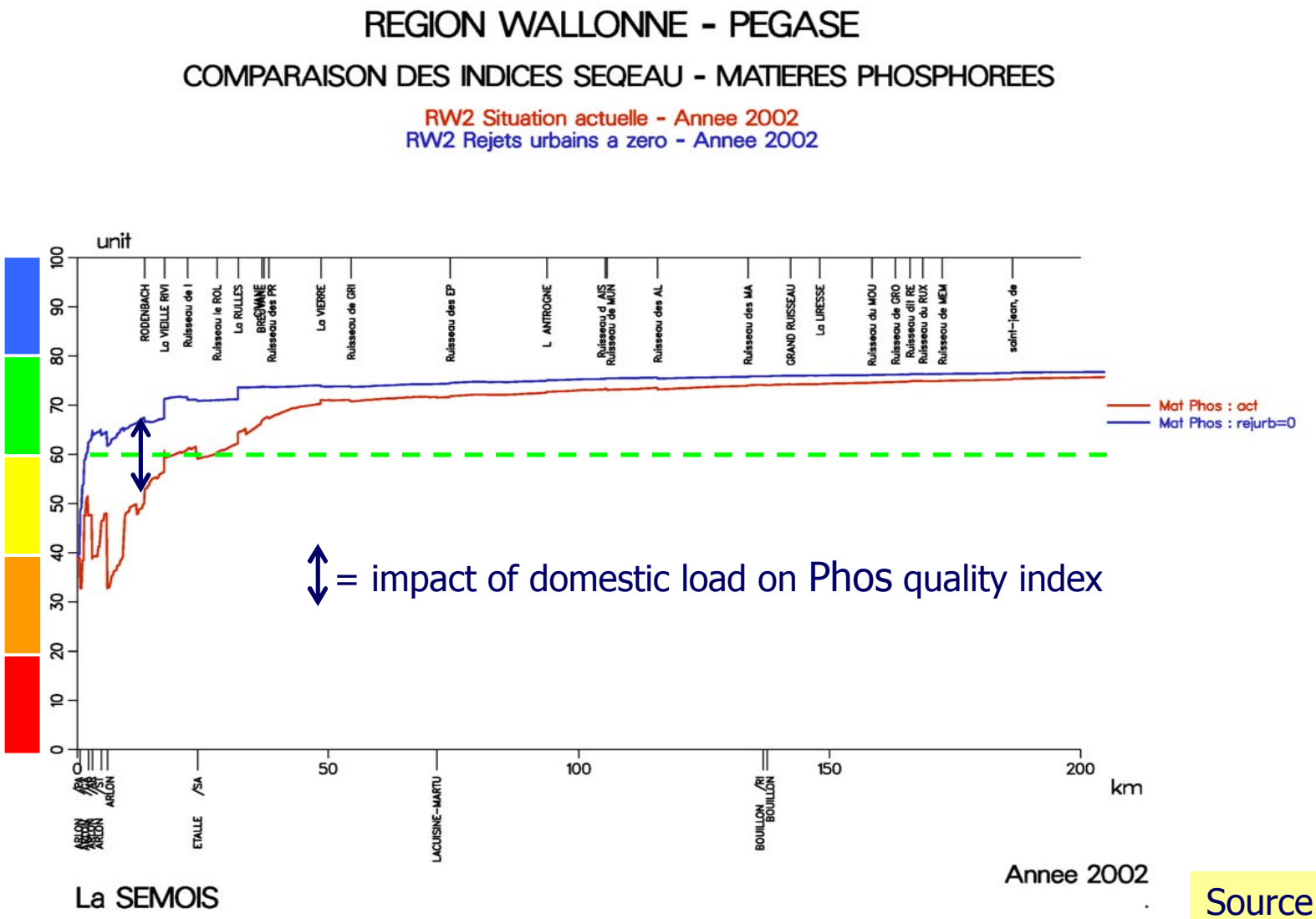
PEGASE : utilisation in the scope of the WFD

VALIDATION : SIMULATION OF PAST / PRESENT SITUATIONS



PEGASE : utilisation in the scope of the WFD

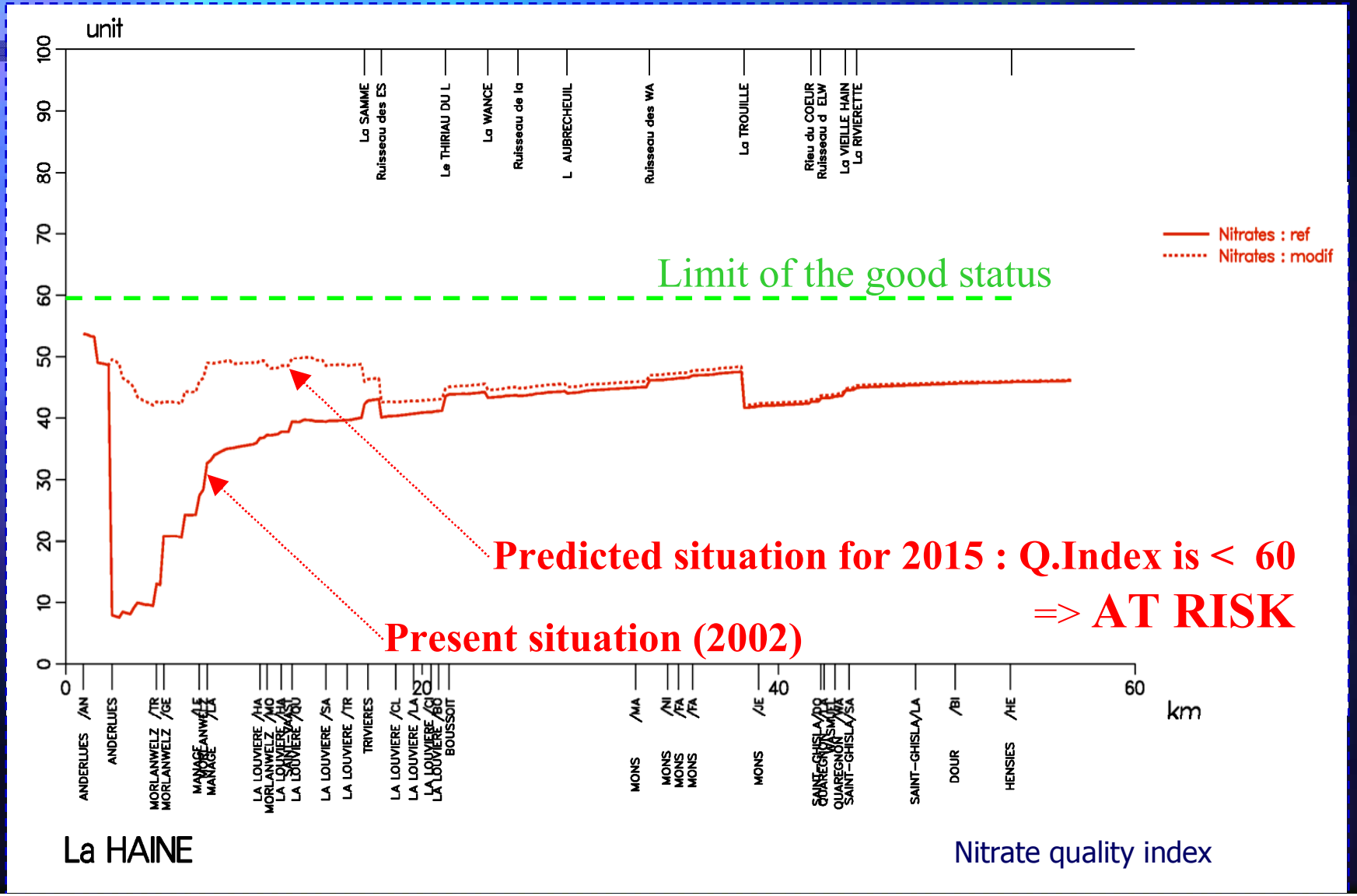
ANALYSIS OF PRESSURE / IMPACT RELATIONS



Source : DGRNE

PEGASE : utilisation in the scope of the WFD

SIMULATION OF 2015 SCENARIO'S / ASSESSMENT OF THE RISK



PEGASE : utilisation in the scope of the WFD

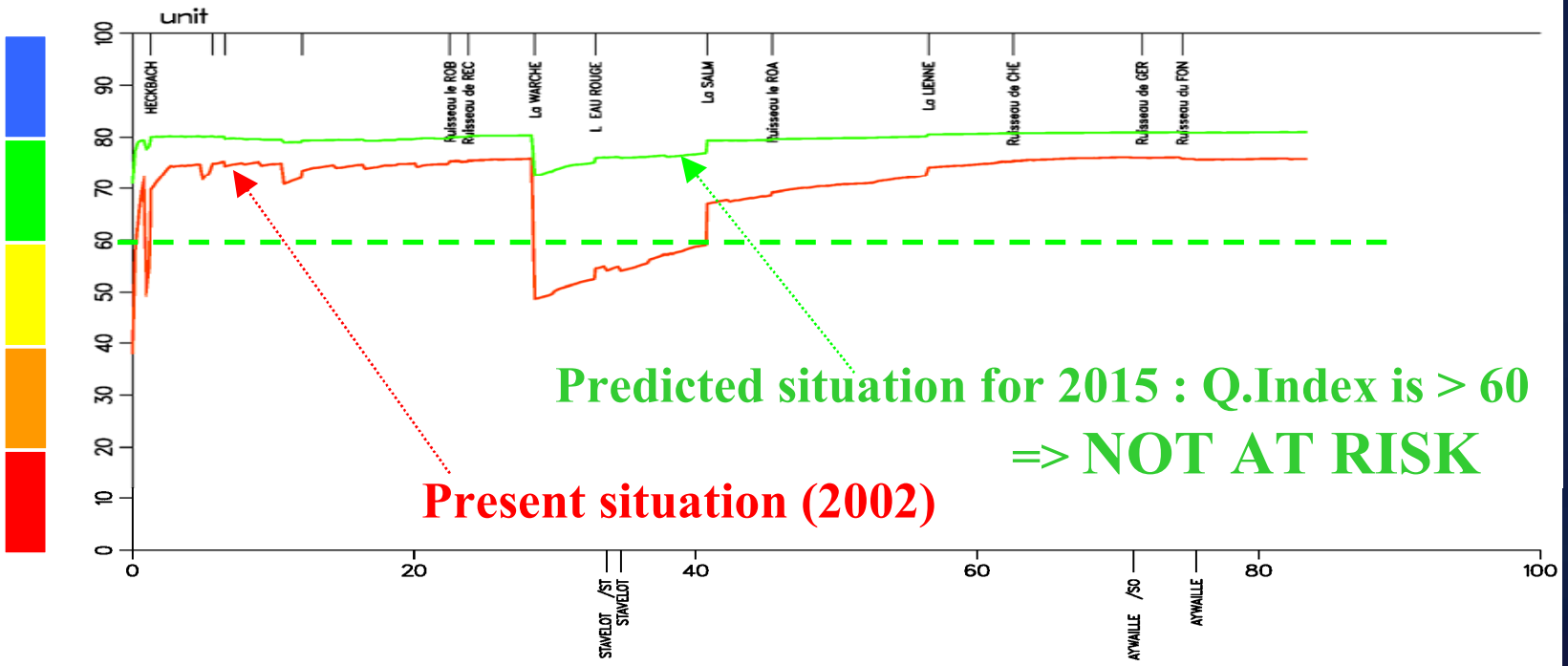
SIMULATION OF 2015 SCENARIO'S / ASSESSMENT OF THE RISK

REGION WALLONNE - PEGASE

COMPARAISON DES INDICES SEQEAU - MATIERES ORGANIQUES

RW2 Situation actuelle - Annee 2002

RW2 Scenario complexe avec normes ind - Annee 2015



Predicted situation for 2015 : Q.Index is > 60

=> NOT AT RISK

Present situation (2002)

L AMBLEVE

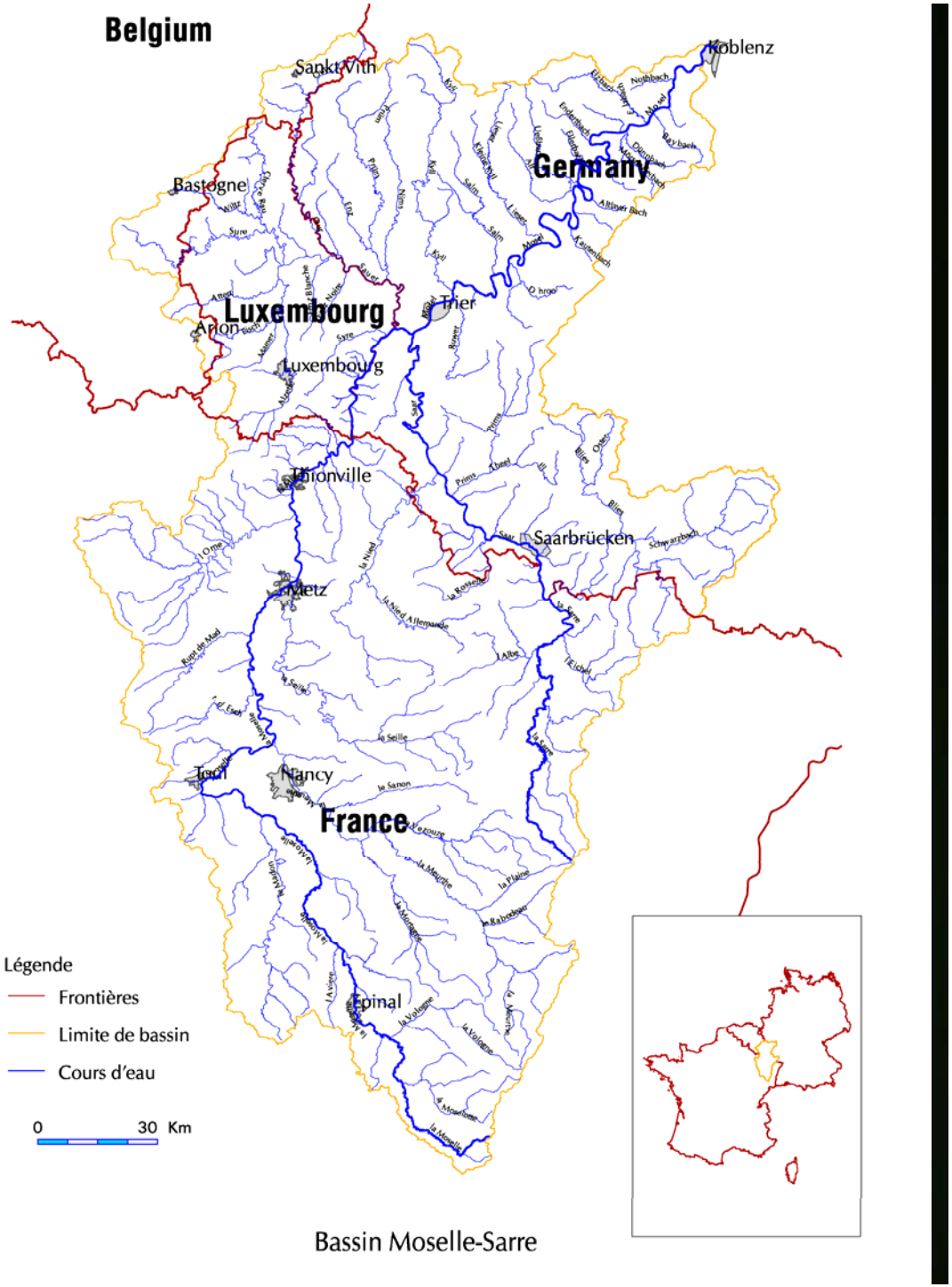
Source : DGRNE

PEGASE

For international basins / districts :

The MOSEL-SAAR Basin

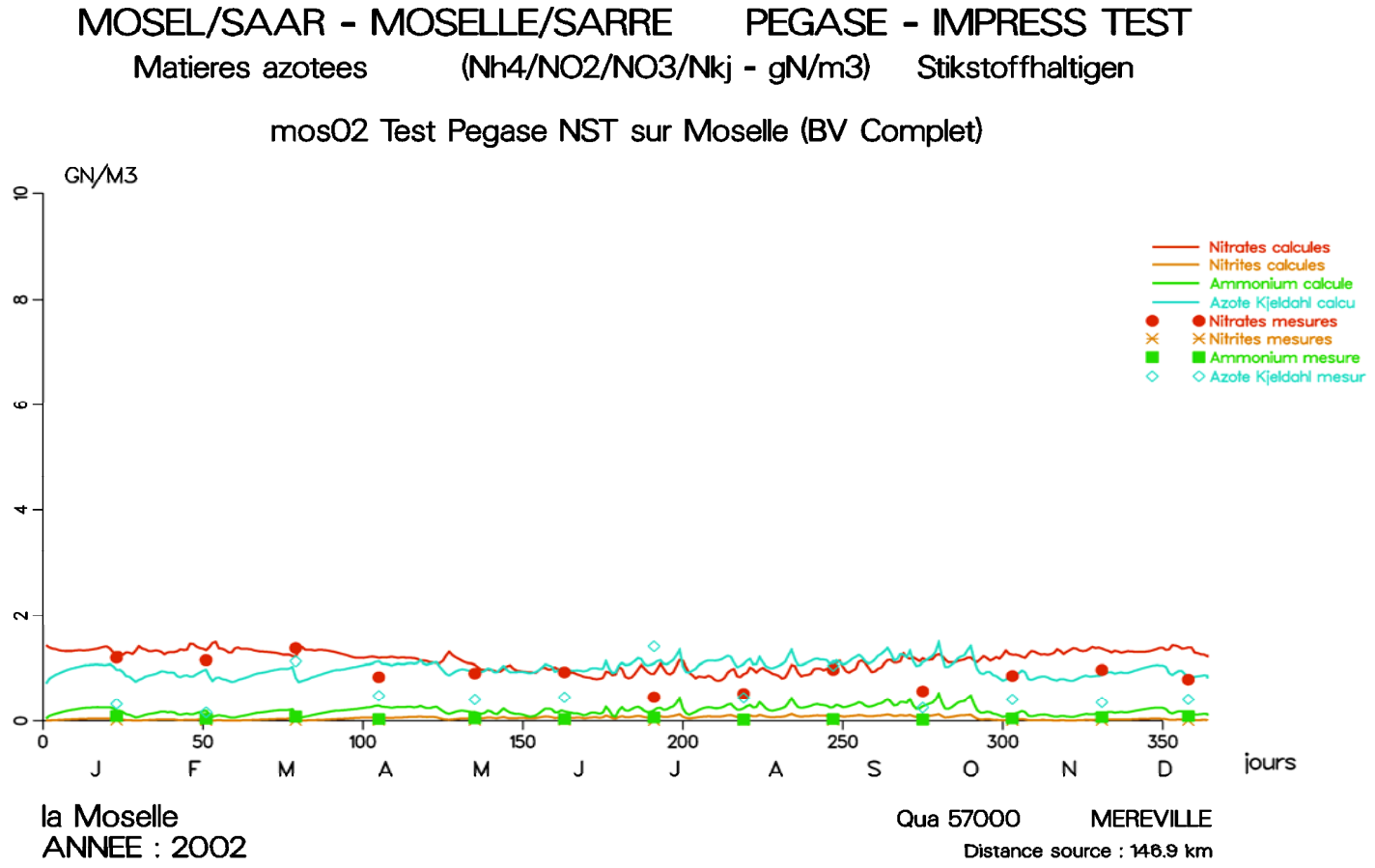
Agence de l'eau Rhin-Meuse
Land Rhenanie-Palatinat
Land Saar
Luxemburg
Wallonia



Bassin Moselle-Sarre

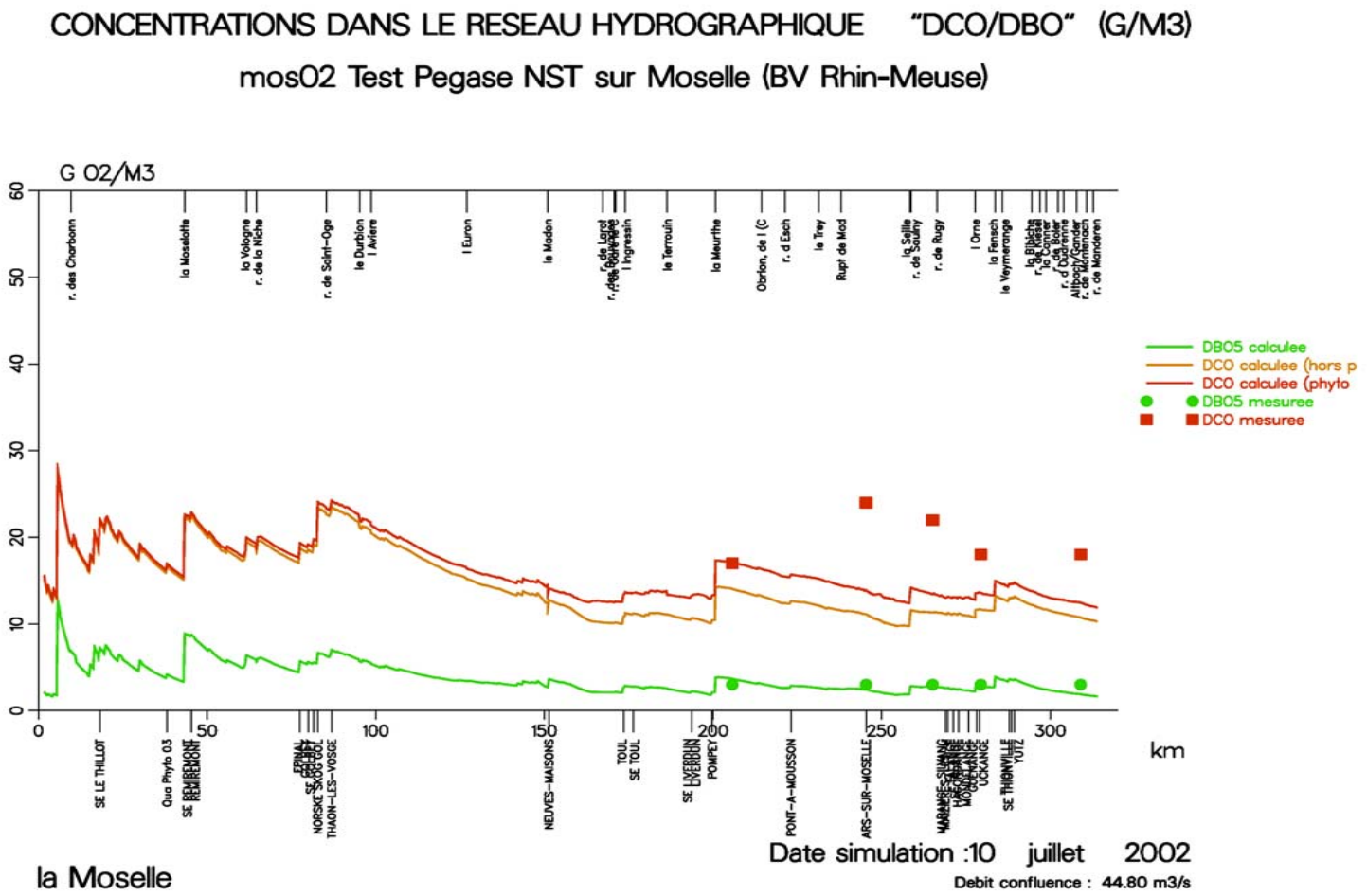
PEGASE for international basins / districts :

The MOSEL-SAAR Basin



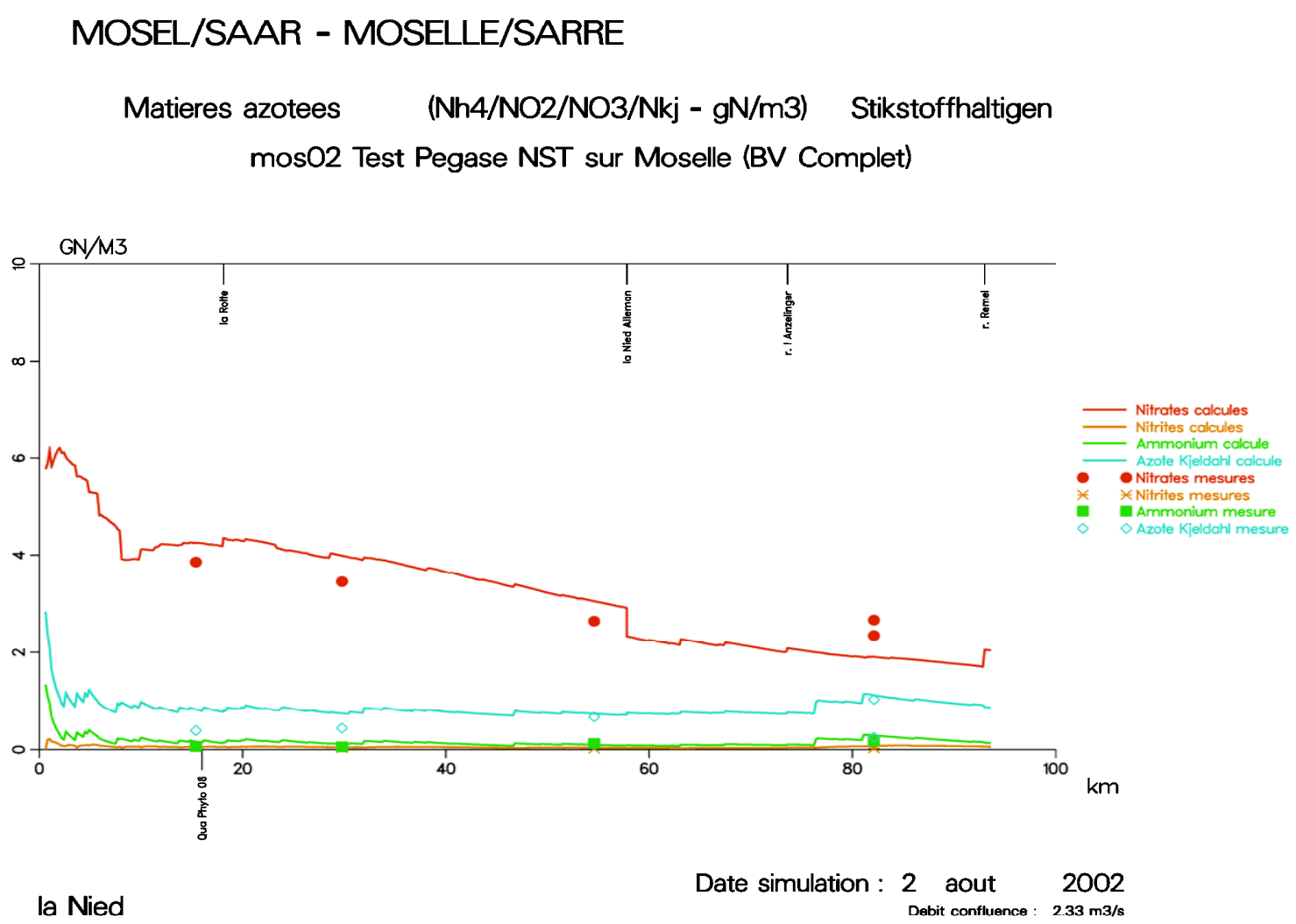
PEGASE for international basins / districts :

The MOSEL-SAAR Basin



PEGASE for international basins / districts :

The MOSEL-SAAR Basin



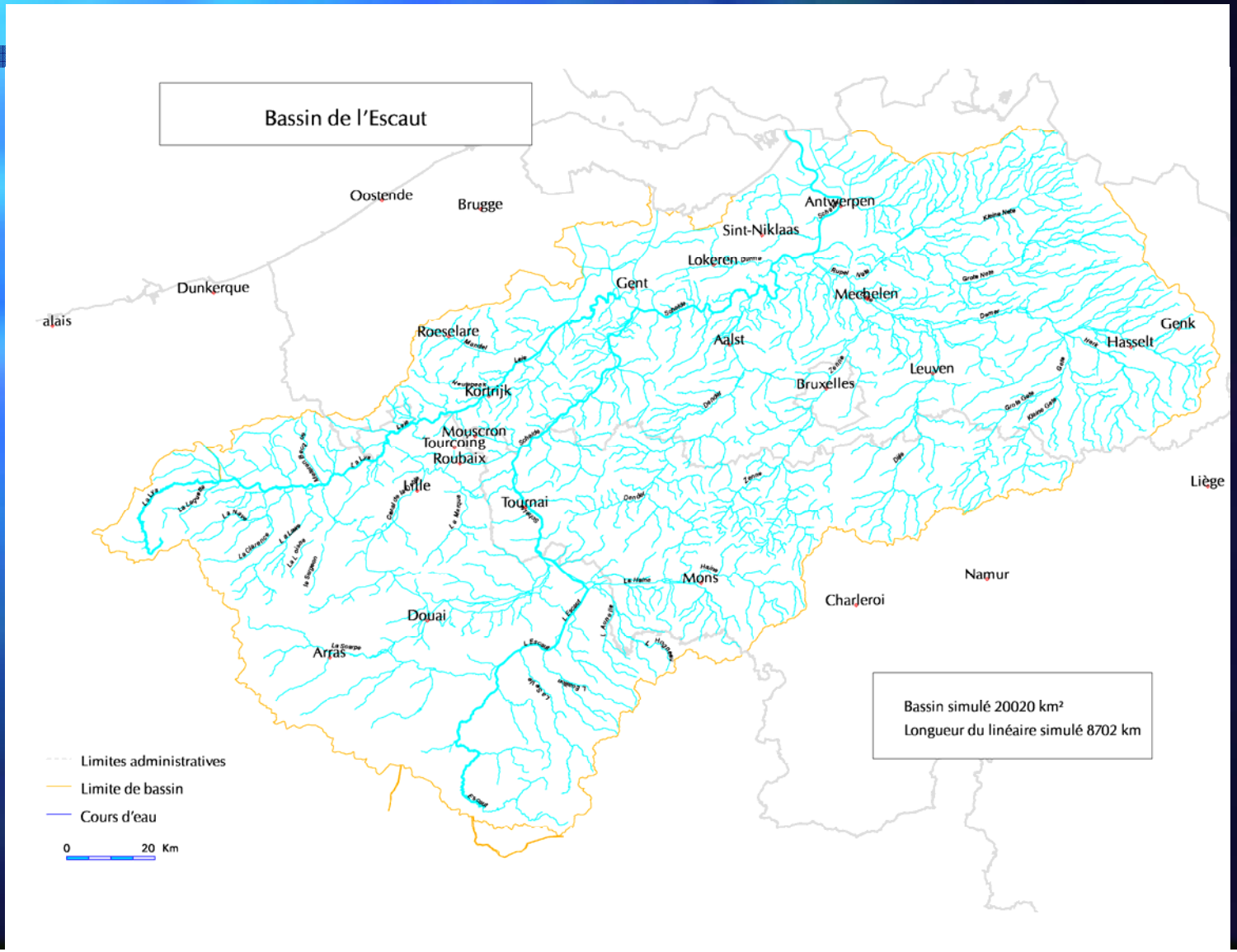
PEGASE for international basins / districts :

The SCHELDT Basin (F + W + VL + BR)

20.020 km²

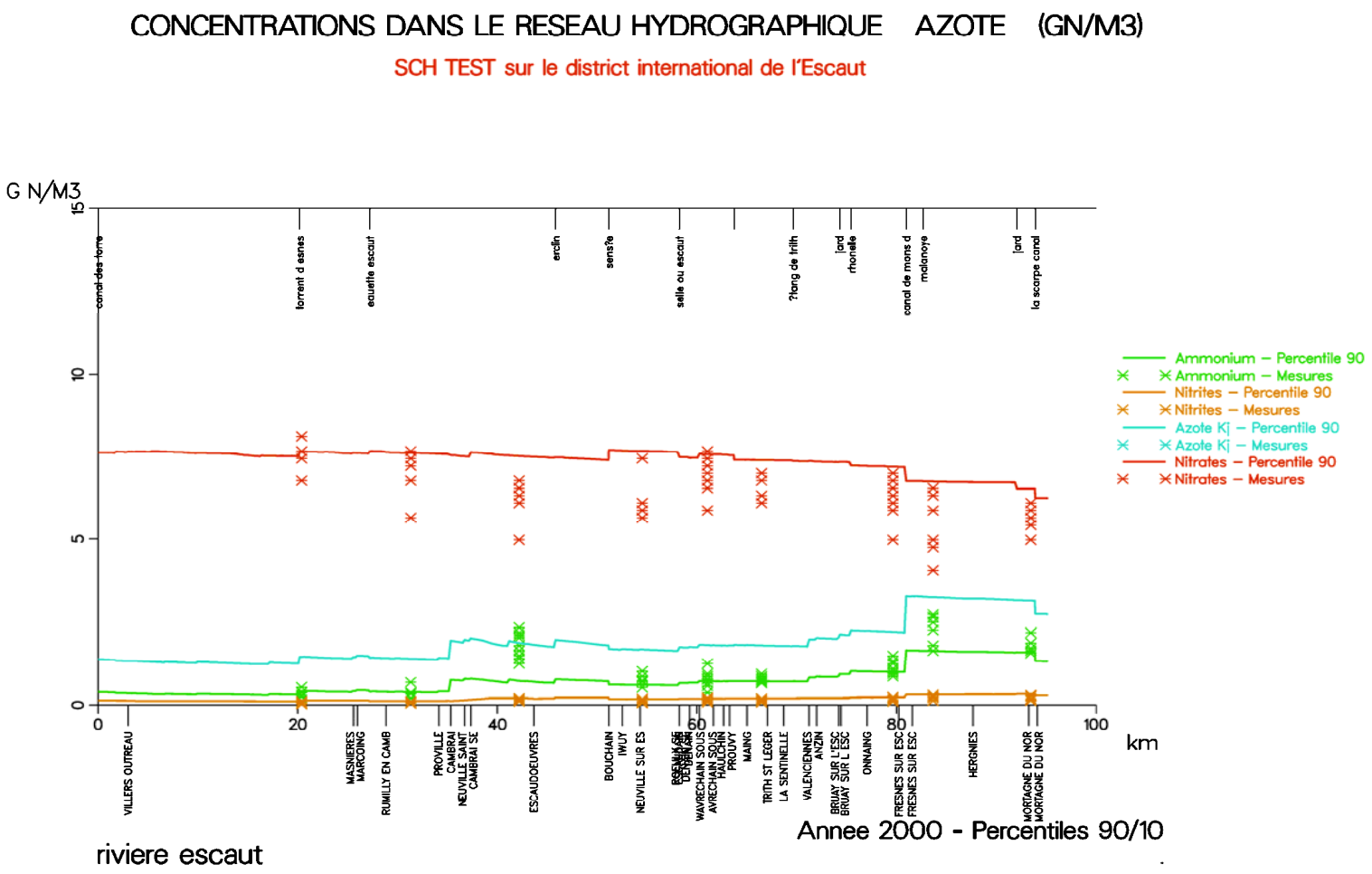
858 rivers

Total length :
8.702 km



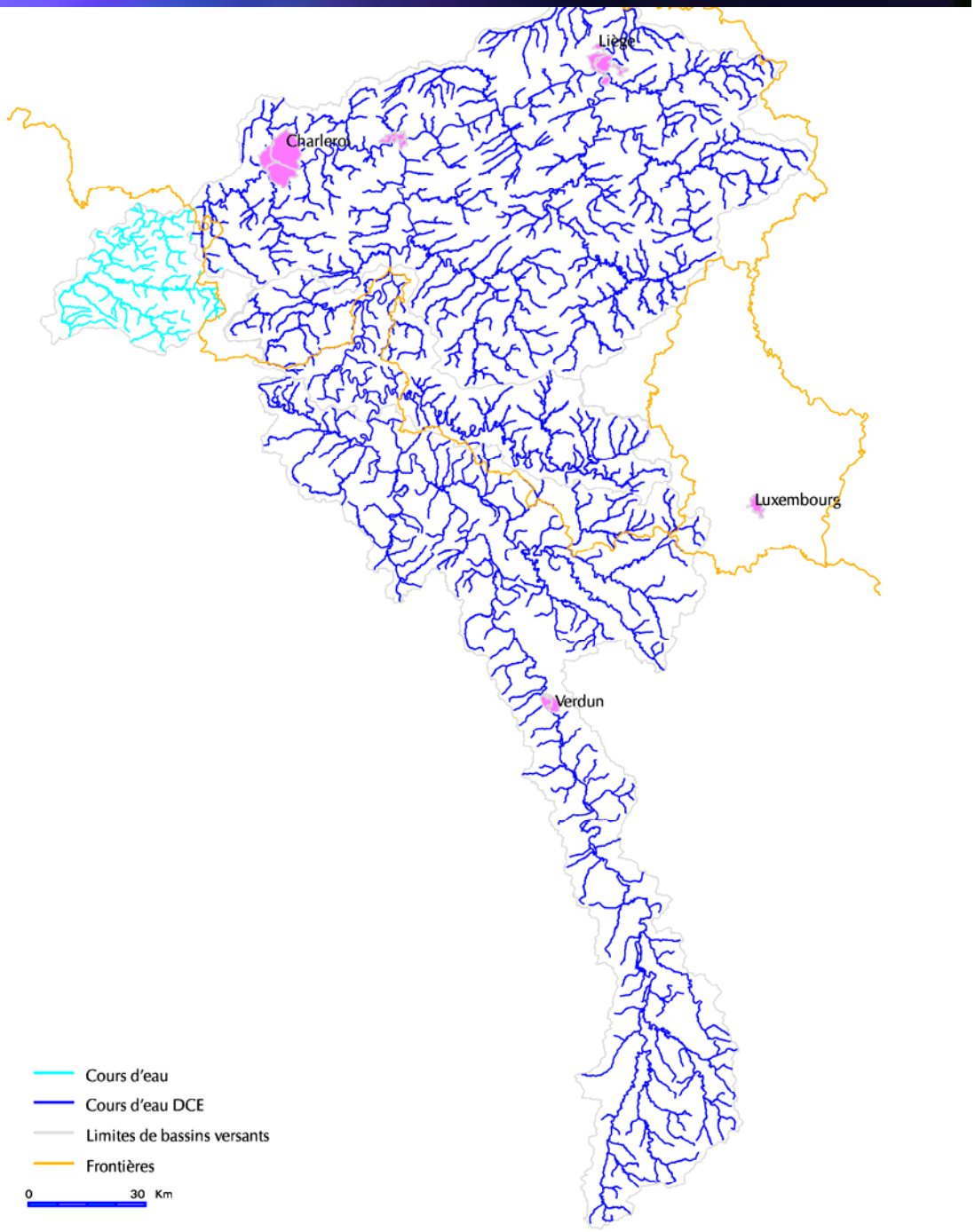
PEGASE for international basins / districts :

The SCHELDT Basin (F + W + VL + BR)



PEGASE for international basins / districts :

The MEUSE Basin (F + W + VL + ... ?)

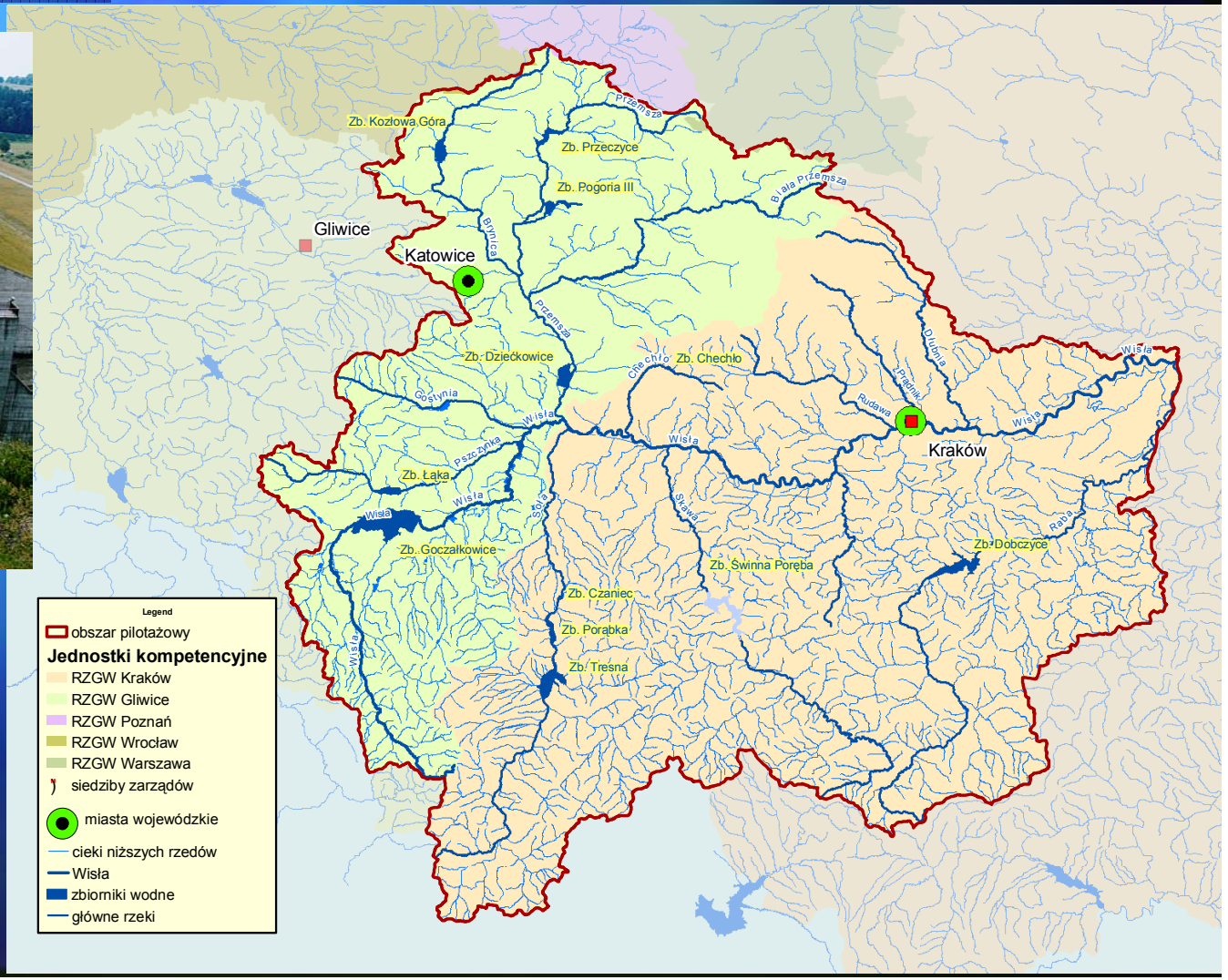


PEGASE

in the cooperation POLAND – FRANCE : The UPPER VISTULA basin

REGIONALNY ZARZĄD GOSPODARKI WODNEJ W KRAKOWIE

REGIONALNY ZARZĄD GOSPODARKI WODNEJ W GLIWICACH



In the scope of the PIRENE programme : new developments :

1) Modelling of the micro-pollutant concentrations

- Domestic discharges : Eq-InHab µP
- Industrial discharges : inventory of discharges
- Direct discharge by the bovines / porcines
- Diffuse load from the soil : emission factors

- Calculation of concentrations in the water column :
  - in the dissolved phase (water)
  - in the particulate phase (solid particles)
- Calculation of sedimentation processes
- Calculation of adsorption / désorption processes water ⇔ solid particles

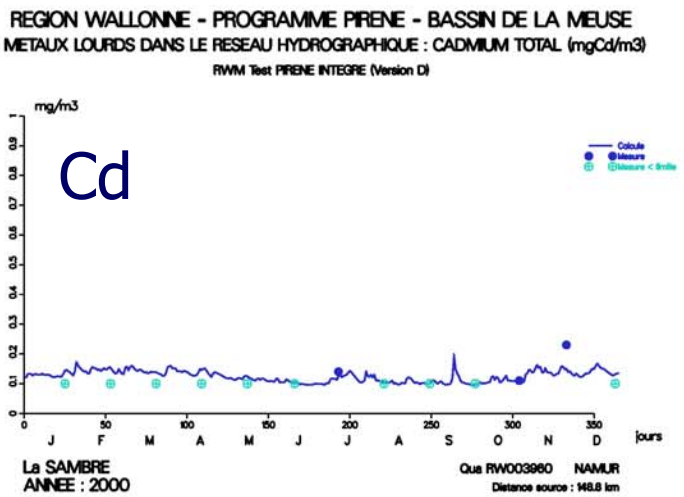
Tests have been made for : Cd, Cu, Zn, Pb

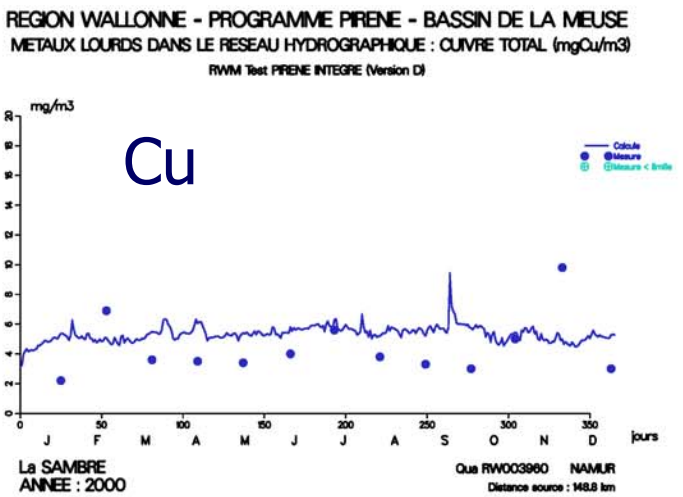
Cr, Ni, As, Hg

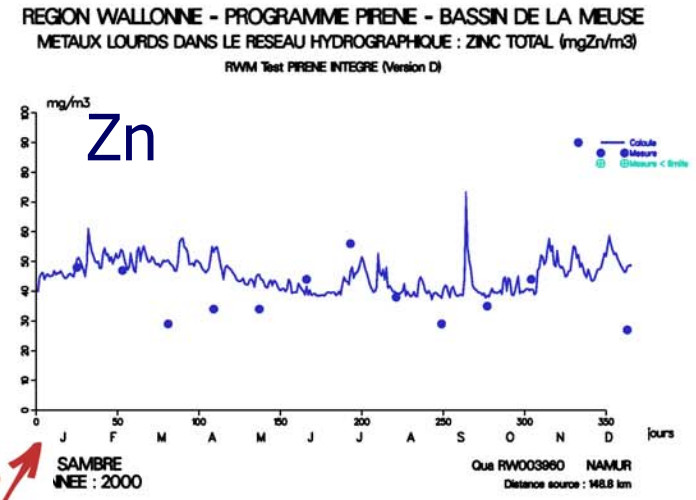
RÉGION WALLONNE

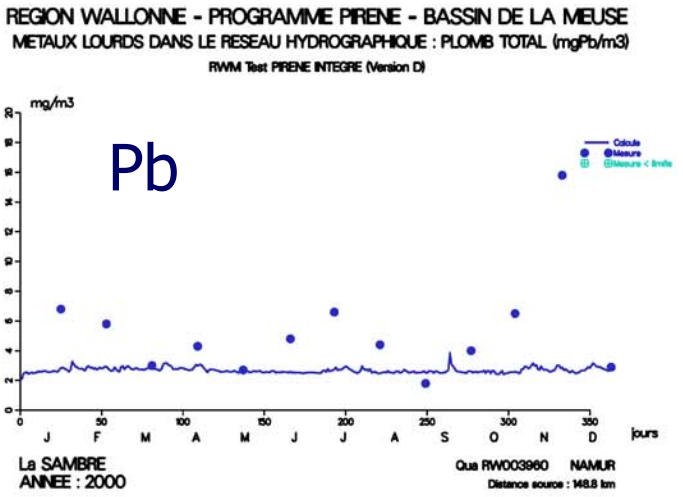
PIRENE

Concentration of µPollutants in the SAMBRE river – Year 2002









RÉGION WALLONNE

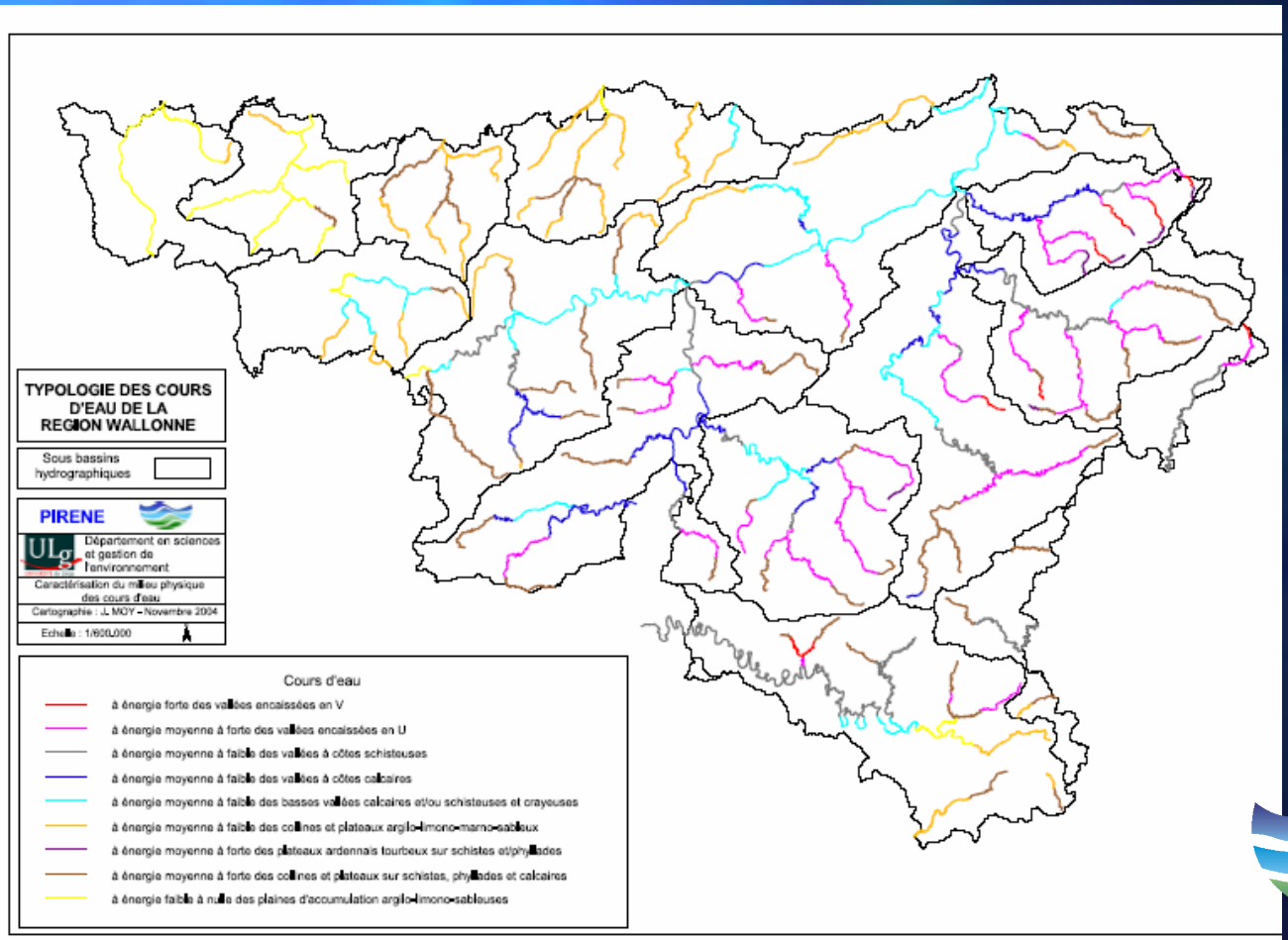
PEGASE : recent developments

2) Modelling of **biological quality** (biological indexes)

Step 1 : assessment of the hydromorphological quality (ULg-Arlon)

QUAL-PHY quality indexes

(AERM)



RÉGION WALLONNE

PIRENE

PEGASE : recent developments

2) Modelling of **biological quality** (biological indexes)

Step 2 : statistical sub-models *(multiple linear regressions)*

DIATOM INDEX :

IPS = F (MOOX, MAZ, NIT, MPhos, QPhys_fond)

test W : R2 > 0.80

MACRO-INVERTEBRATES INDEX :

IBGN = F (MOOX, MAZ, NIT, MPHOS, Qphys_fond)

test W : R2 > 0.92

RÉGION WALLONNE

PIRENE

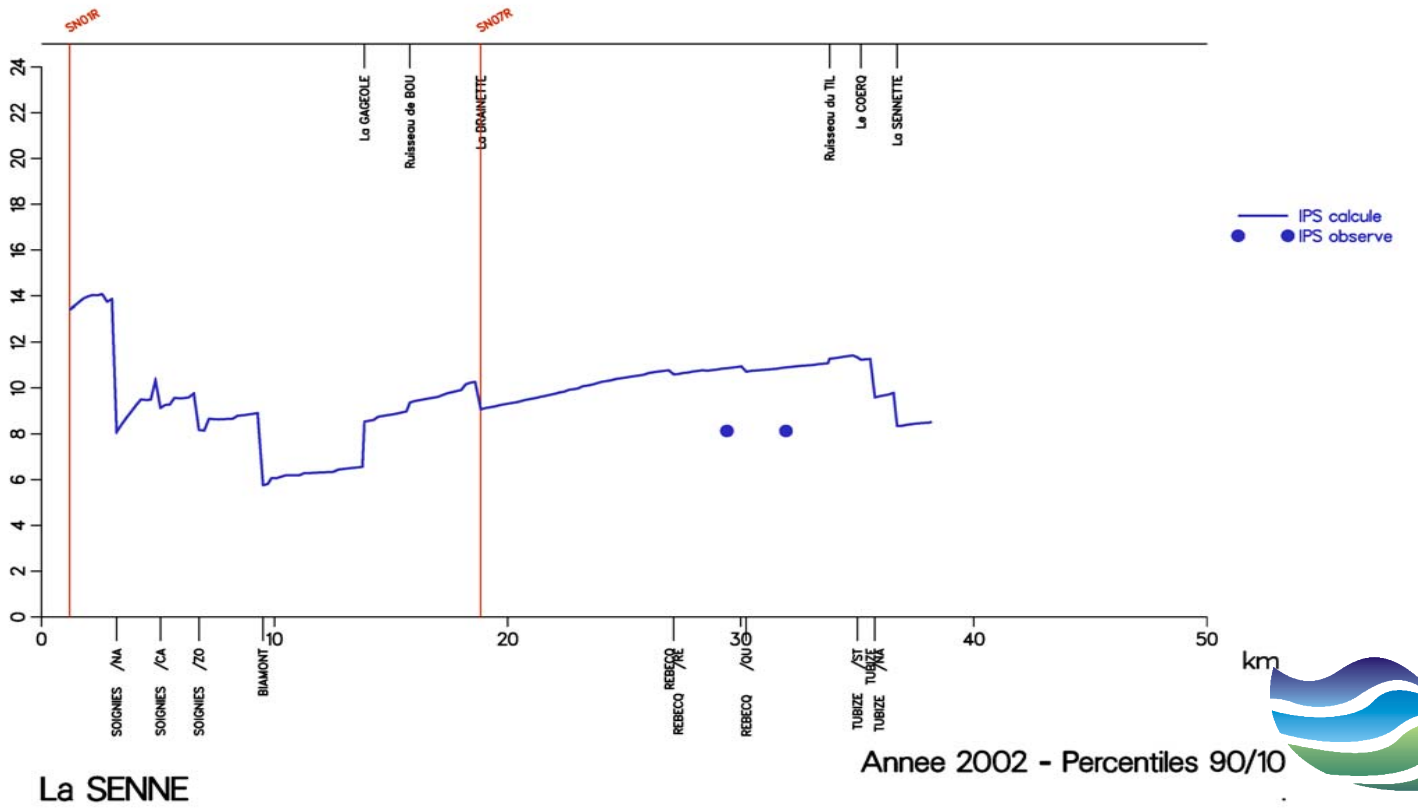
PEGASE : recent developments

2) Modelling of **biological quality** (biological indexes)

REGION WALLONNE

INDICES DE QUALITE BIOLOGIQUE : IPS

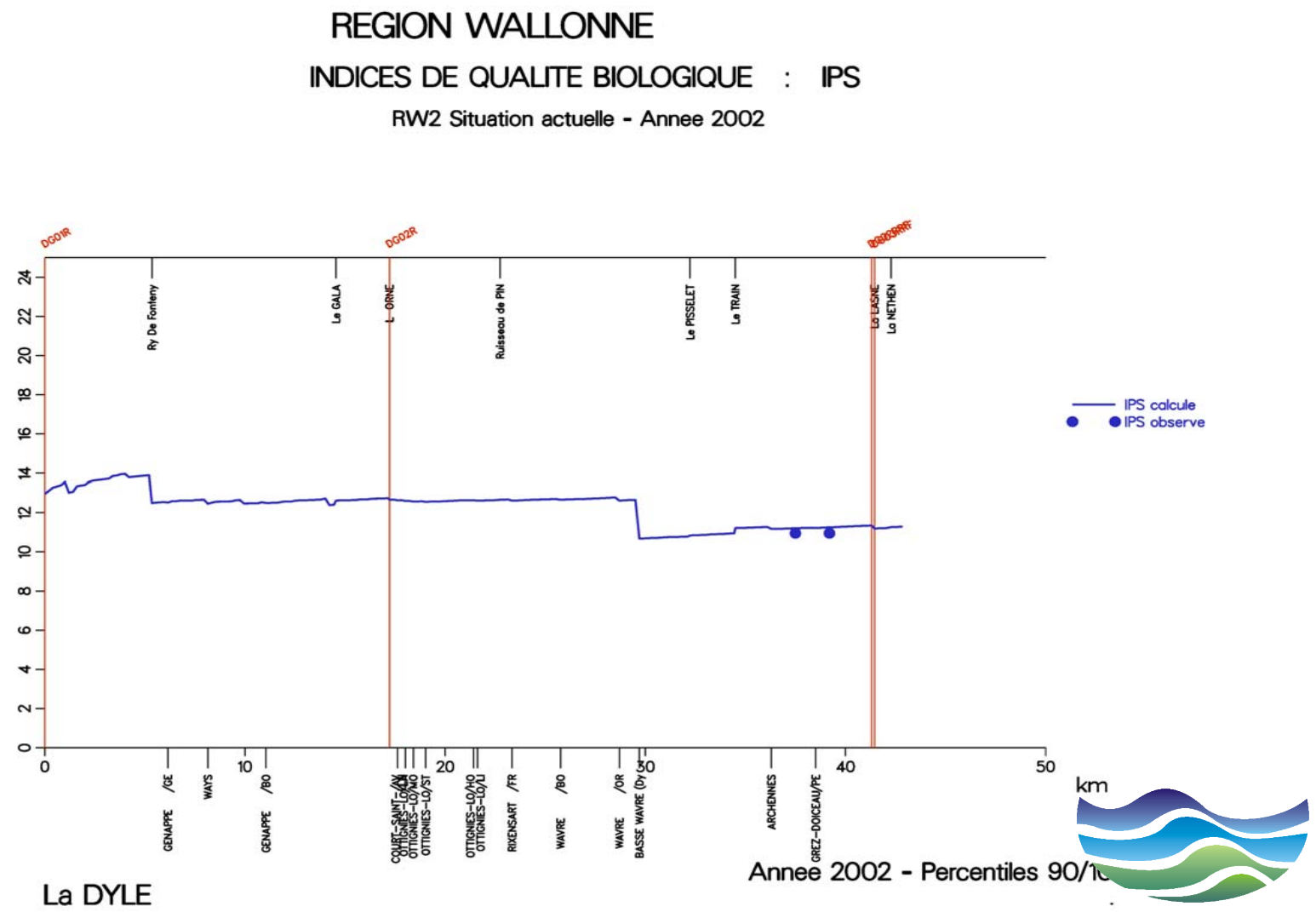
RW2 Situation actuelle - Annee 2002



RÉGION WALLONNE

PEGASE : recent developments

2) Modelling of **biological quality** (biological indexes)



PEGASE : recent developments

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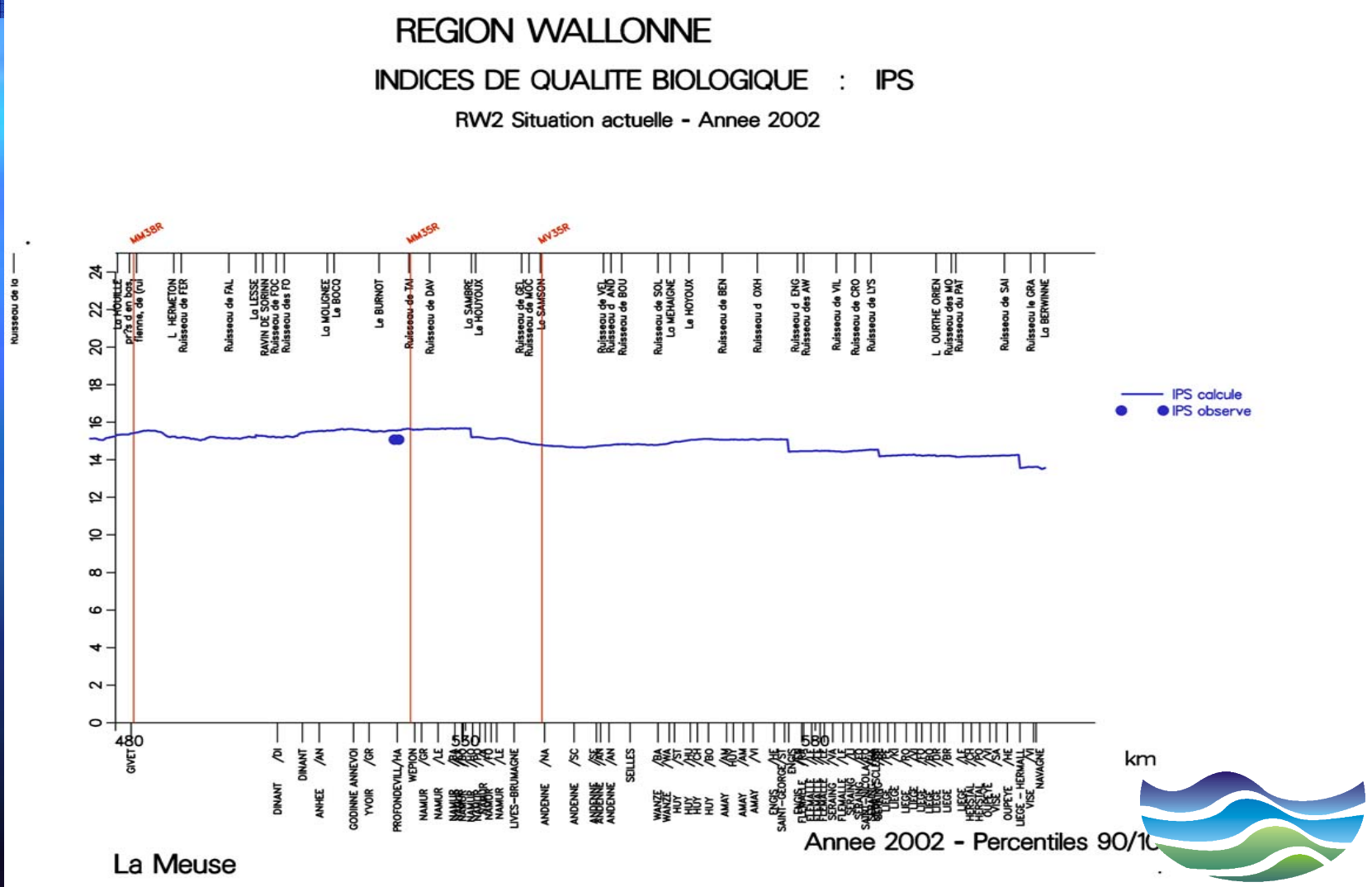

RÉGION WALLONNE

PEGASE : recent developments

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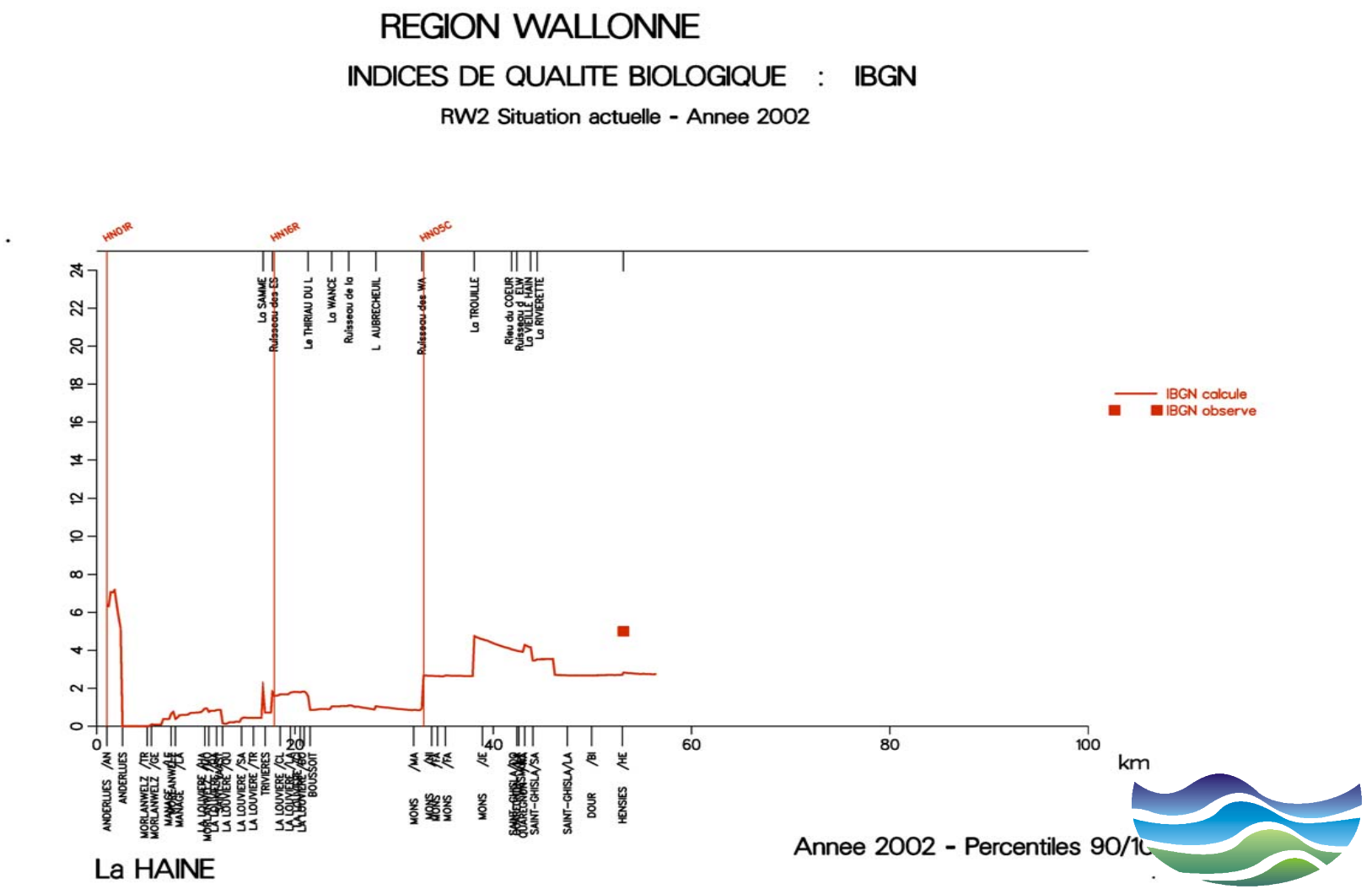

PEGASE : recent developments

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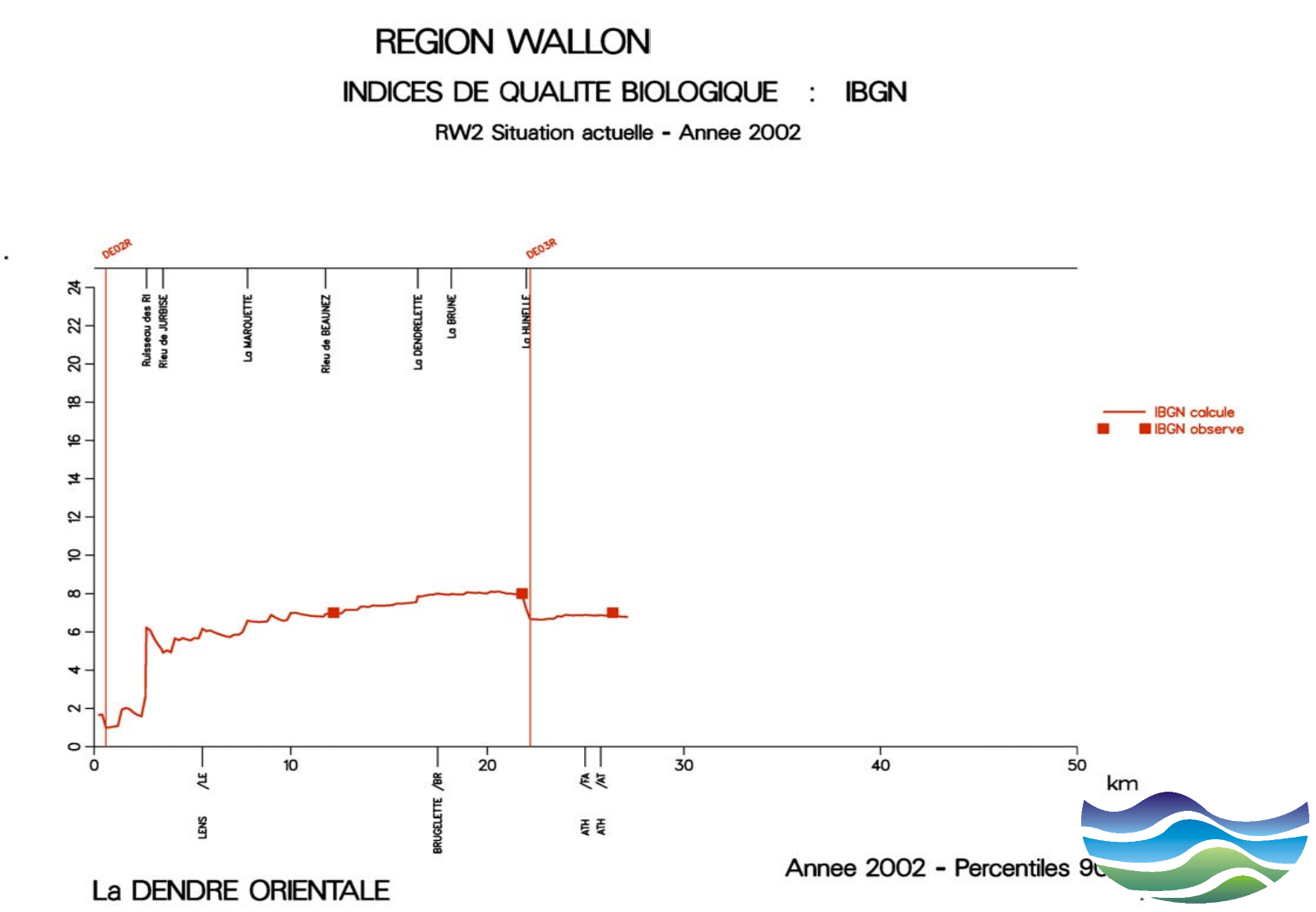
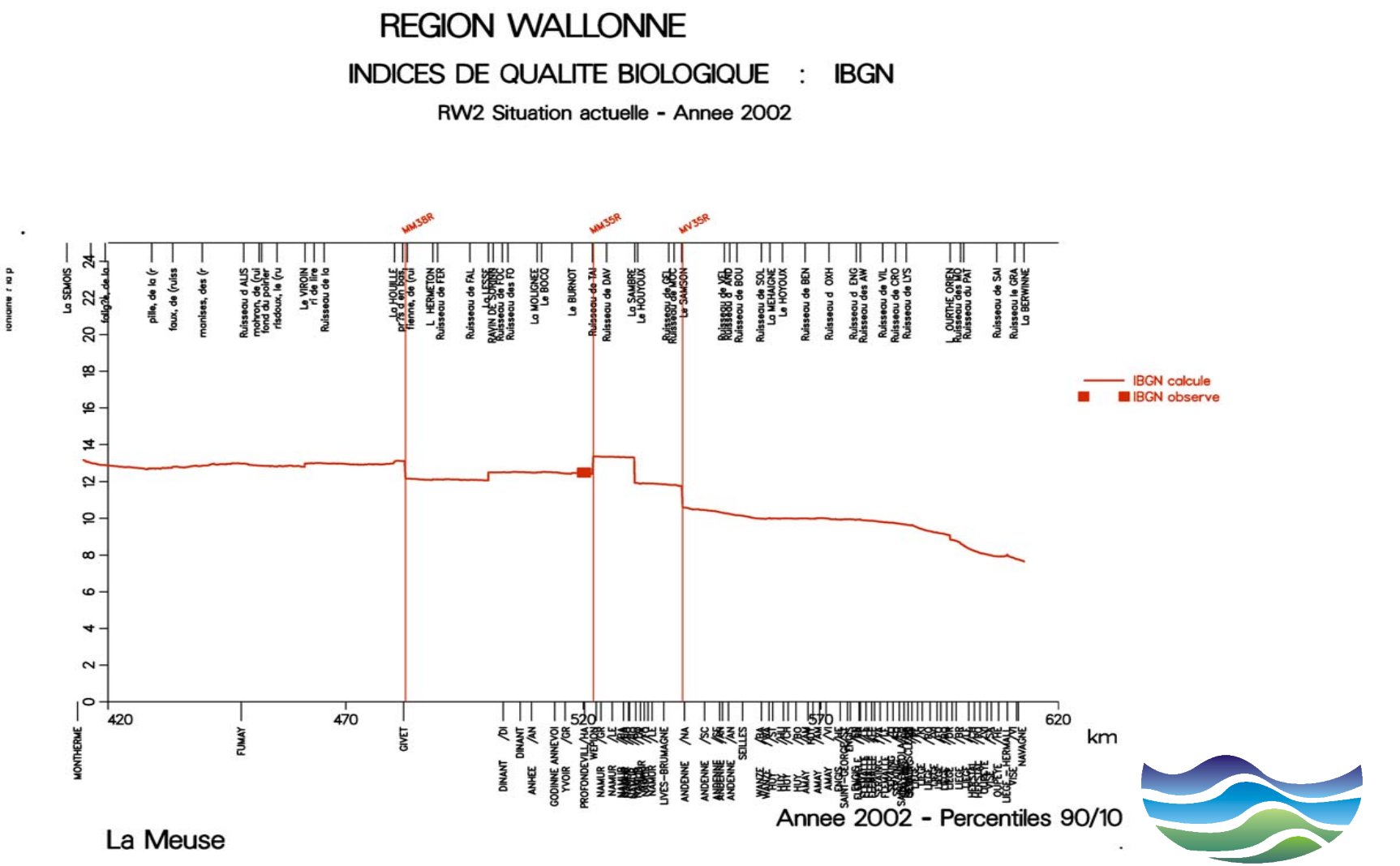


RÉGION WALLONNE

PEGASE : recent developments

2) Modelling of **biological quality** (biological indexes)

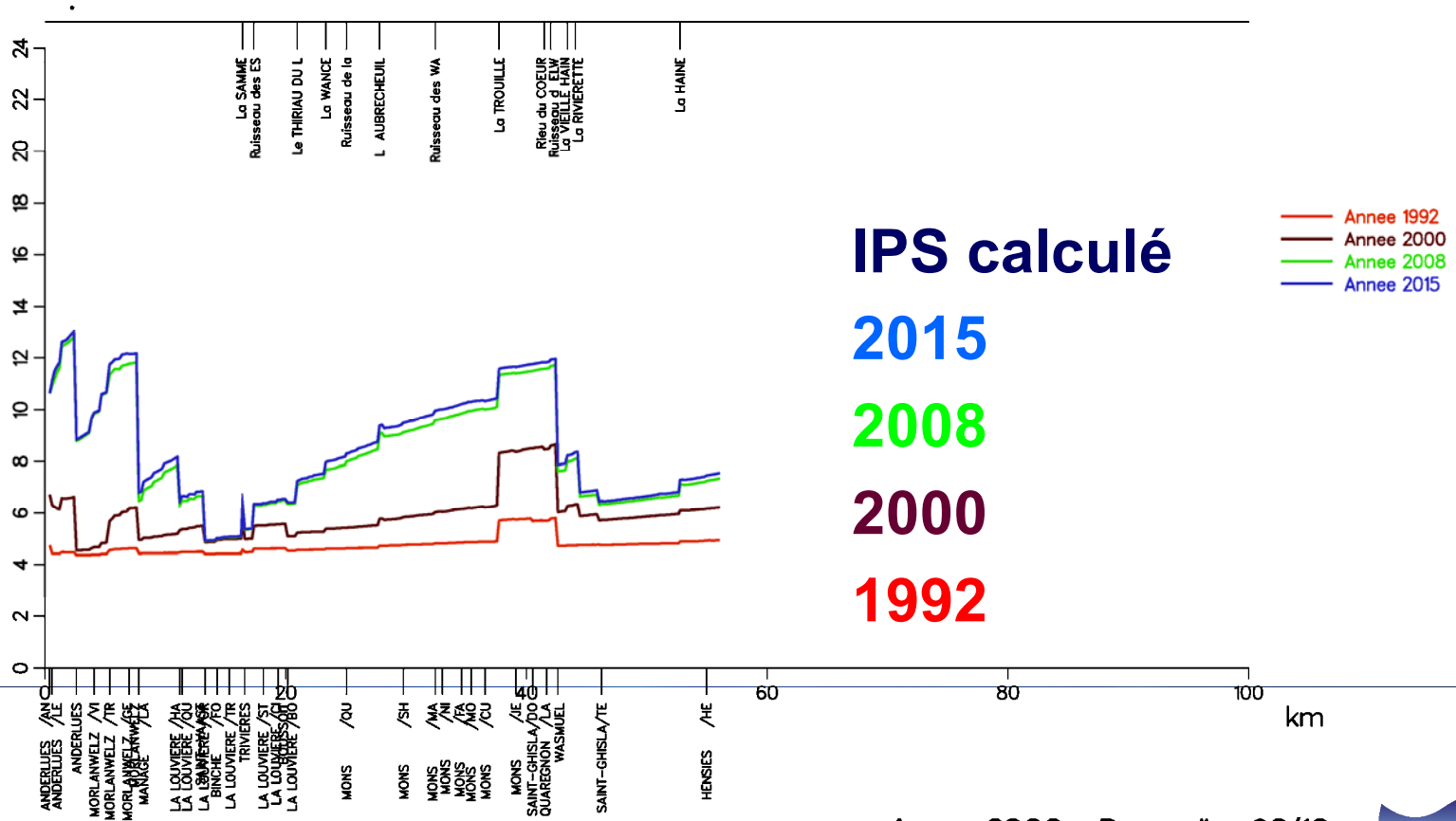


RÉGION WALLONNE

REGION WALLONNE - PROGRAMME PIRENE - BASSIN DE L'ESCAUT

ESTIMATION DES INDICES DE QUALITE BIOLOGIQUE : IPS

RWE Situation historique - Annee 1992
RWM Situation actuelle - Annee 2000
RWE Situation prospective - Annee 2008
RWE Situation prospective - Annee 2015



IPS calculé

2015

2008

2000

1992

Annee 1992
Annee 2000
Annee 2008
Annee 2015

La HAINE

Annee 2000 - Percentiles 90/10

RÉGION WALLONNE

PIRENE programme (2000 – 2005)

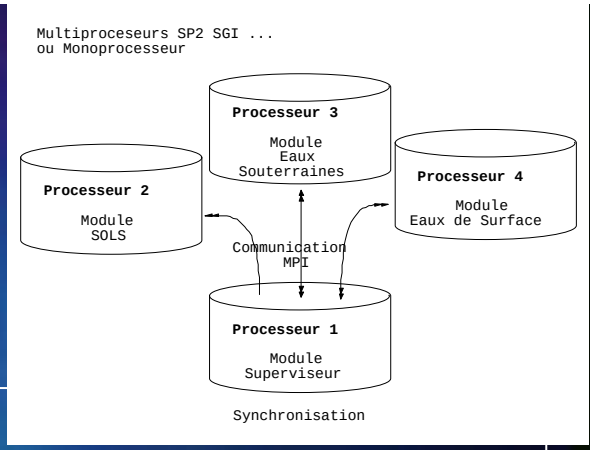
Full integrated modelling
in the perspective of the WFD

- + Explicit (deterministic) modelling of SOILS
- + Explicit (deterministic) modelling of GROUNDWATER
- + Detailed (deterministic) modelling of the RIVER NETWORK (incl. full hydrodynamic modelling)

PIRENE

PIRENE programme :

Full integrated modelling :
SOILS + GROUNDWATER + SURFACE WATERS



SOIL sub-model (3-D)
(Epic-Grid)

(FUSAGx)

Deep percolation

Runoff +
hypodermic flux

GROUNDWATER
sub-model (3-D)

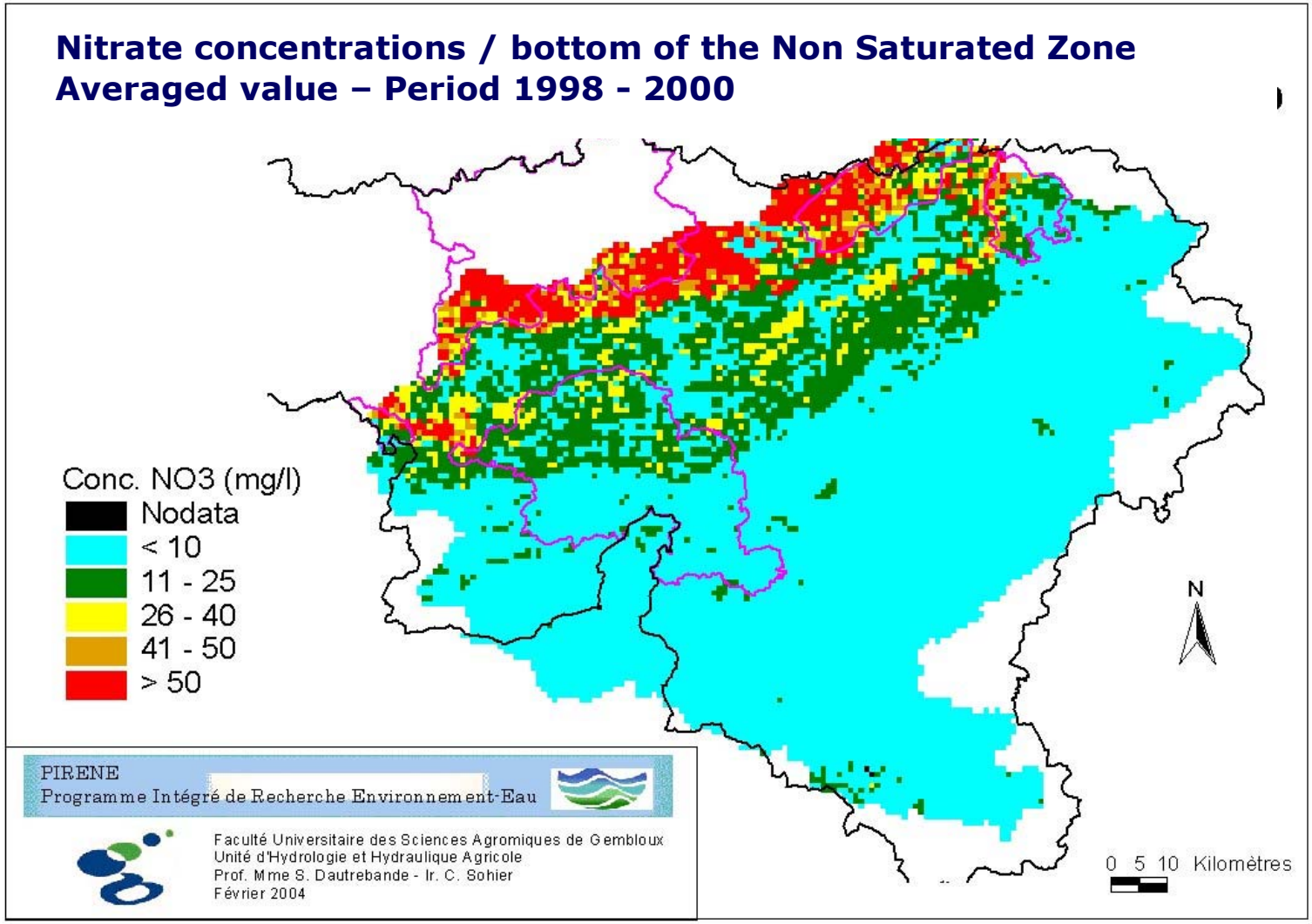
(HYD + CEME-ULg)

(GEOMAC-ULg
+ HG – FPMs)

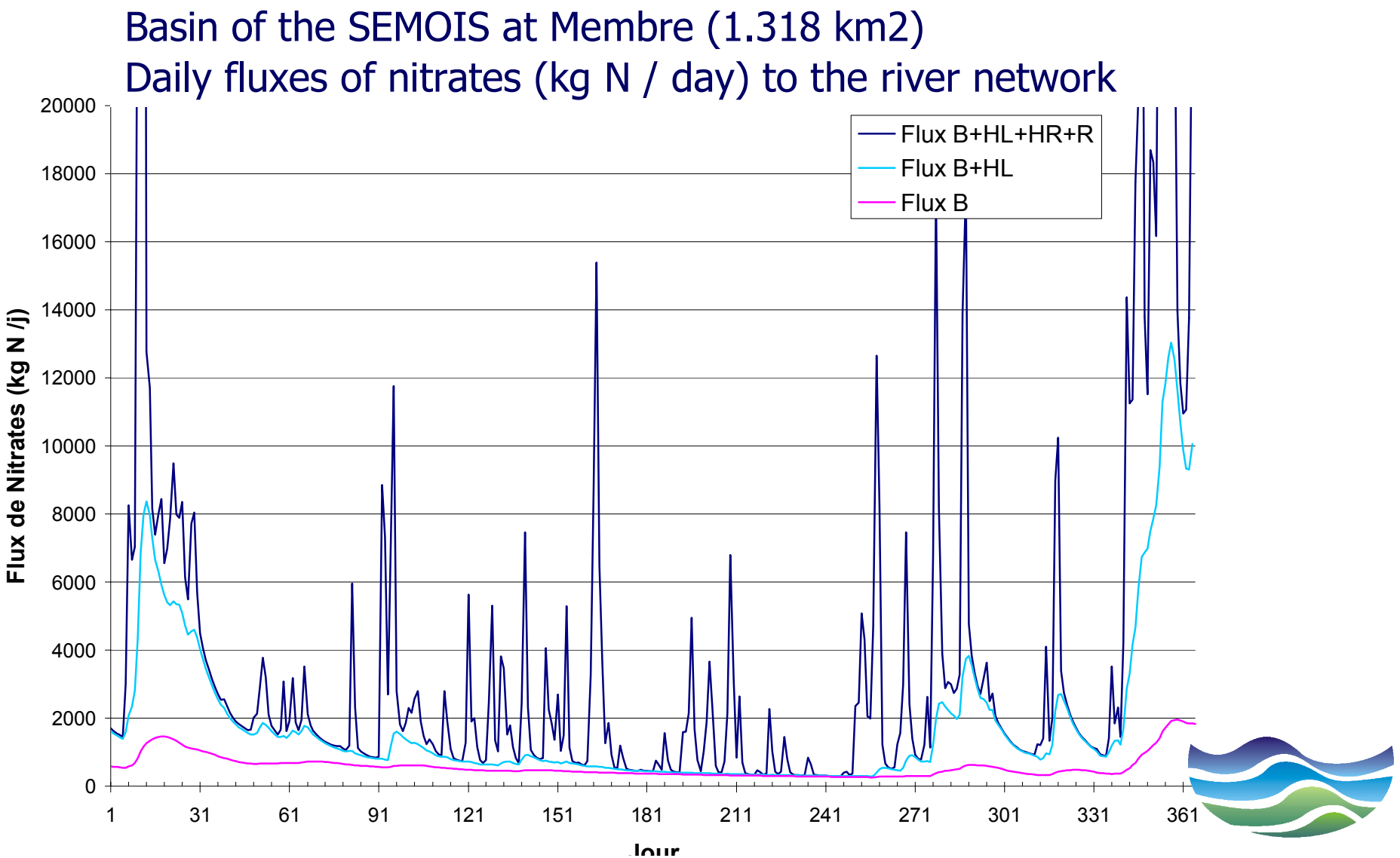
SURFACE WATERS
sub-model

PIRENE programme :

Results of the soil sub-model (FUSAGx) :



PIRENE programme : Results of the integrated model : Daily fluxes of nitrates from the SOILS and GROUNDWATER to the SURFACE WATERS



ACKNOWLEDGEMENTS to :

E.EVERBECQ, JF.DELIEGE, M.BOUROUAG, S. LANGE, A. GRARD, University of Liège
X. COGELS, Fr. GUYON, University of Liège (Arlon)
M. PIROTTON, S. ERPICUM, University of Liège
A. DASSARGUES, S. BROUYERE, University of Liège
A.RORIVE, F. VANWITTENBERGHE, University Faculty of Mons
JP. DESCY, V. GOSSELAIN, Cl. FAUVILLE, University Faculty of Namur
S. DAUTREBANDE, C. SOHIER, University Faculty of Gembloux
M. VERBANCK, C. PIRON, Free University of Brussels
L. VANDEVENNE, Fr. PIRARD, H. PEETERS, CEBEDEAU
C. CONAN, G. DEMORTIER, JL. SALLERON, P.WEINGERTNER, Ag. Eau RHIN-MEUSE
O. COULON, L-Ch.OUDIN, J. MOY, Ag. Eau LOIRE-BRETAGNE
G. NAVARRO, Fr. SIMONET, Ag. Eau ADOUR-GARONNE
D. MARTIN, C. EUVERTE, Ag. Eau ARTOIS-PICARDIE
Y. RONSE, Vlaams Milieu Maatschaapij
O. THUNUS, DGRNE, Région Wallonne