RIVERTWIN EU-FP6 PROGRAMME

Simulation of water quality in different climate zones using the QUAL2K model: The Neckar and the Oueme river basins

AUTh FSA

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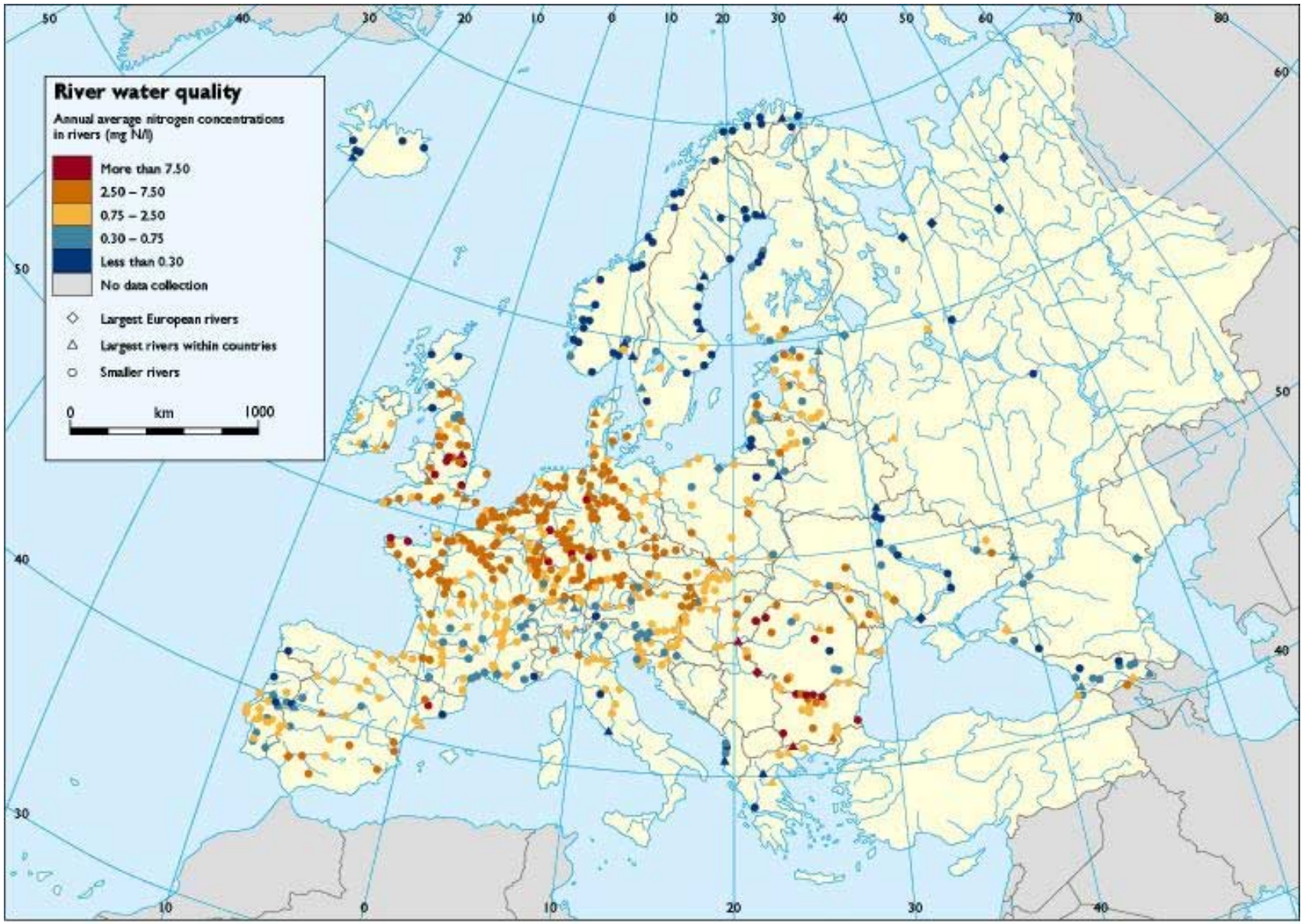
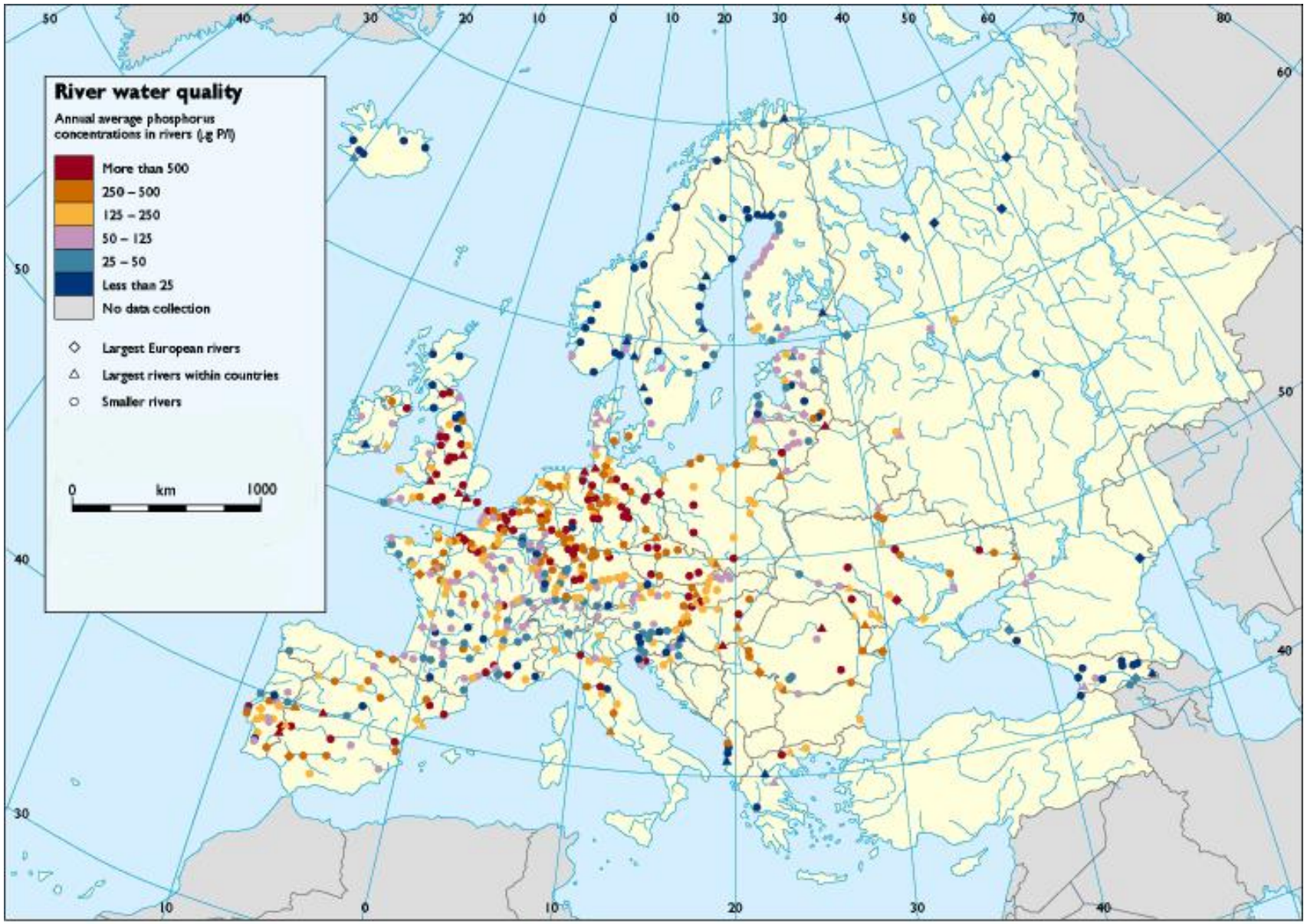
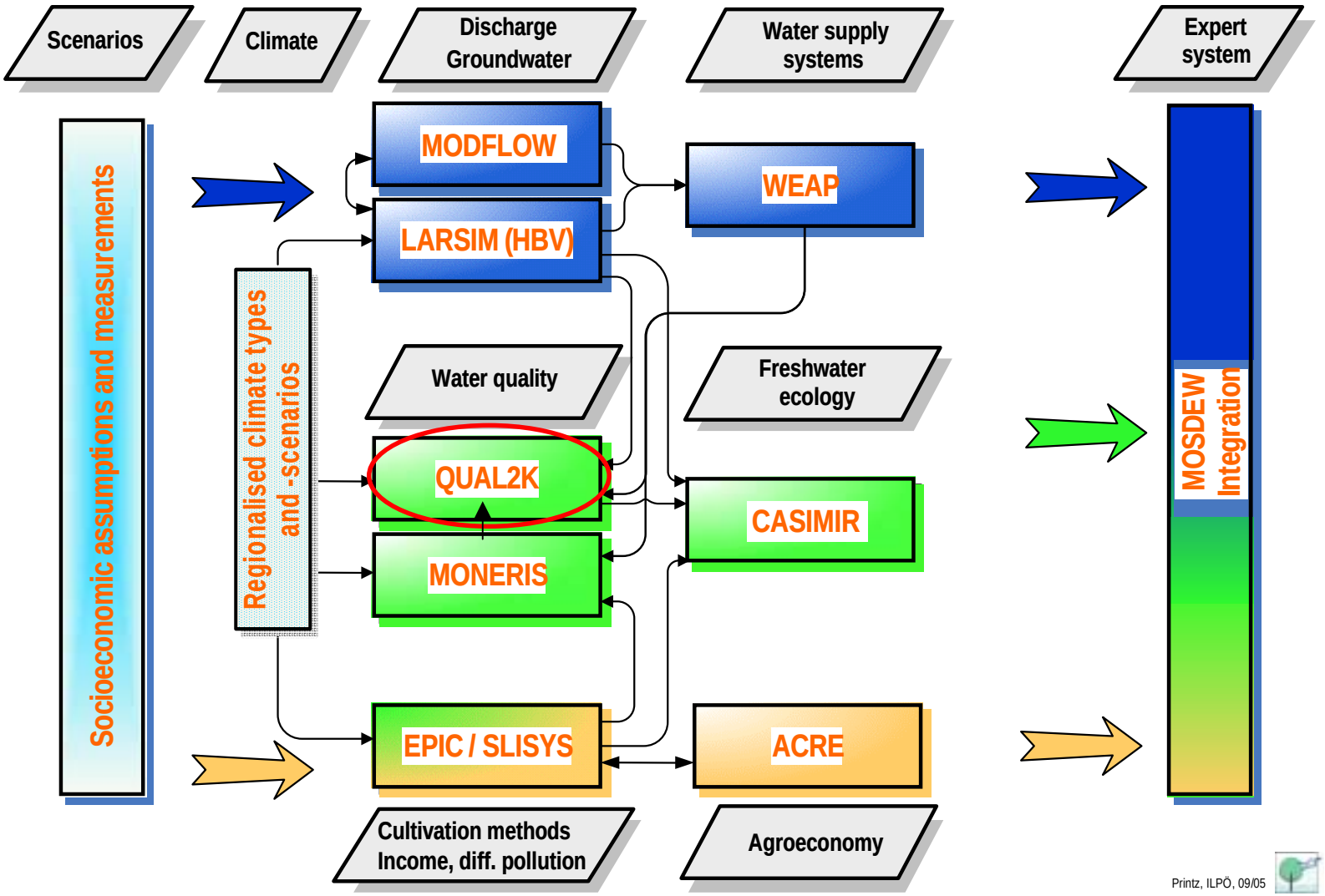

River water quality
Annual average nitrogen concentrations in rivers (mg N/l)
More than 7.50
2.50 – 7.50
0.75 – 2.50
0.30 – 0.75
Less than 0.30
No data collection
Largest European rivers
Largest rivers within countries
Smaller rivers
0
km
1000


River water quality
Annual average phosphorus concentrations in rivers (µg P/l)
More than 500
250 – 500
125 – 250
50 – 125
25 – 50
Less than 25
No data collection
Largest European rivers
Largest rivers within countries
Smaller rivers
0
km
1000

INTEGRATED COUPLING SCHEME NECKAR RIVER BASIN

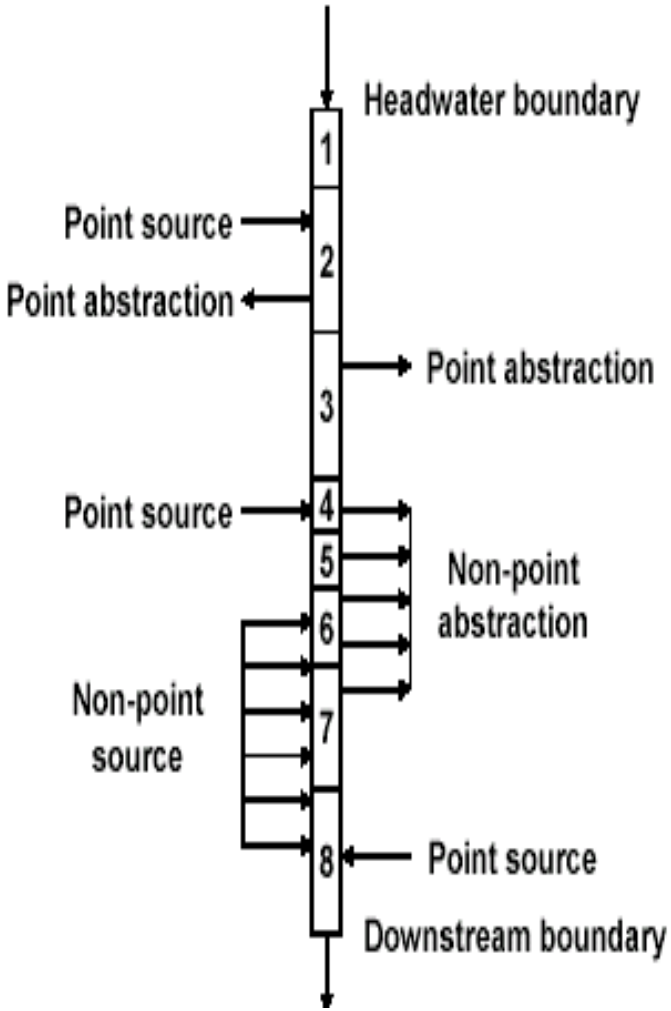


QUAL2K Model (US-EPA)

QUAL2K uses unequally-spaced reaches. Multiple loadings and abstractions can be input to any reach.

The model presently simulates the main stem of a river. Tributaries are taken as point sources.

For each reach, a hydrologic balance in terms of flow, a heat balance in terms of temperature, and a constituent balance in terms of concentration is written.



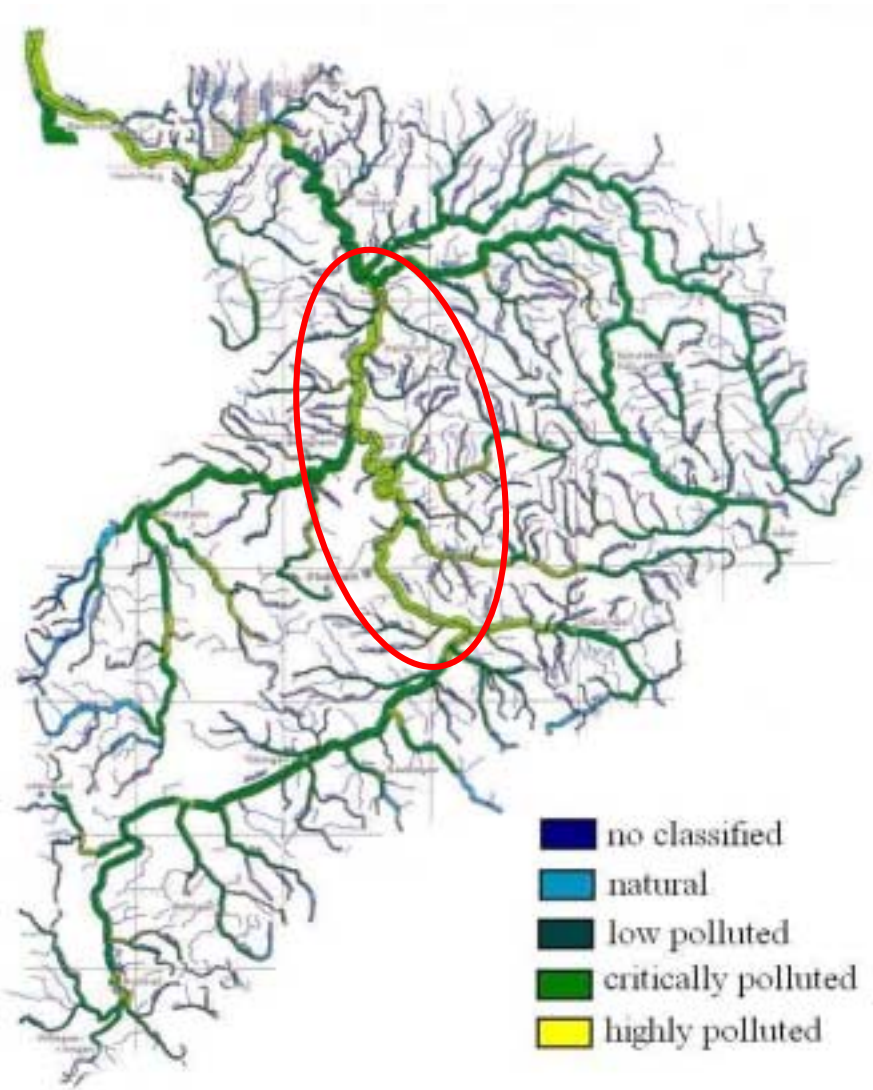
Required data for water quality	Available data for the Neckar basin (hourly/daily)	Available data for the Oueme basin (dry/wet season)
Temperature	14 water quality stations (LFU 1972-2002)	8 wq stations (4 measurements in 2004-2006)
Conductivity	14 water quality stations (LFU 1972-2002)	8 wq stations (4 measurements in 2004-2006)
Inorganic Solids	14 water quality stations (LFU 1972-2002)	N/A
Dissolved Oxygen	14 water quality stations (LFU 1972-2002)	N/A
BOD	14 water quality stations (LFU 1972-2002)	N/A
Dissolved Organic Nitrogen	Estimated from Total N – NH_4-NO_3	N/A
NH_4-Nitrogen	14 water quality stations (LFU 1972-2002)	8 wq stations (4 measurements in 2004-2006)
NO_3-Nitrogen	14 water quality stations (LFU 1972-2002)	8 wq stations (4 measurements in 2004-2006)
Dissolved Organic Phosphorous	Estimated from Total P - Inorganic P	N/A
InorganicPhosphorus	14 water quality stations (LFU 1972-2002)	8 wq stations (4 measurements in 2004-2006)
Phytoplankton	N/A	N/A
Detritus	14 water quality stations (LFU 1972-2002)	N/A
Pathogen	N/A	N/A
Alkalinity	N/A	8 wq stations (4 measurements in 2004-2006)
pH	14 water quality stations (LFU 1972-2002)	8 wq stations (4 measurements in 2004-2006)
Hydraulics data		
Cross section profiles	Available cross section profiles at each km of River Neckar	4 cross section profiles along the River Oueme (discharge,velocity,slope, water level, width)
Elevation	DEM	DEM
Station coordinates	Longitude/latitude	Longitude/latitude
Meteorological data		3-5 national stations with daily data from 1980 to 2003
Temperature	LFU 1988-2003	ASECNA: mean values in 2004-2005
Dew-point temperature	LFU 1988-2003	Max. & min. values of humidity
Wind speed	LFU 1988-2003	ASECNA: mean values in 2004-2005
Cloud cover shade	N/A	N/A
Effective shade	N/A	N/A
Point sources data	Available	Water quality at Oueme tributaries
Point abstraction data	From statistics and WEAP	From WEAP
Diffuse sources data	From Moneris	From Moneris

QUAL2K Results

According to the available input data and the output requirements for other models the water quality parameters that were simulated for the river Nectar and the river Oueme are:

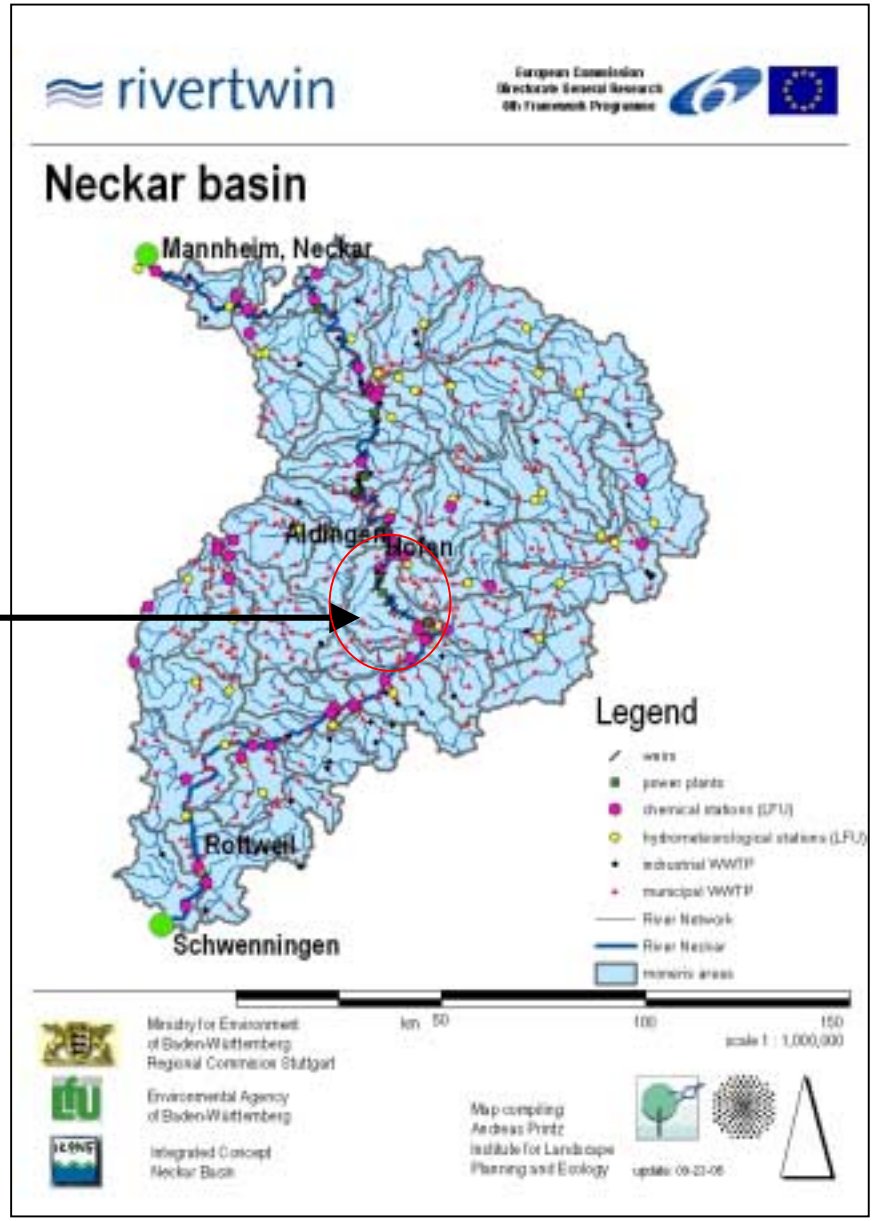
River Neckar	River Oueme
Water temperature (^{0}C)	Water temperature (^{0}C)
Dissolved Oxygen (mg/l)	Conductivity (μS/cm)
Biological Oxygen Demand (mg/l)	Ammonium (mg/l)
pH	Nitrate Nitrogen (mg/l)
Total Nitrogen (mg/l)	Phosphate (mg/l)
Total Phosphorus (mg/l)	Alkalinity (mg/l)
	pH

River reaches with pollution problems (LFU 1998)

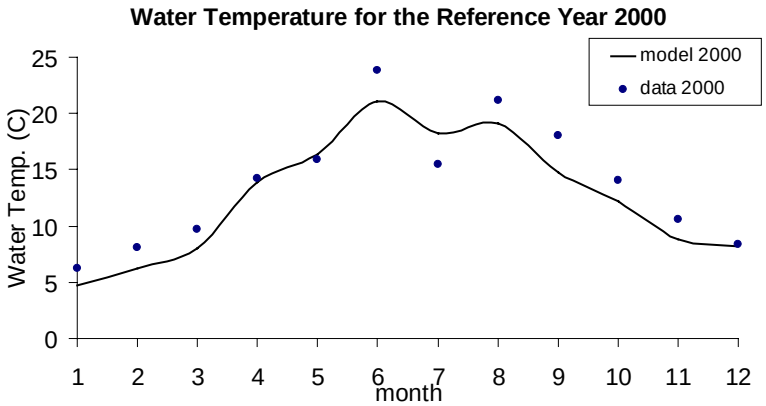


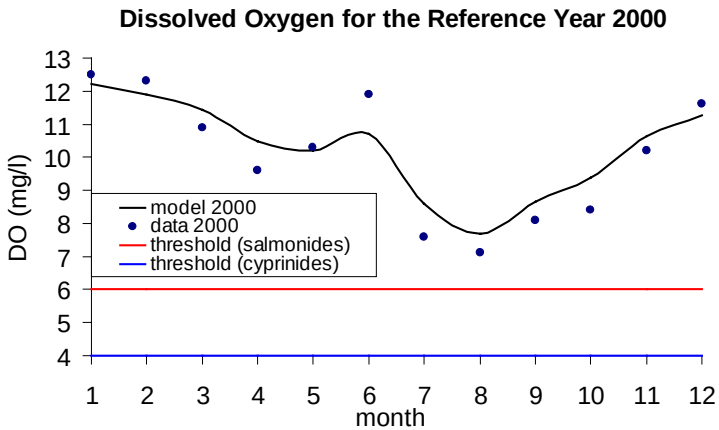
The River Neckar was divided into 40 reaches from Schwenningen (headwater) to Mannheim (downstream end)

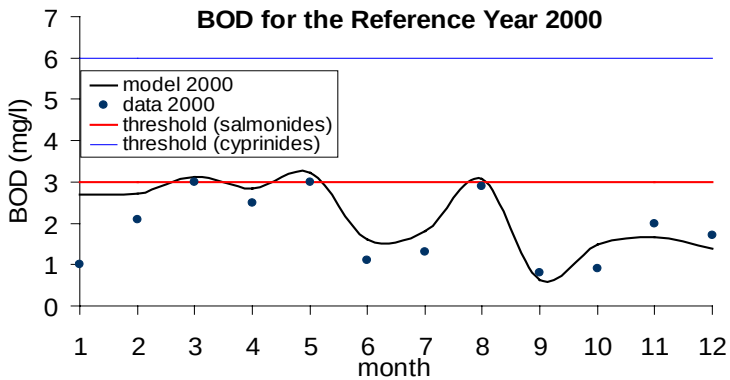
Reference river segment (length 33km)
reach 18 – reach 23

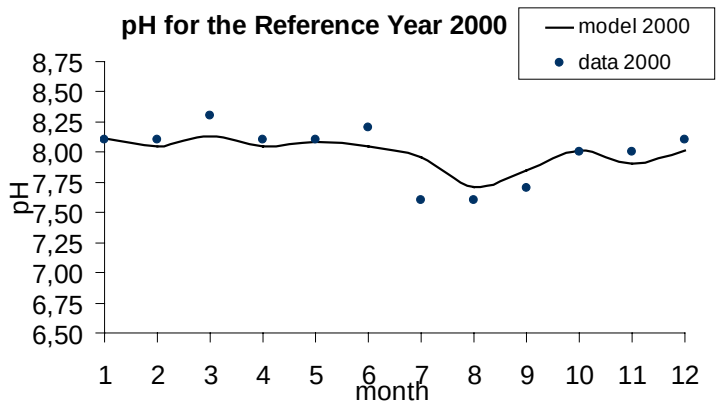


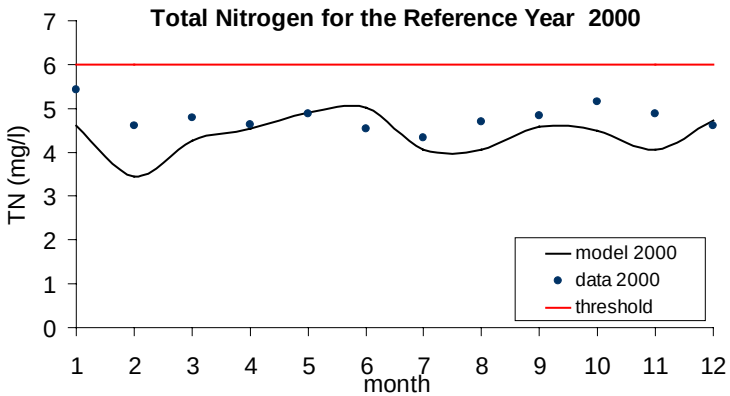
QUAL2K Results for the Reference Year 2000

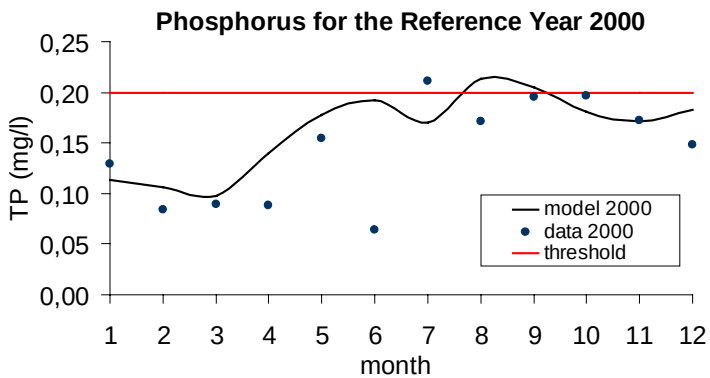

Water Temperature for the Reference Year 2000
model 2000
data 2000
Water Temp. (C)
month


Dissolved Oxygen for the Reference Year 2000
model 2000
data 2000
threshold (salmonides)
threshold (cyprinides)
DO (mg/l)
month


BOD for the Reference Year 2000
model 2000
data 2000
threshold (salmonides)
threshold (cyprinides)
BOD (mg/l)
month

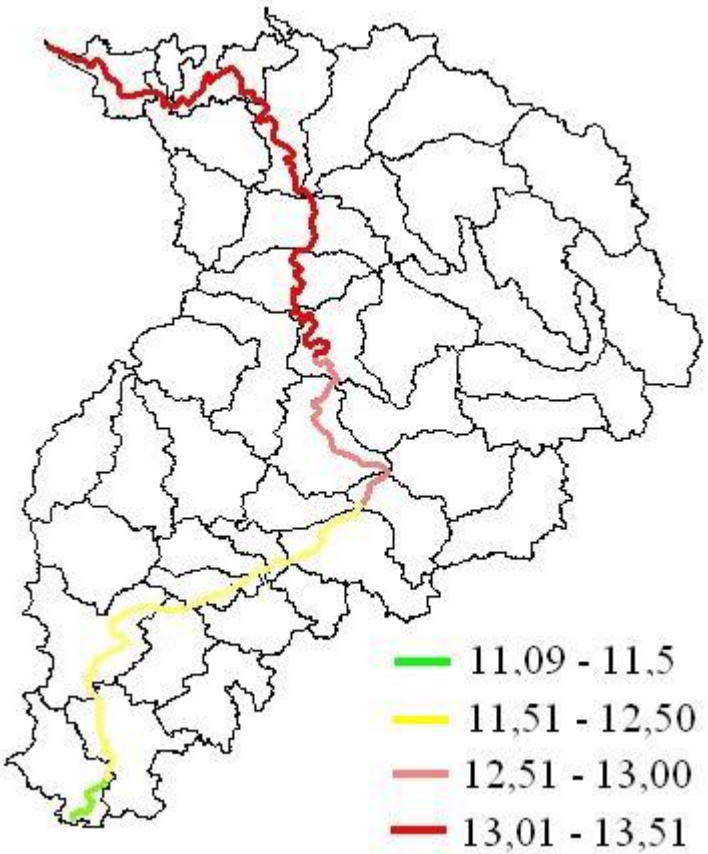

pH for the Reference Year 2000
model 2000
data 2000
pH
month


Total Nitrogen for the Reference Year 2000
model 2000
data 2000
threshold
TN (mg/l)
month

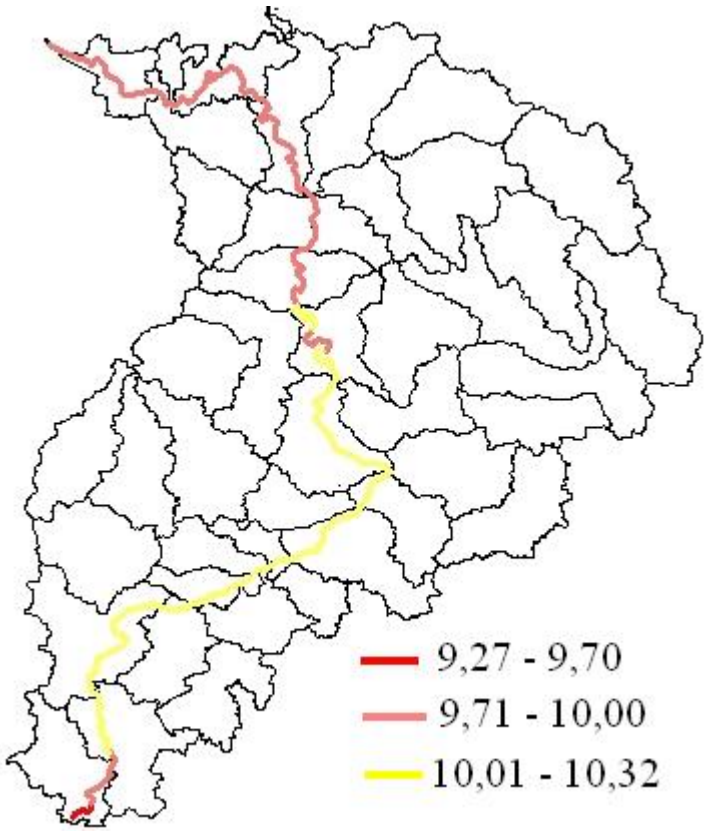

Phosphorus for the Reference Year 2000
model 2000
data 2000
threshold
TP (mg/l)
month

QUAL2K Results for the Reference Year 2000

Water Temperature (°C)

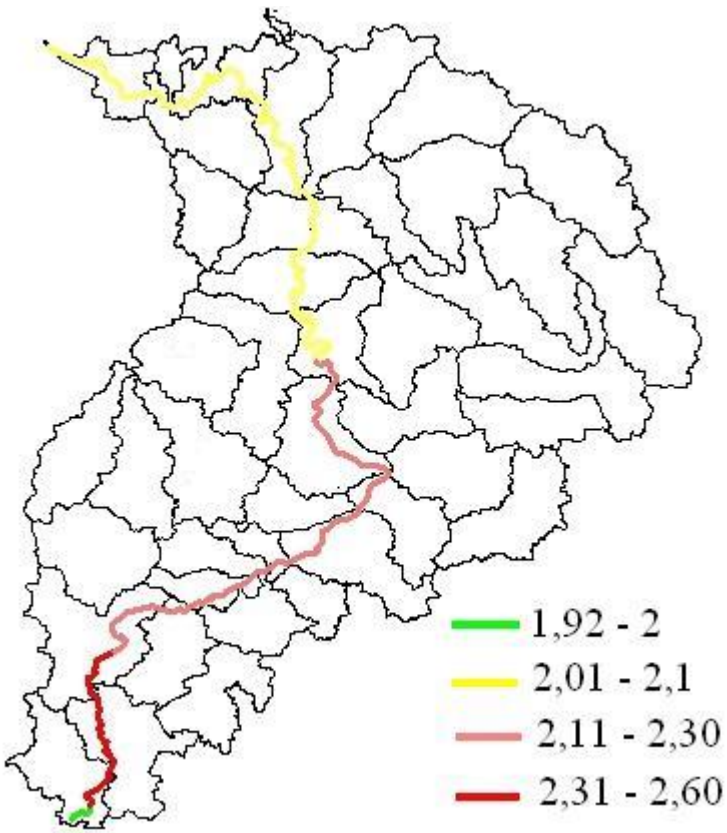


Dissolved Oxygen (mg/l)

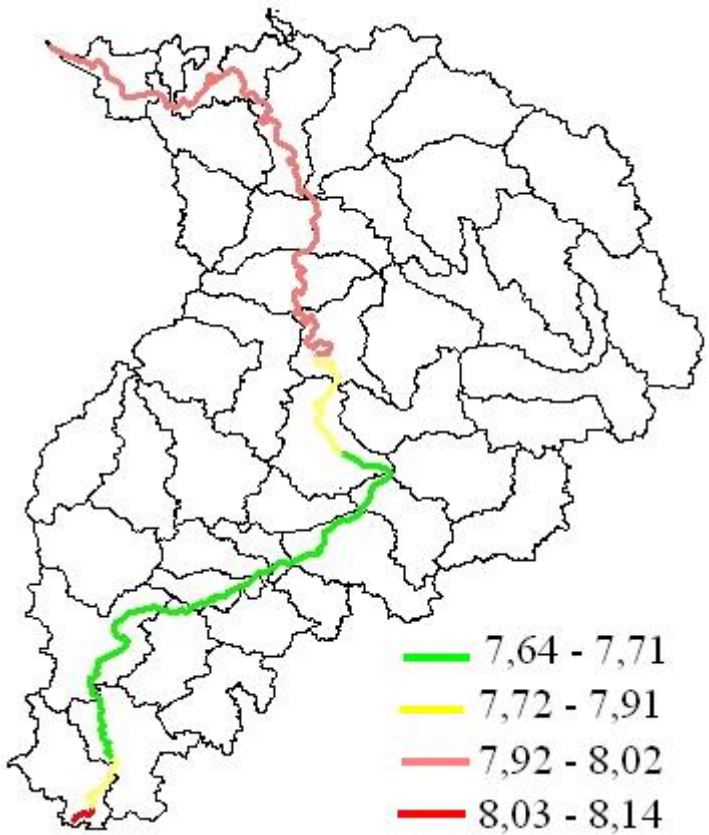


QUAL2K Results for the Reference Year 2000

Biological Oxygen Demand (mg/l)

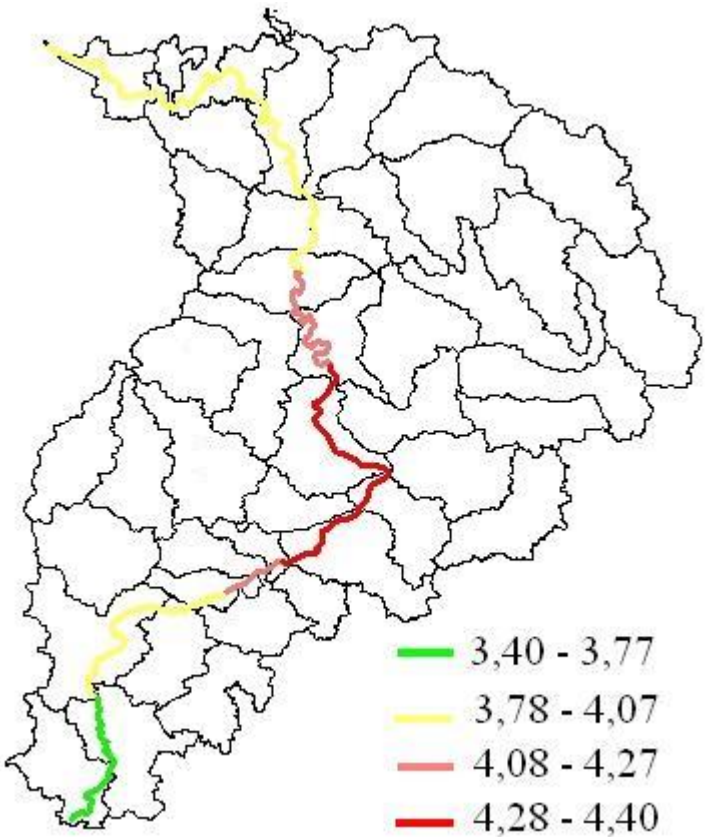


pH

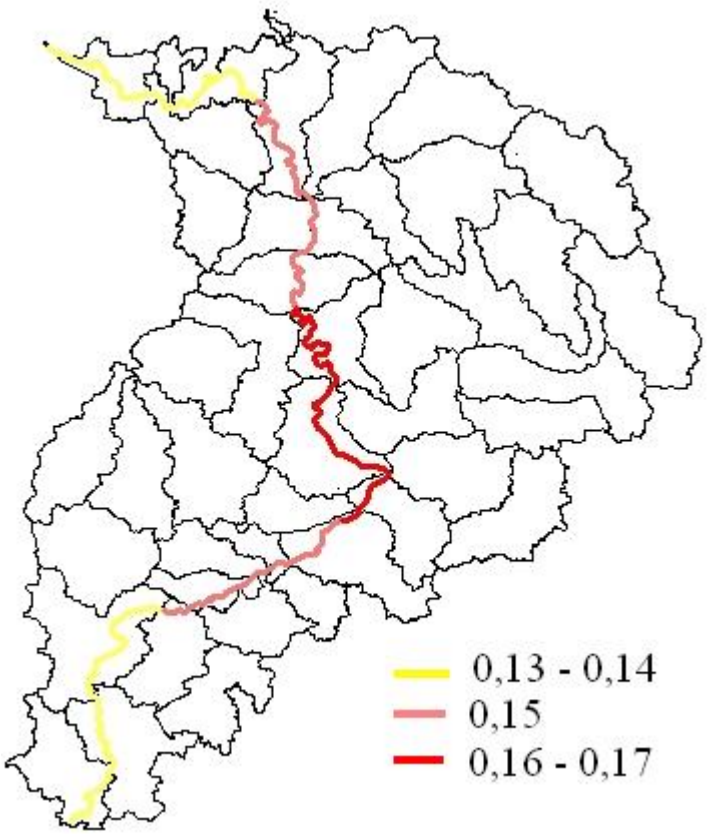


QUAL2K Results for the Reference Year 2000

Total Nitrogen (mg/l)

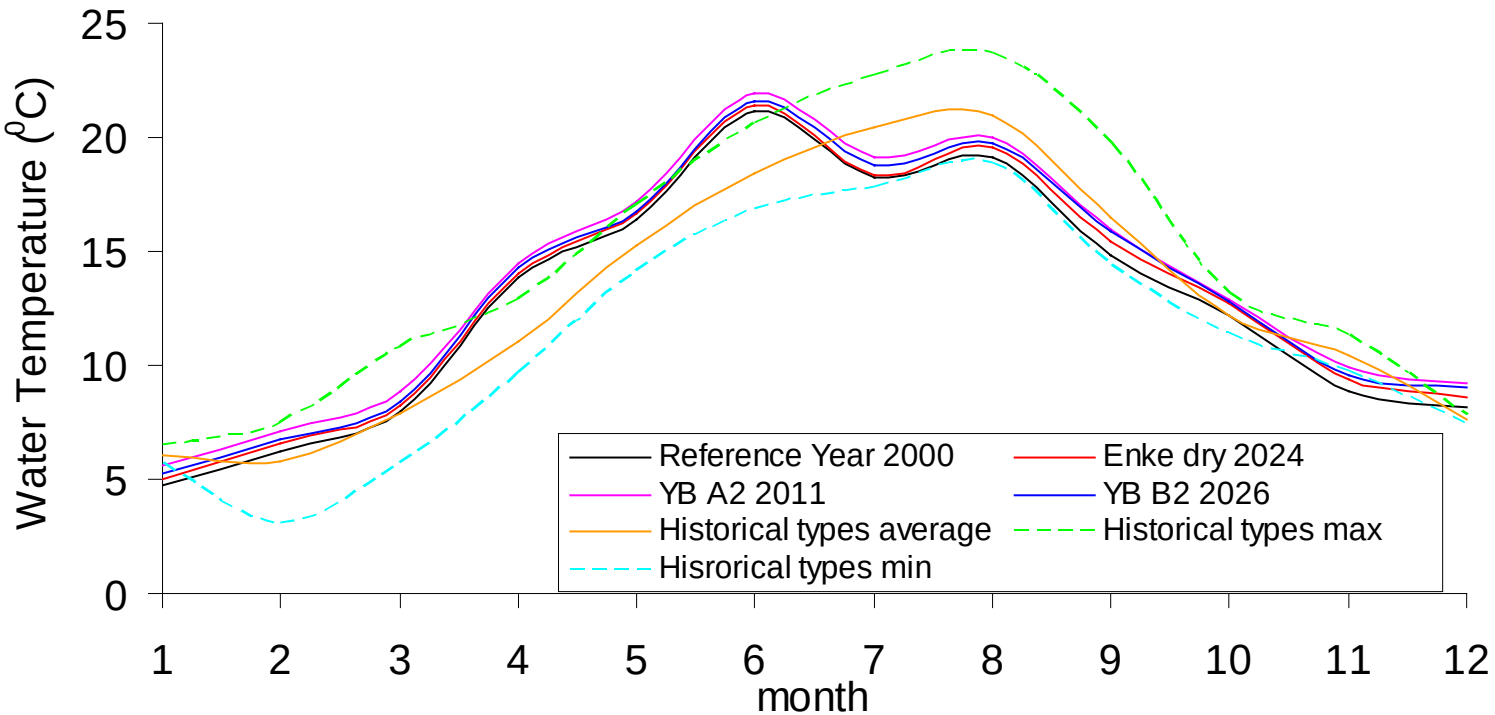


Total Phosporus (mg/l)

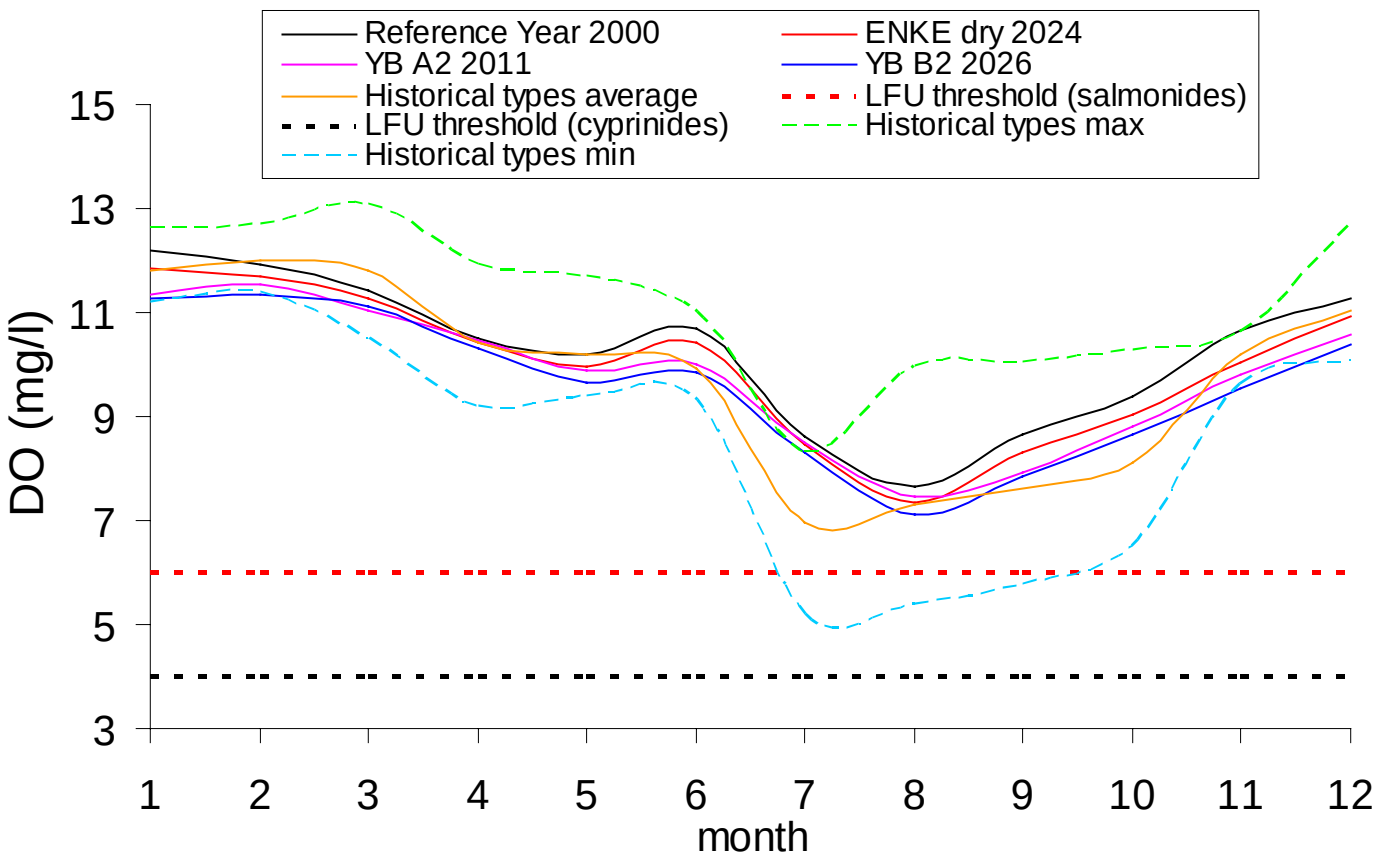


QUAL2K Results for ENKE dry (extreme year 2024), YB(A2) (extreme year 2011), YB(B2) (extreme year 2026) climate scenarios and for historical climate types 1988-2003

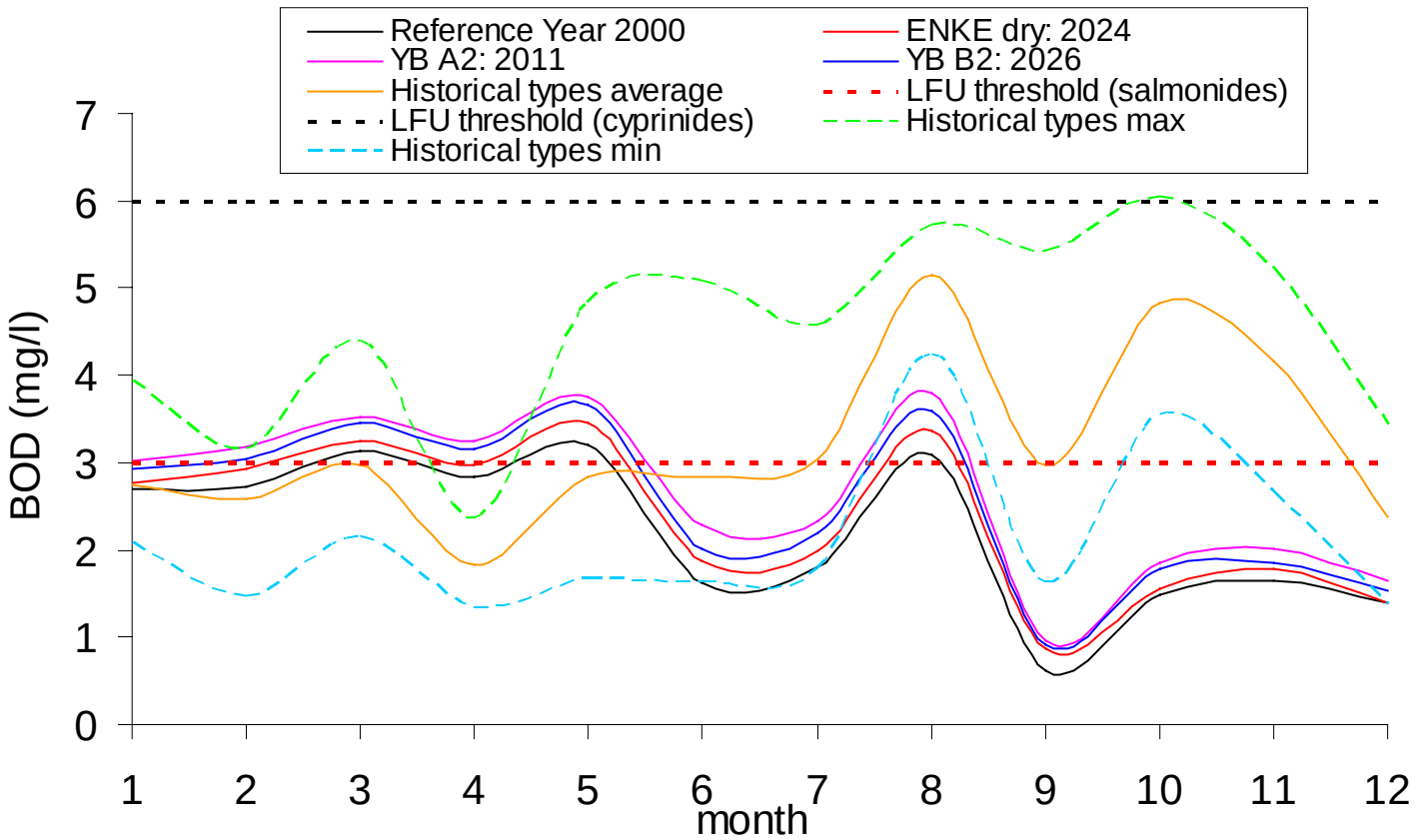
Water temperature for climate scenarios and historical climate types 1988-2003



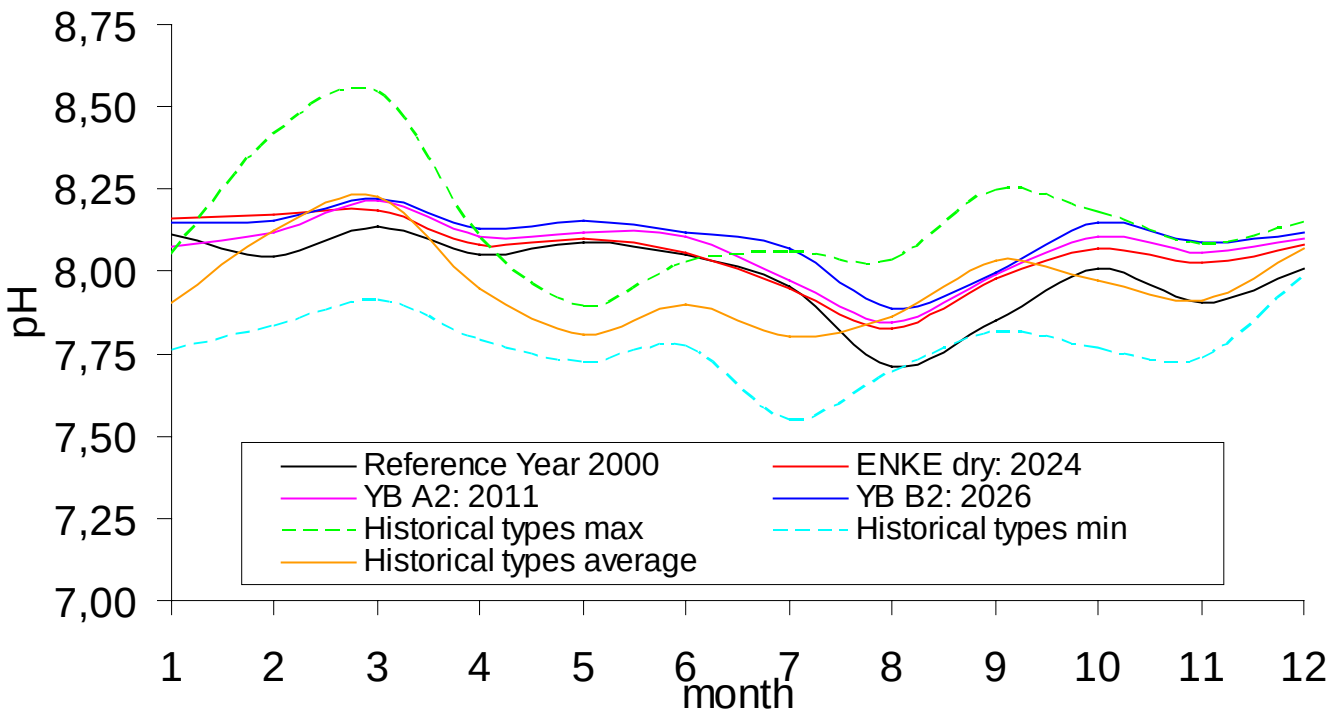
Dissolved Oxygen for climate scenarios and historical climate types 1988-2003



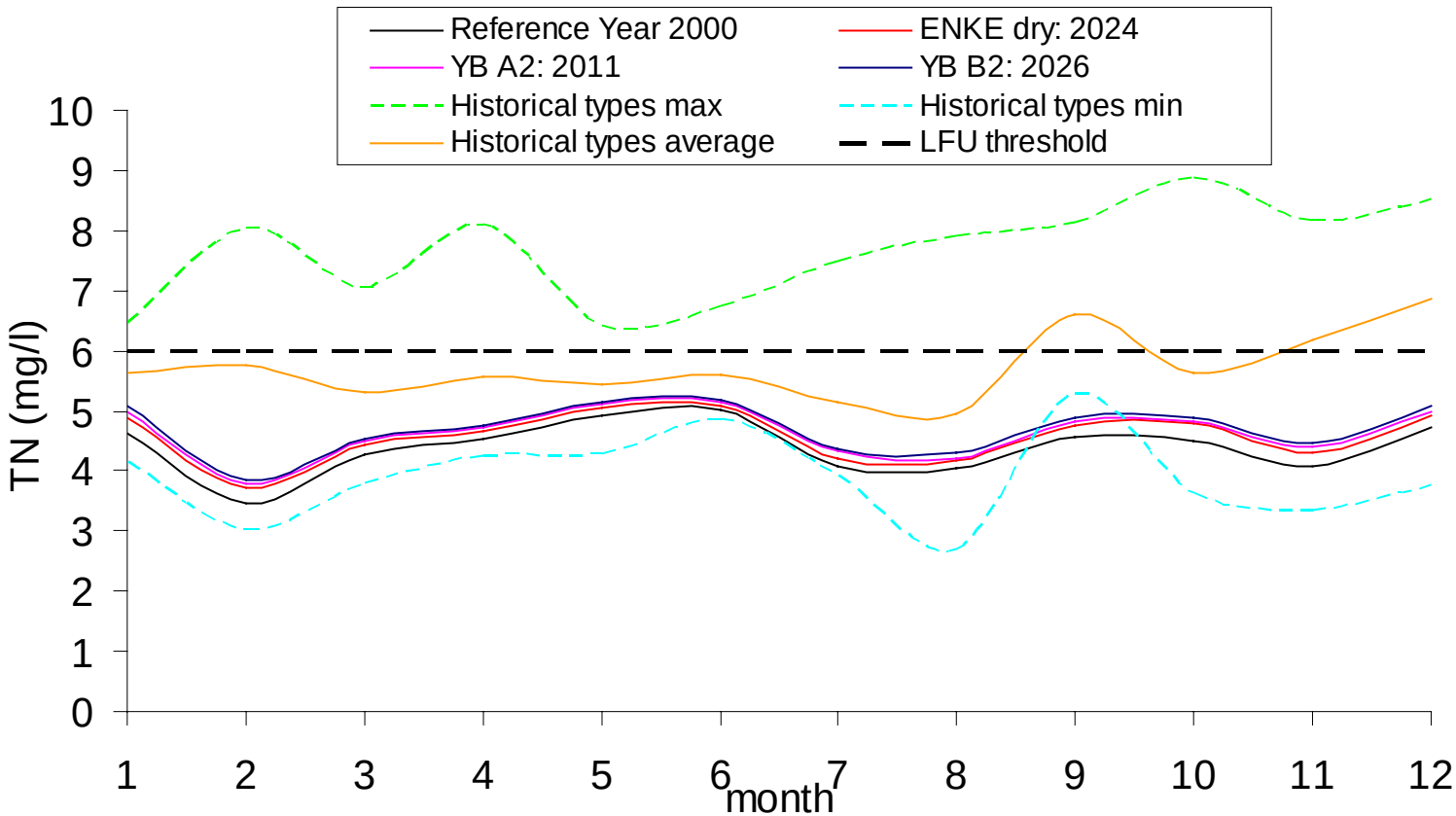
Biological Oxygen Demand for climate scenarios and historical climate types 1988-2003



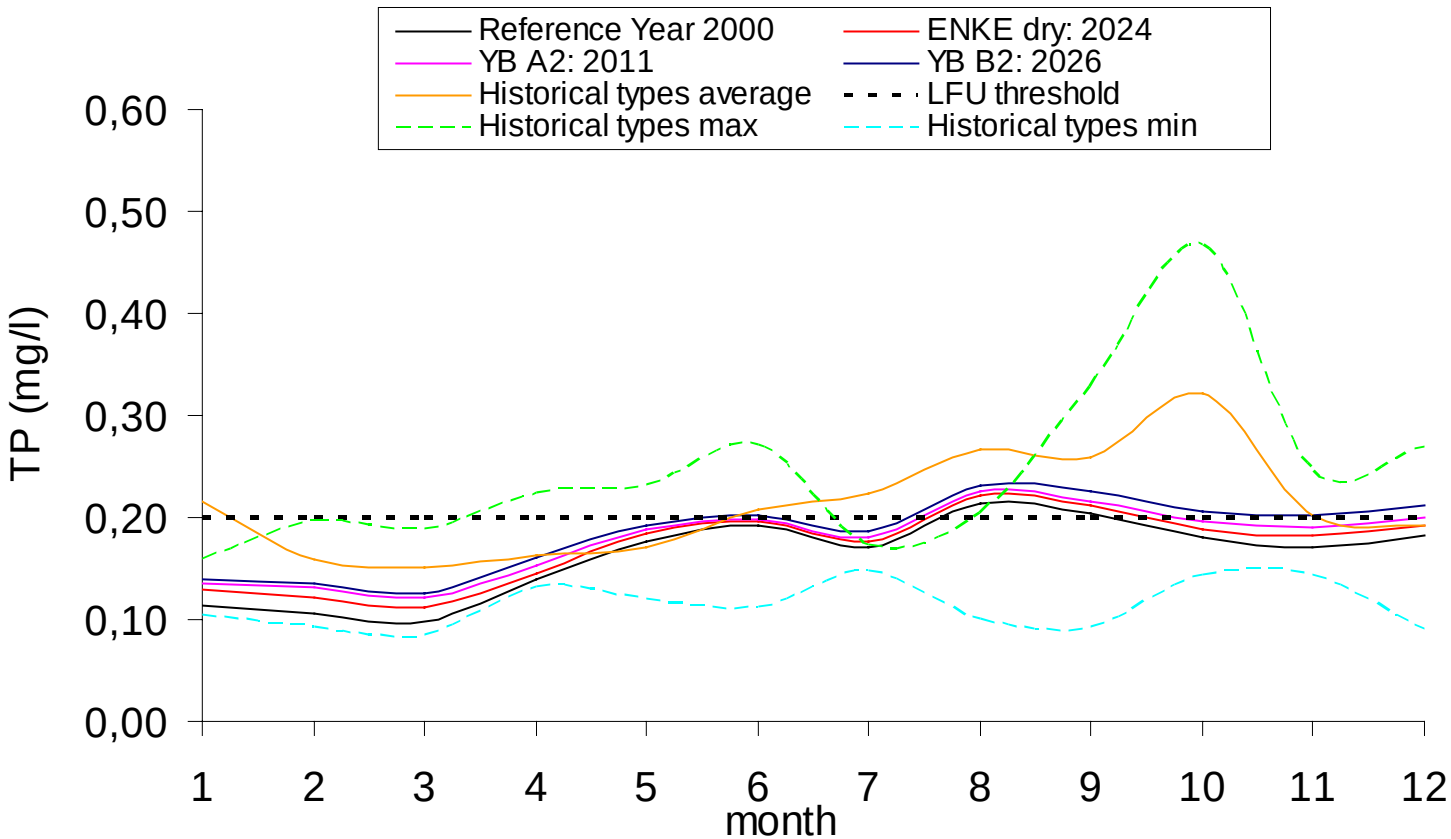
pH for climate scenarios and historical climate types 1988-2003



Total Nitrogen for climate scenarios and historical climate types 1988-2003



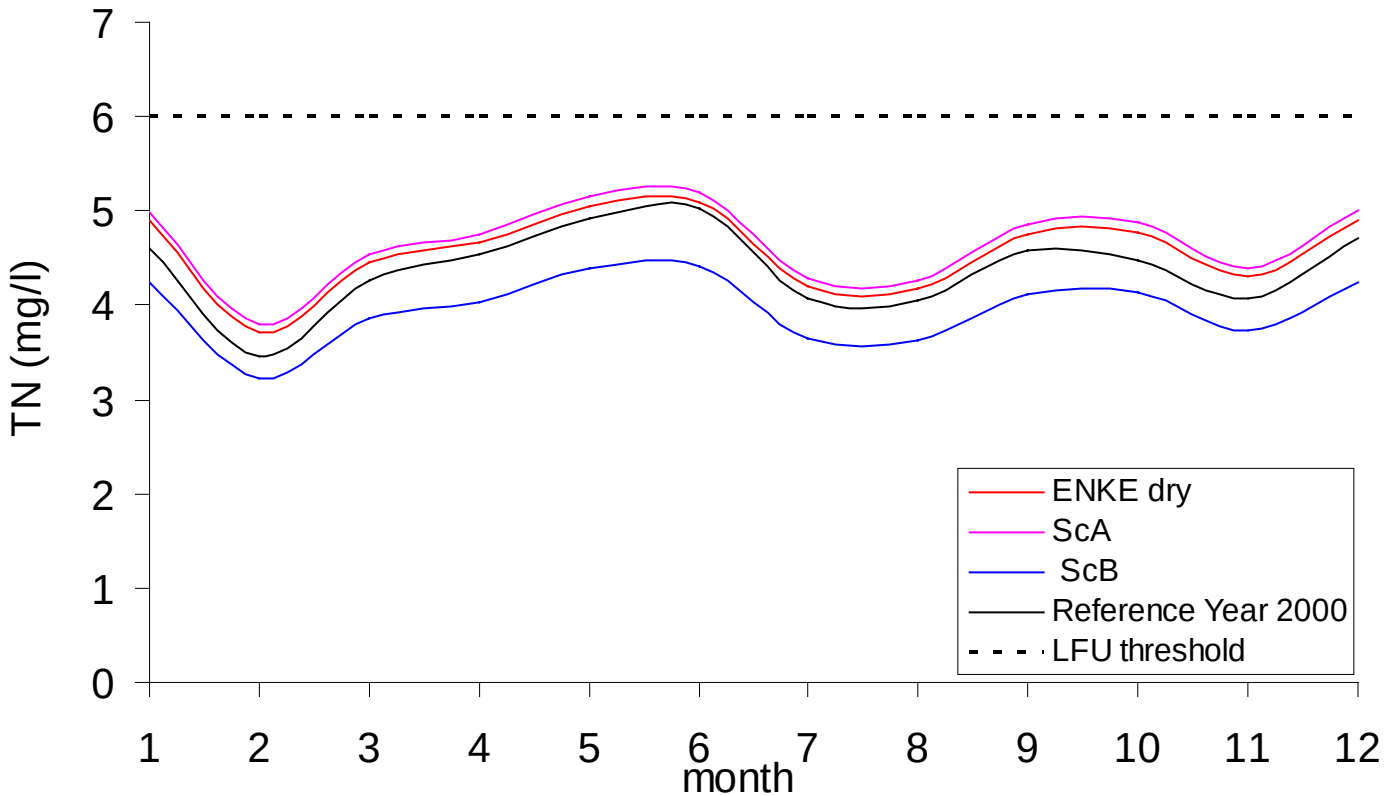
Total Phosphorus for climate scenarios and historical climate types 1988-2003



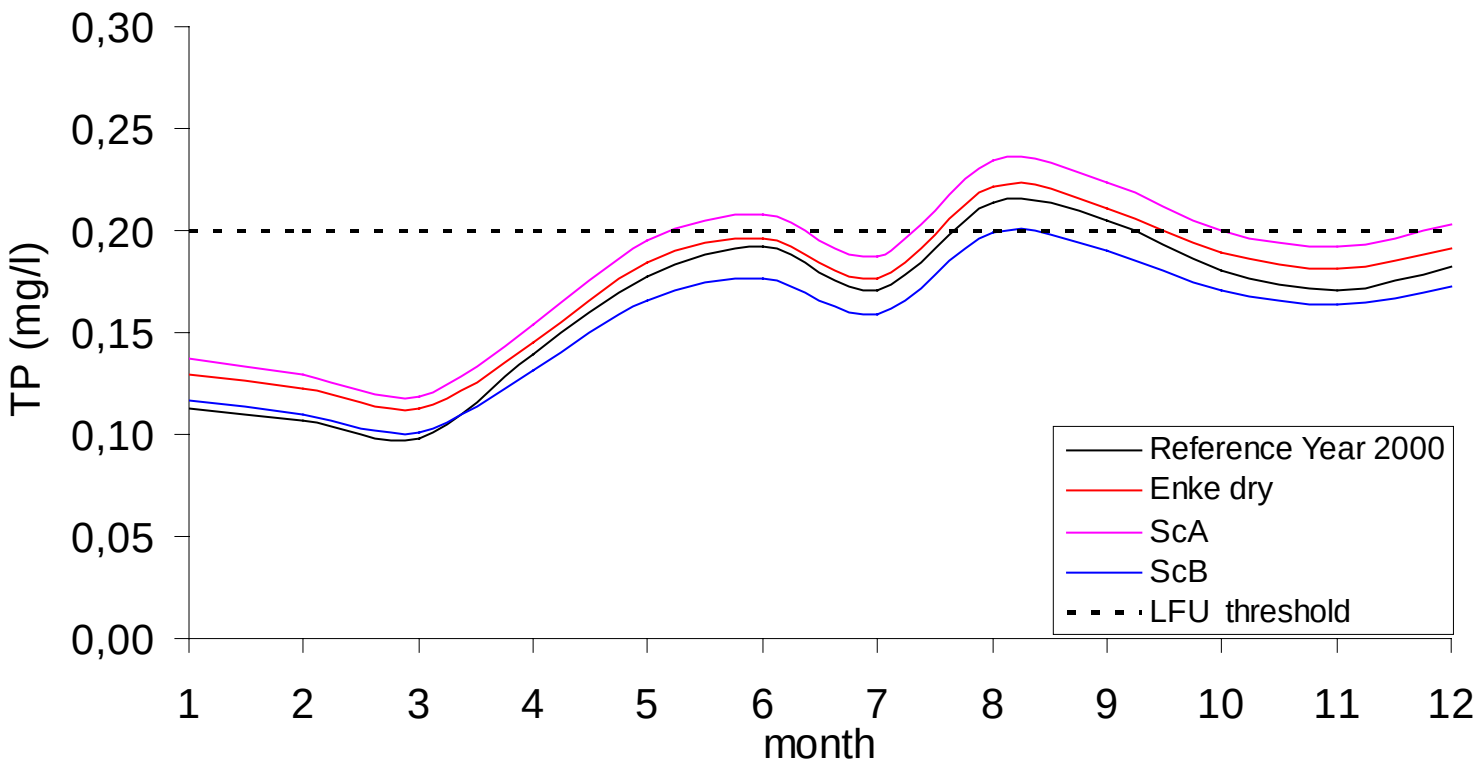
Climate scenario	Water Temp. (^{0}C)	DO (mg/l)	pH	BOD (mg/l)	TN (μg/l)	TP (μg/l)
ENKE dry (2024)	+ 0.35 (max increase during autumn /winter: +0.47)	- 0.28 (max decrease during autumn /winter: -0.36)	+ 0.06 (max increase end of summer /autumn: +0.09)	+ 0.16 (max increase during summer: +0.24)	+ 190 (max increase during autumn /winter: +240)	+ 9 (max increase during autumn /winter: +12)
YB A2 (2011)	+0.91 (max increase during autumn/winter:+ 0.98)	- 0.49 (max decrease during autumn /winter: -0.68)	+ 0.07 (max increase end of summer /autumn: +0.12)	+ 0.44 (max increase during summer: +0.6)	+ 260 (max increase during autumn /winter: +320)	+ 16 (max increase during autumn /winter: +20)
YB B2 (2026)	+0.61 (max increase during autumn /winter: +0.73)	- 0.65 (max decrease during autumn /winter: -0.83)	+ 0.11 (max increase end of summer /autumn: +0.14)	+ 0.32 (max increase during summer: +0.43)	+ 32 (max increase during autumn /winter: +39)	+ 23 (max increase during autumn /winter: +28)

QUAL2K Results (Socioeconomic Scenarios A,B)

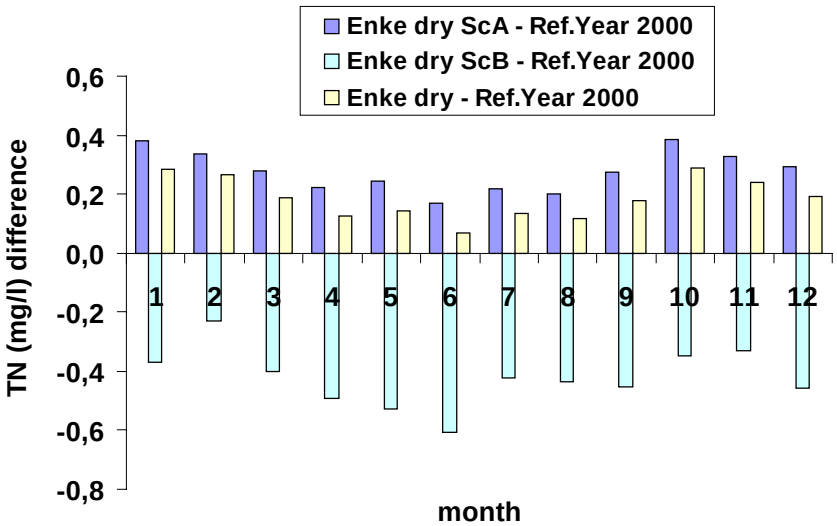
Concentration of total Nitrogen for Enke dry Socioeconomic Scenarios A,B (extreme year 2024)

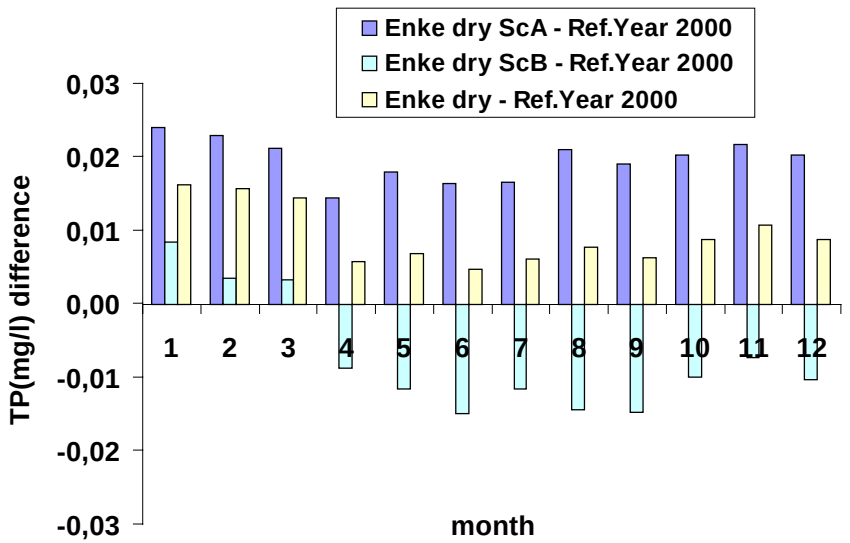


Concentration of total Phosphorus for Enke dry Socioeconomic Scenarios A,B (extreme year 2024)



Difference in TN,TP concentrations between the Enke dry scenario, Enke dry socioeconomic scenarios A,B (2024) and the reference year 2000






rivertwin
European Commission
Directorate General Research
6th Framework Programme
Benin
Oueme basin
River Network
River Oueme
River segment
River gauges
Moneris areas
State of Benin
Communes

QUAL2K model:

Due to limited available data the part from Beterou to Bonou of the River Oueme has been selected for the application of QUAL2K. This part was divided into 3 reaches.

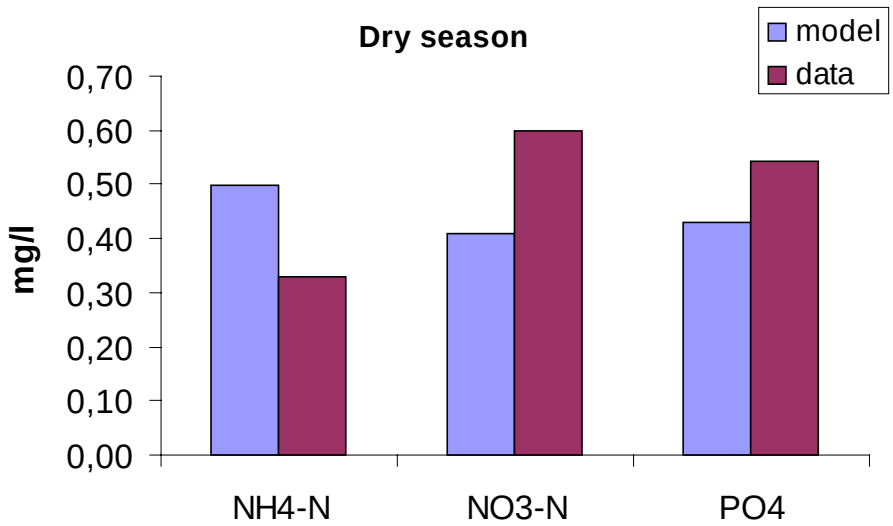
Reach 1: 0-128km

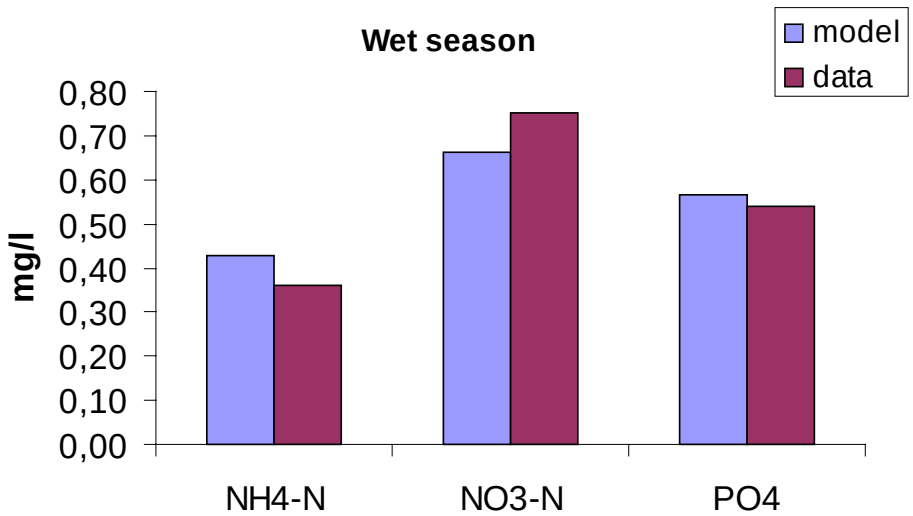
Reach 2: 129-240km

Reach 3: 241-345km

Water temperature, conductivity,alkalinity,pH,NH_4-N,NO_3-N and PO_4 were simulated for each reach.

Model calibration (Reach 2, Reference Year)



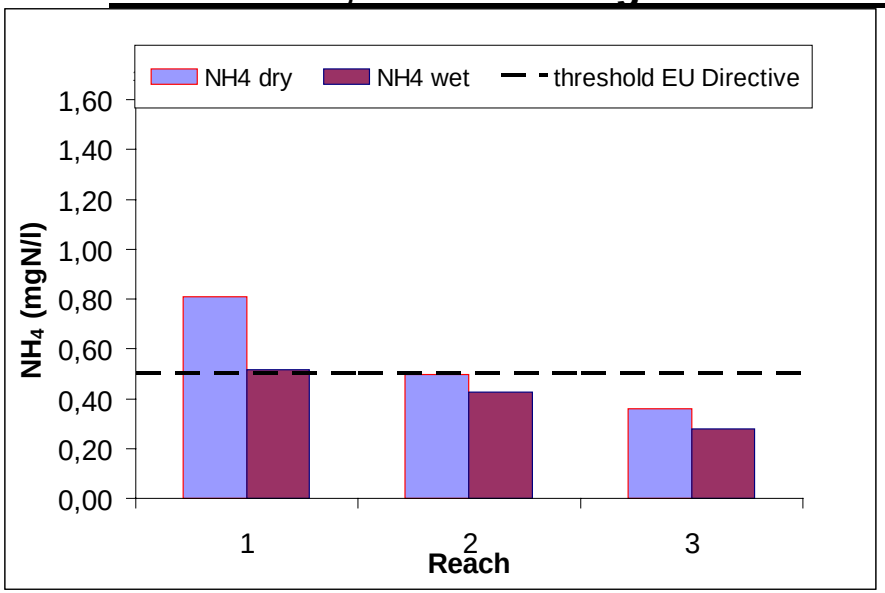


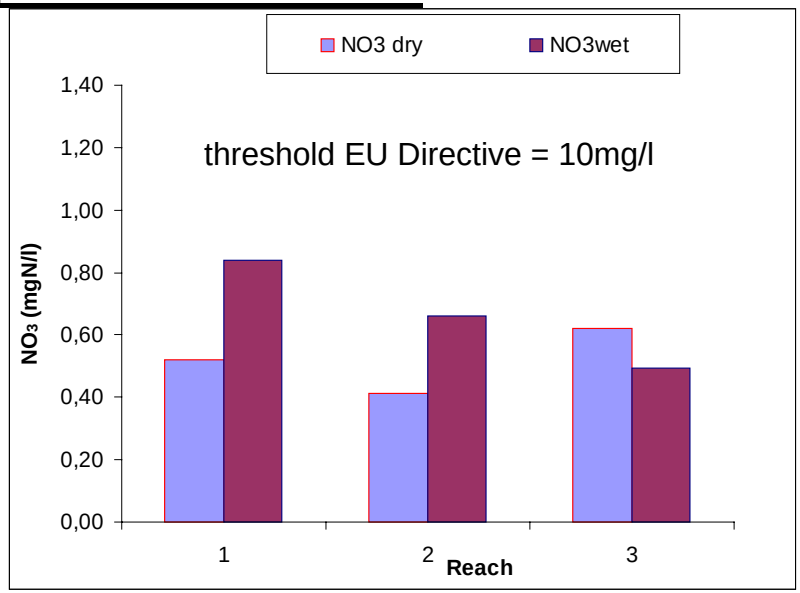
QUAL2K RESULTS

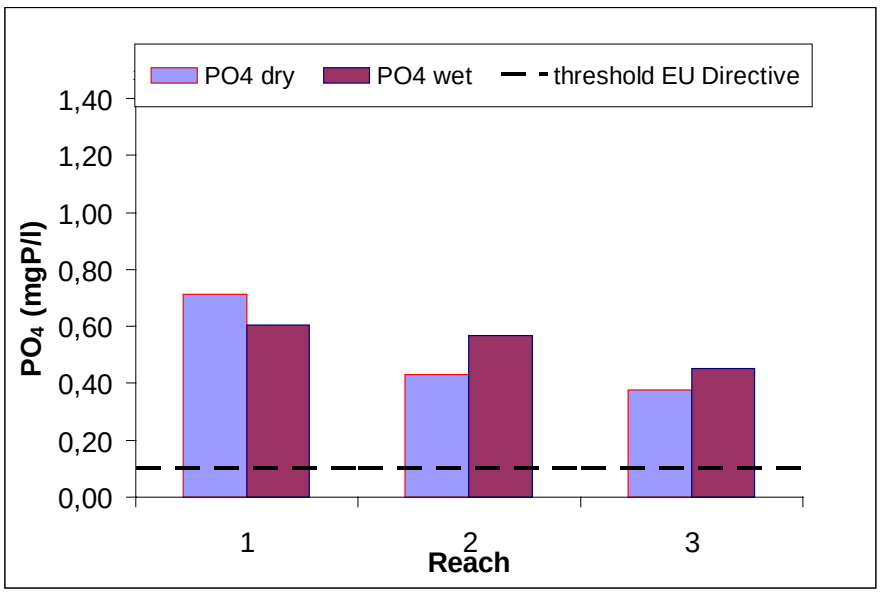
Water quality parameters were simulated for dry (April-November) and wet season (December-March)

- Simulated concentrations of Ammonium (NH_4), Nitrate-Nitrogen (NO_3), Phosphate (PO_4) in the river Oueme for the reference year 2003
- Comparison between the reference year and historical climate types for the selected river reach 2
- Comparison between the reference year and socioeconomic scenarios lu2030 (Alafia, Wahala) for the selected river reach 2
- Comparison between the reference year, socioeconomic lu2030A and agropolitical & hydrological interventions lu2030A for the selected river reach 2

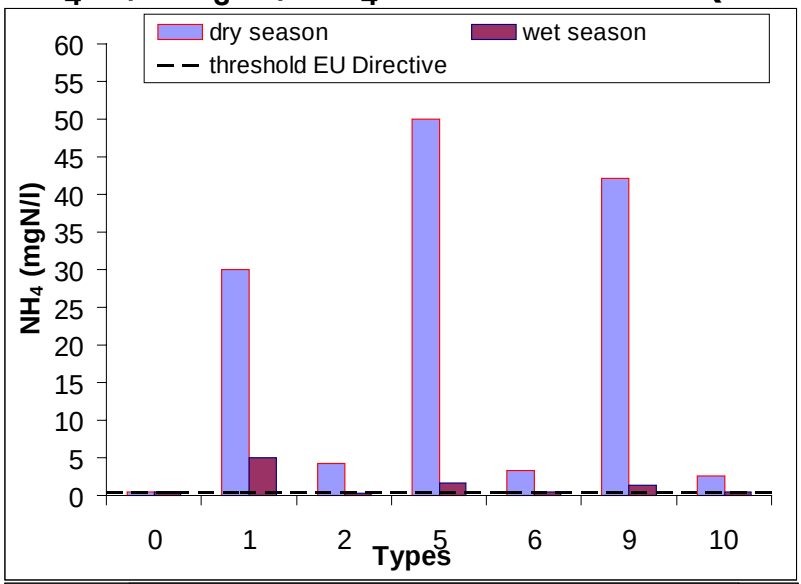
Ammonium, Nitrate Nitrogen and Phosphate concentrations *Reference Year*

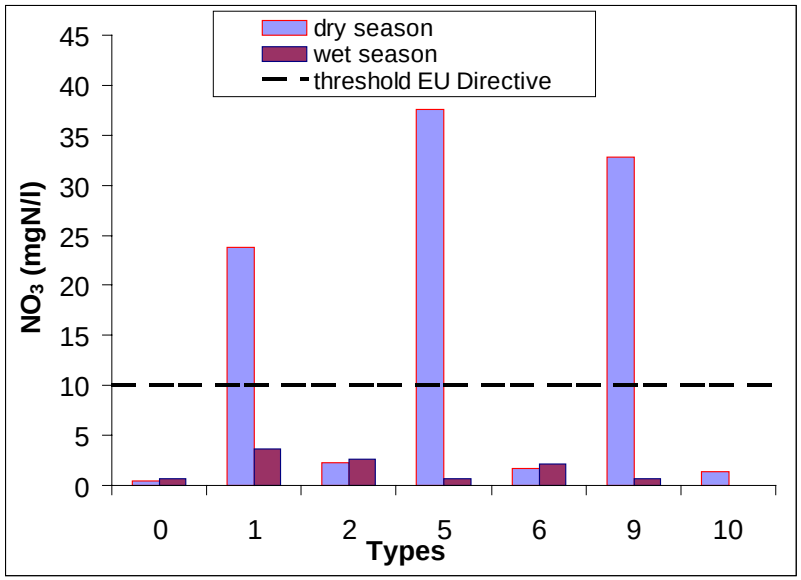


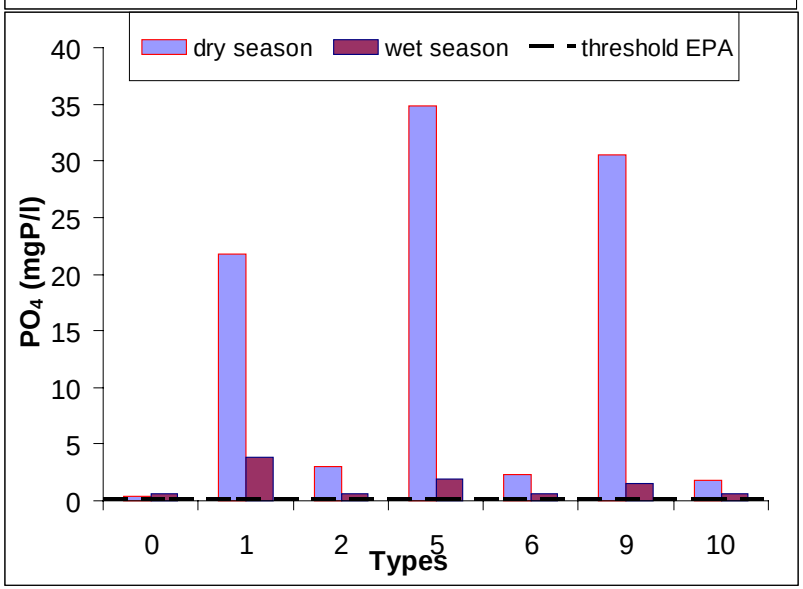




NH_4-N, NO_3-N, PO_4 concentrations (Reach 2) *Reference Year VS Historical Climate types*







Types:

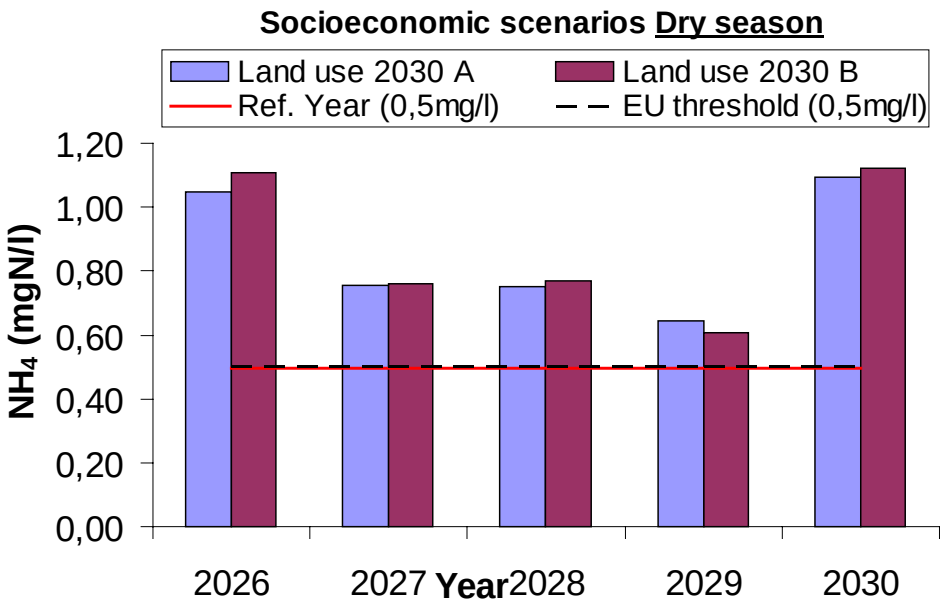
0: Reference Year
1: 1983+lu2003
2: 1999+lu2003
5: 1983+lu2030A
6: 1999+lu2030A
9: 1983+lu2030B
10: 1999+lu2030B

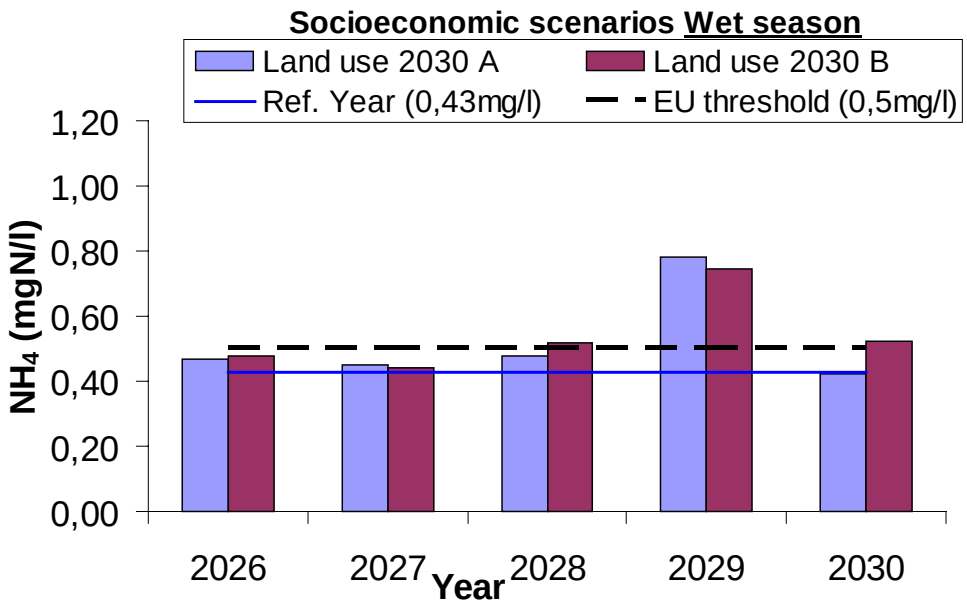
Reach 2: 129-240km

Ammonium (NH_4-N) concentration

Socioeconomic scenarios:

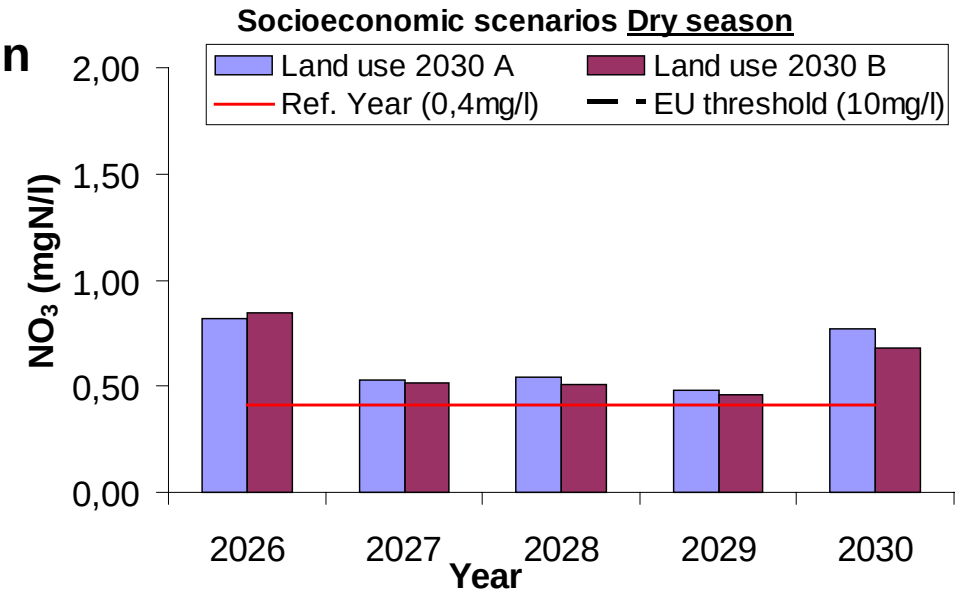
Alafia (A) and Wahala (B)
with land use 2030 (2026-2030)

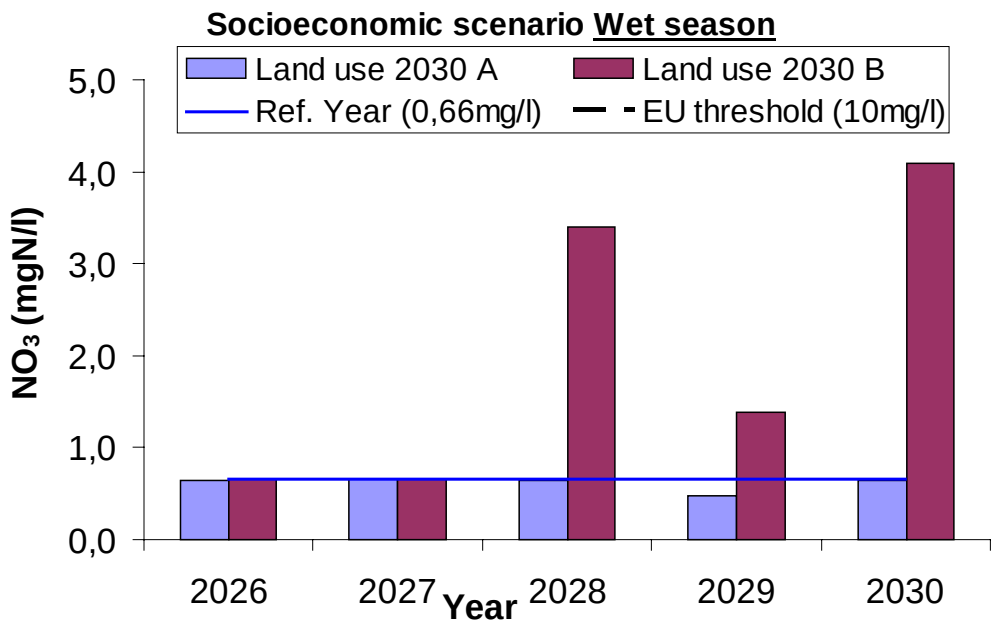




Nitrate Nitrogen (NO_3-N) concentration

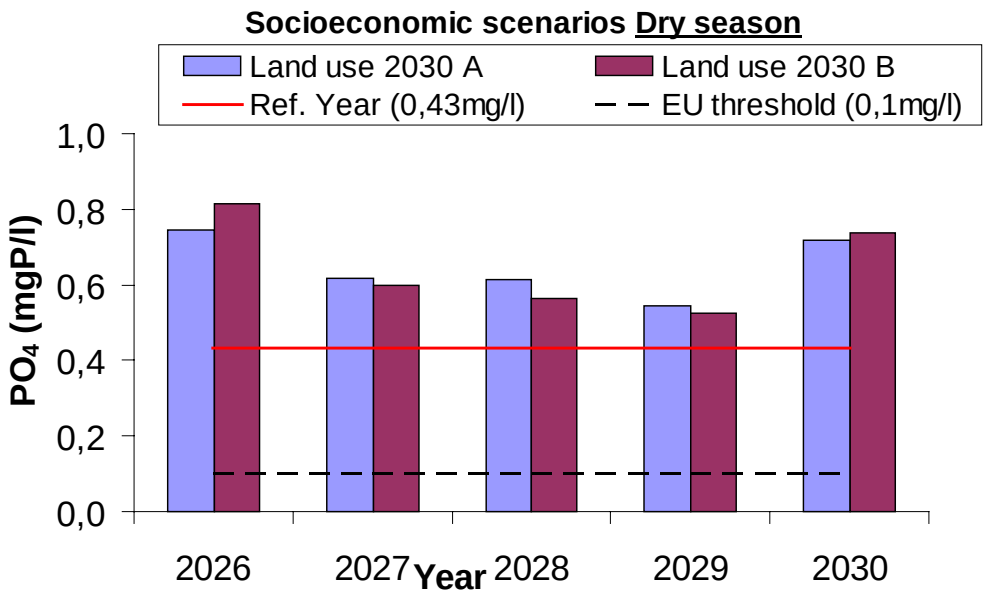
Socioeconomic scenarios:
Alafia (A) and Wahala (B)
with land use 2030 (2026-2030)

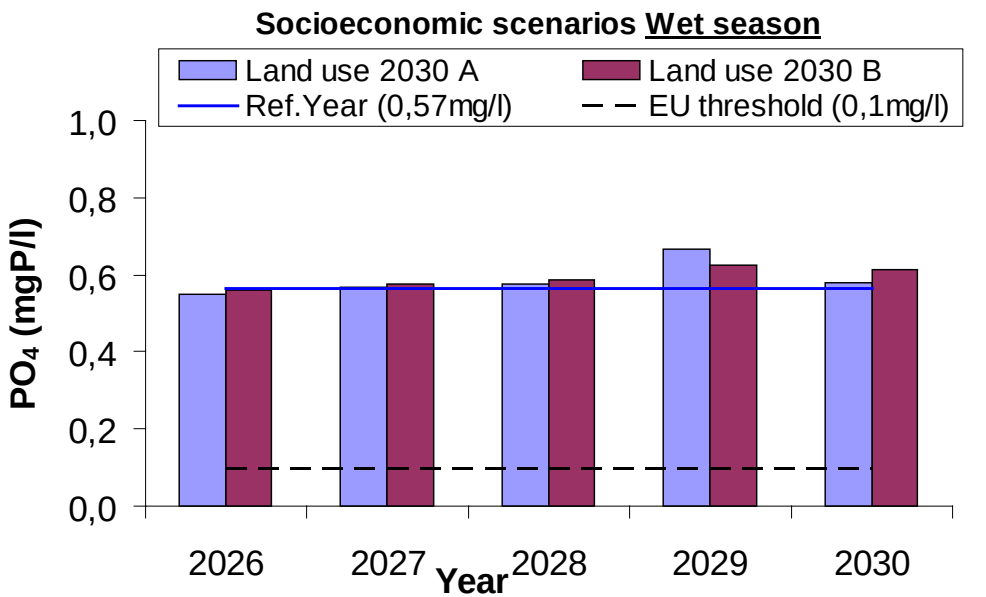




Phosphate (PO_4) concentration

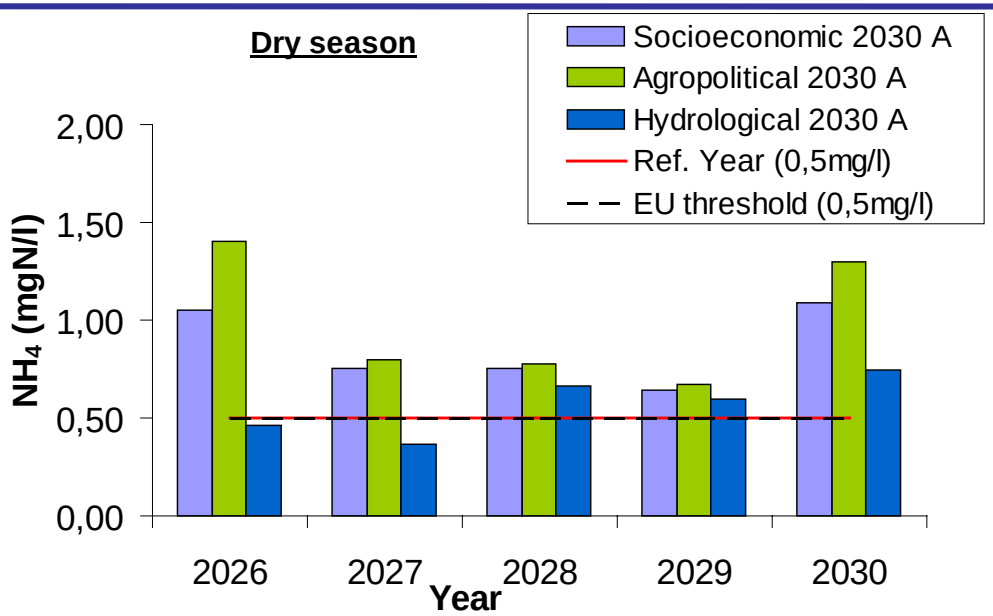
Socioeconomic scenarios:
Alafia (A) and Wahala (B)
with land use 2030 (2026-2030)

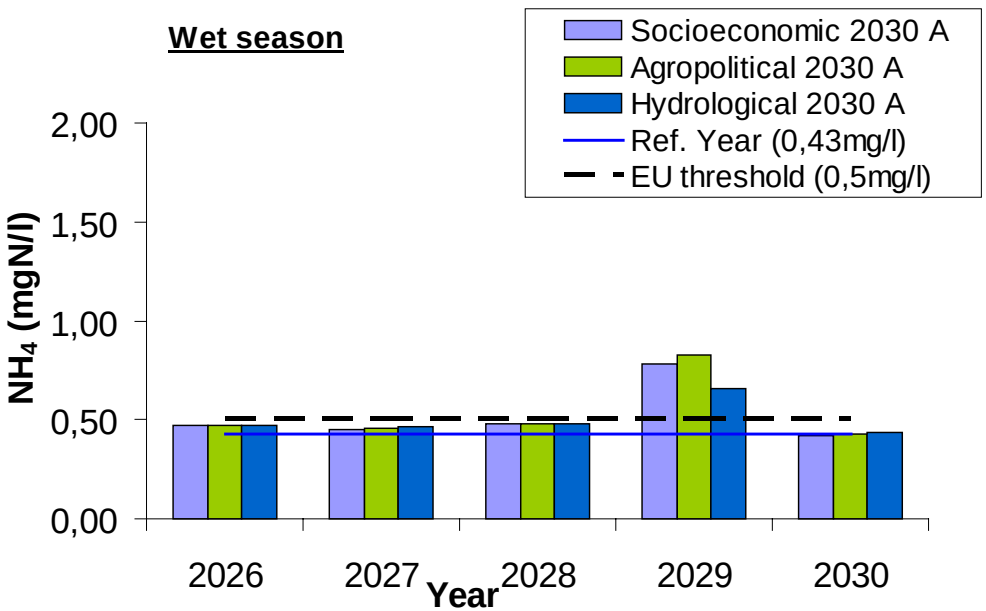




Ammonium (NH_4-N) concentration

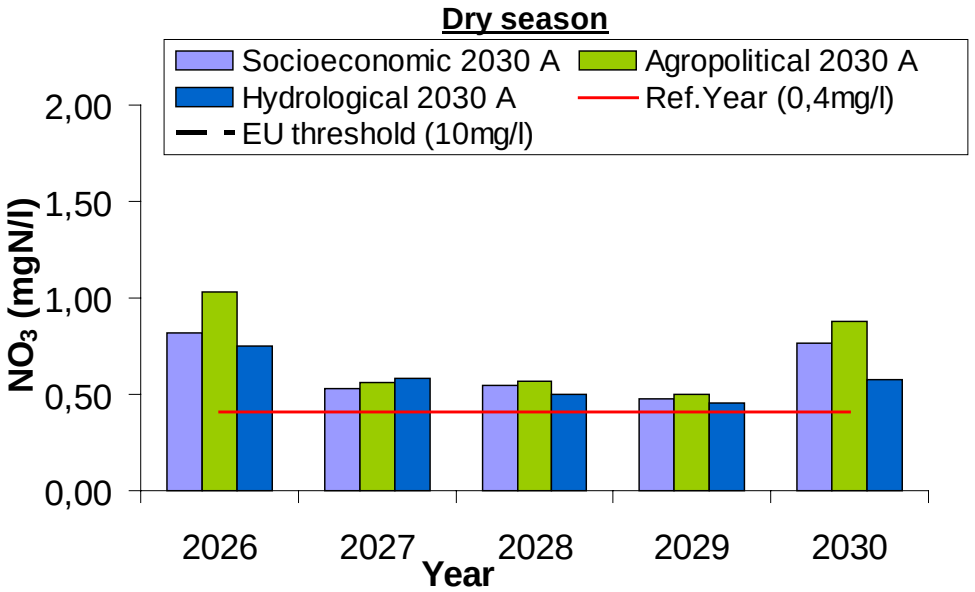
Agropolitical and hydrological interventions compared with the socioeconomic scenario Alafia with landuse 2030 (2026-2030)

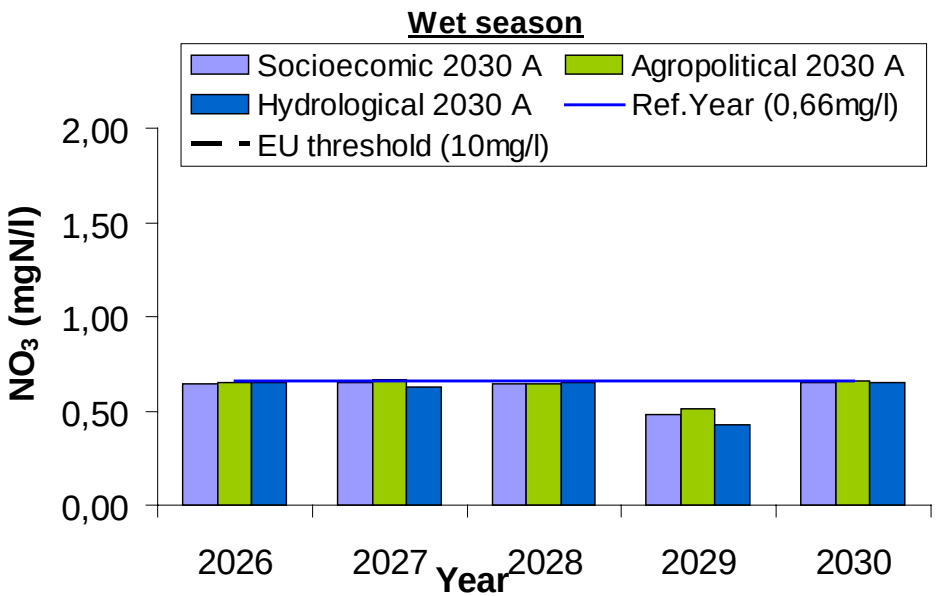




Nitrate Nitrogen (NO_3-N) concentration

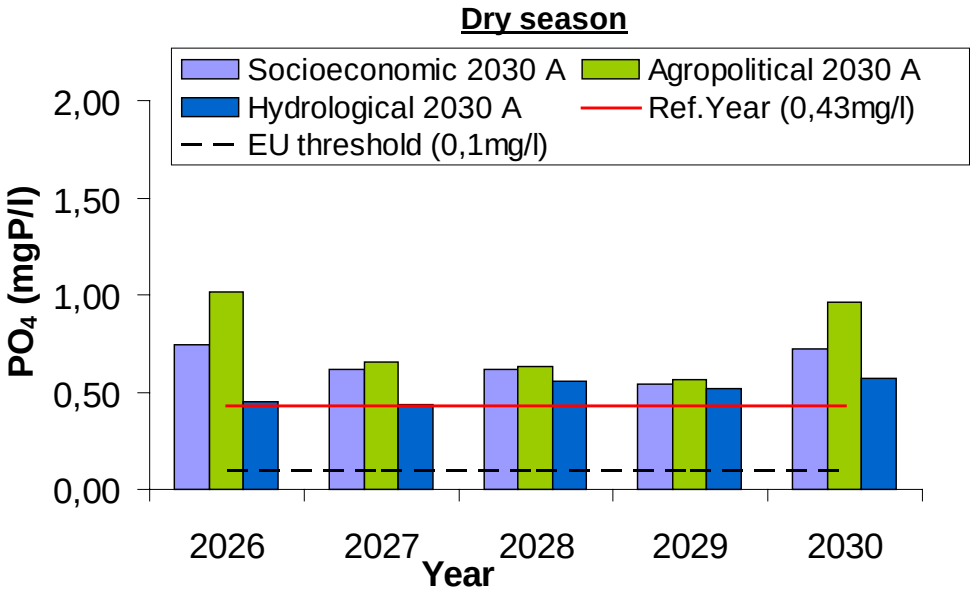
Agropolitical and hydrological interventions compared with the socioeconomic scenario Alafia with landuse 2030 (2026-2030)

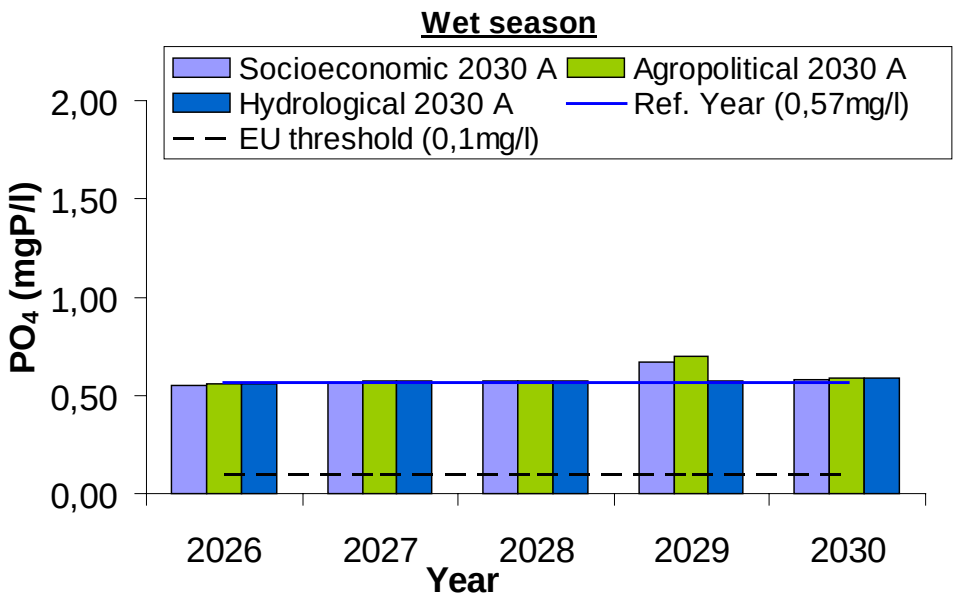




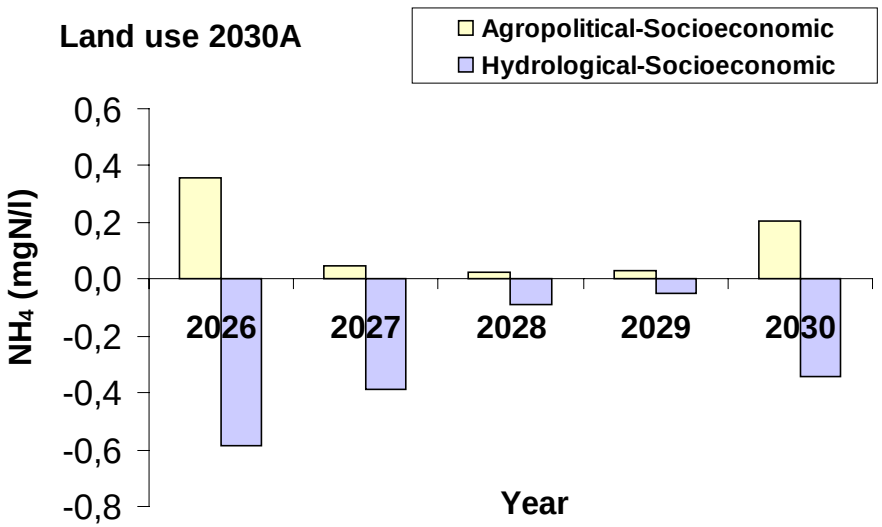
Phosphate (PO_4) concentration

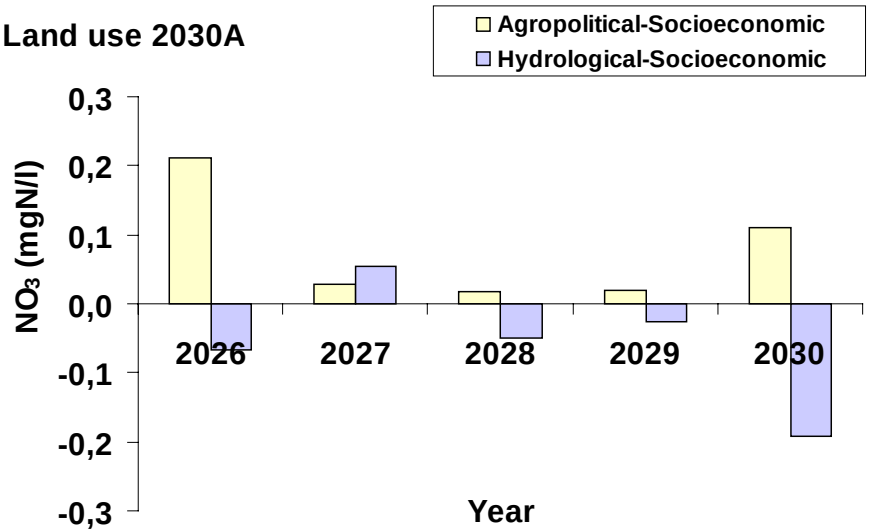
Agropolitical and hydrological interventions compared with the socioeconomic scenario Alafia with landuse 2030 (2026-2030)

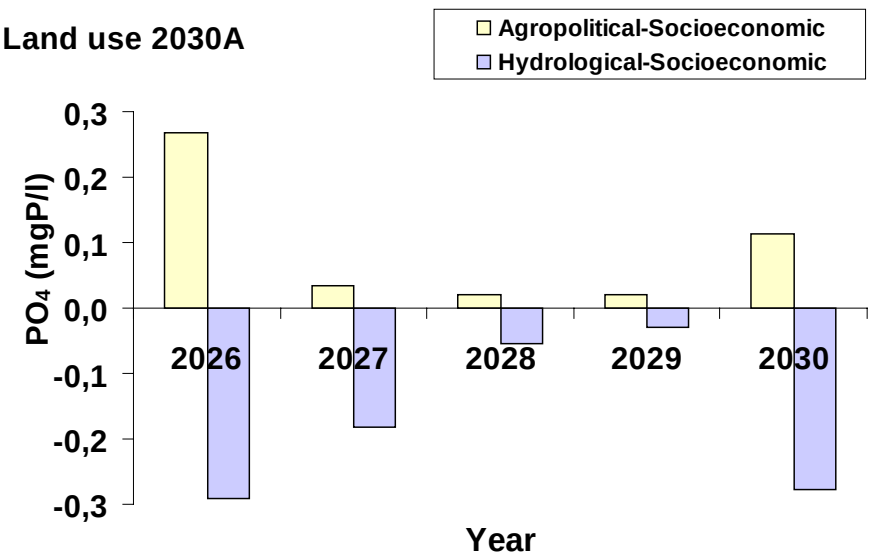




Impact of agropolitical and hydrological interventions of Sc A lu2030 to water quality parameters







CONCLUSIONS

River Neckar, Germany

- Climate scenarios seem to have no significant affect to the concentrations of the water quality parameters.
- Socioeconomic scenario A leads to a slight increase of nutrients concentrations (larger in P concentration that exceeds the LFU threshold).
- Socioeconomic scenario B leads to a decrease o nutrients concentrations (larger in P concentration)
- Next step: simulation of the conversion to grassland and increase of livestock interventions that expect to have significant affect to water quality.

River Oueme, Benin

- There is an increase in the concentrations of $N\text{-}NH_4$, $N\text{-}NO_3$ and PO_4 in the socioeconomic scenarios and the agropolitical intervention (larger in the case of agropolitical intervention).

  The highest concentrations of $N\text{-}NH_4$, $N\text{-}NO_3$ and PO_4 both in the socioeconomic and agropolitical scenarios, were observed in the years 2026,2028 and 2030.

- In the case of hydrological intervention there is a significant decrease of the $N\text{-}NH_4$, $N\text{-}NO_3$ and PO_4 concentrations.








Thank You!