

Vrije Universiteit Brussel (VUB)

Department Hydrology and Hydraulic Engineering

On the use of SWAT for the identification of the most cost-effective nitrogen abatement measures for river basins

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Zürich, Switzerland, 13-15 July 2005

Towards river basin management plans

- High environmental concerns
- Limited financial resources
- 'Good' water status to be reached by 2015
 - Set by EU Water Framework Directive (WFD)
 - Objectives to be reached at lowest cost
 - Set of actions; pollution abatement measures
- **My research:** Methodology to reach the water quality objectives at lowest cost

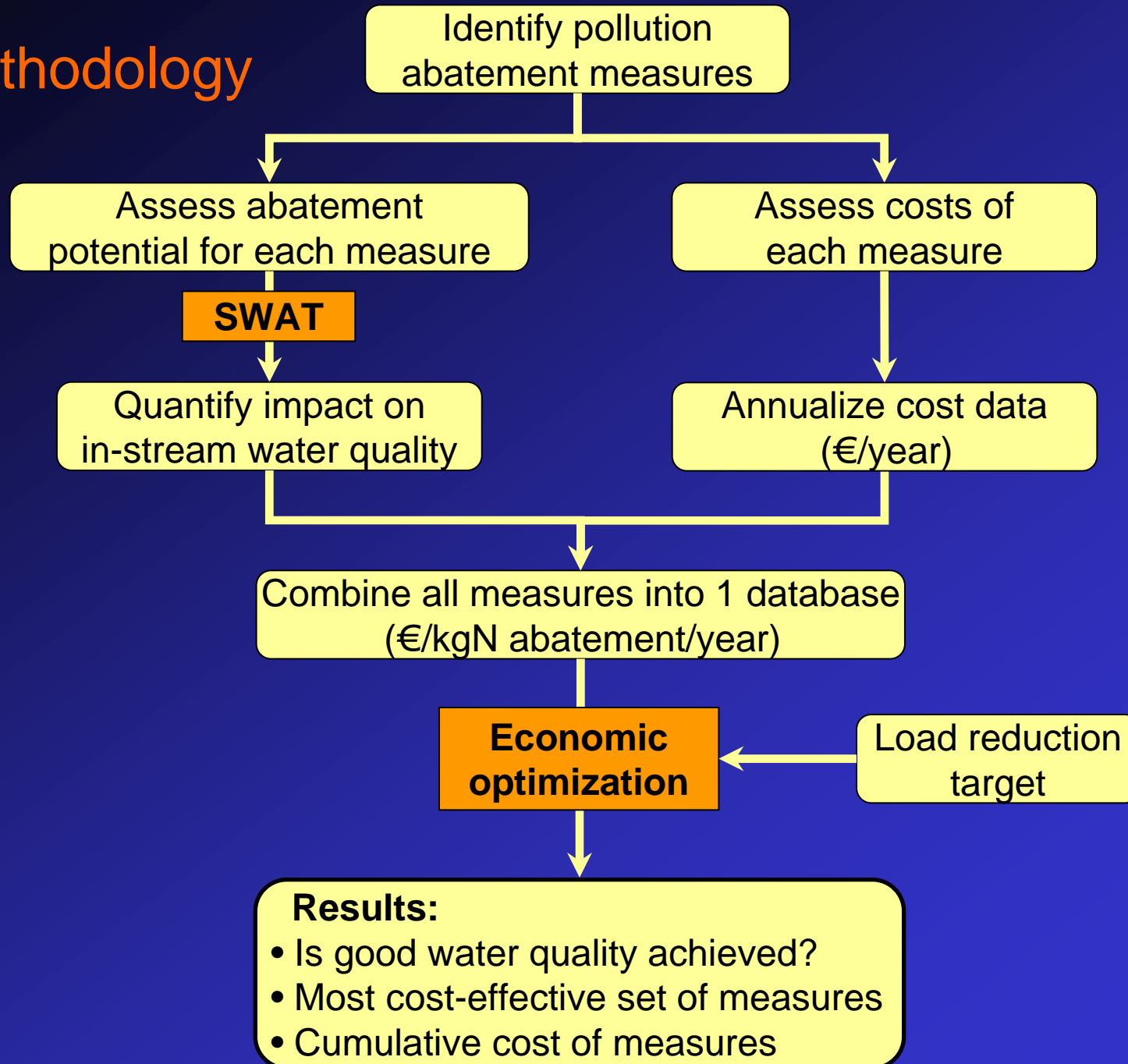
Need for modelling?

- Pollution abatement measures applied randomly
- Worst polluters targeted first
- No evidence that measures will achieve environmental targets
- Complexity \uparrow when subbasin area \uparrow



- SWAT for impact on in-stream water quality
- Economic tool to select cheapest combination of measures
- Coupling SWAT-Economic tool

Methodology



Economic optimization: Cost-Effectiveness

- Cost-minimization as objective function
- When environmental target is fixed
- 'Benefits' = pollution load reduction (kgN reduction)
- Few cost & effect data available (at basin scale)

Impact on water quality in SWAT2005

Needed

- Calibration of a water quality model
- Determine immission coefficients α
- Run scenario's of pollution abatement measures

→ Pre- and Postprocessing tools needed for SWAT2005

immission coefficient

$\alpha = \frac{\text{load that reaches the control section}}{\text{load emitted at the source of the pollution}}$

Pre- and postprocessing tool for SWAT2005

- Make input files for water quality modelling
 - MGT files for fertilizer application
 - Point source pollution files
 - Read-in SWAT2005 output
 - Plot graphs for flow and water quality parameters
 - Calculate objective functions
 - such as BIAS, R^2 , SSQ, NSE
 - Calculate average daily load
-
- **Excel tool:** easy to use, user-friendly interface
 - **Matlab tool:** can be automated AND linked to economic tool

Excel tool for SWAT2005

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ABOUT

Calvaltool.xls v1.05 - SWAT2005 Postprocessor

Developed by **Mutembei**
 Master thesis project - May 2005
 IUPWARE - VUB
<http://www.iupware.be>
 Promotor: Prof. PhD. Ir. W. Bauwens

Help

Run SWAT.EXE

Import New Run

PARAMETERS

- | | | |
|--|---|---|
| <input type="radio"/> FLOW (m ³ /s) | <input type="radio"/> NH3 (mg/L) | <input type="radio"/> CHLOROPHYL A (mg/L) |
| <input type="radio"/> SEDIMENT (mg/L) | <input type="radio"/> NO2 (mg/L) | <input type="radio"/> TEMPERATURE (°C) |
| <input type="radio"/> ORGANIC N (mg/L) | <input type="radio"/> MINERAL P (mg/L) | <input type="radio"/> KJELDAHL N (mg/L) |
| <input type="radio"/> ORGANIC P (mg/L) | <input type="radio"/> CBOD (mg/L) | <input type="radio"/> TOTAL N (mg/L) |
| <input checked="" type="radio"/> NO3 (mg/L) | <input type="radio"/> DISSOLVED OXYGEN (mg/L) | <input type="radio"/> TOTAL P (mg/L) |

OBJECTIVE FUNCTIONS

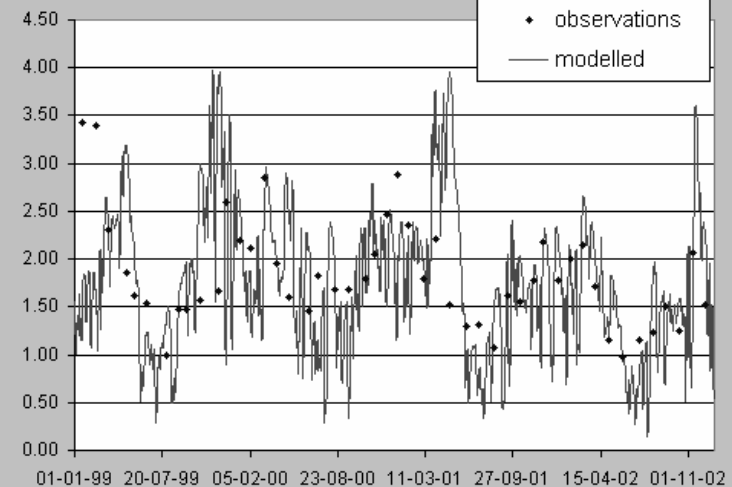
	SEQUENTIAL		RANKED	
Average of observations	MEANobs	1.825	MEANobs	1.825
Average of simulations	MEANsim	1.901	MEANsim	1.901
BIAS	BIAS	-0.076	BIAS	-0.076
Correlation coefficient	R	0.166	R	0.984
Sum of Squares	SSQ	36	SSQR	3
Number of observations	Nobs	48	Nobs	48
Variance of observations	VARobs	0.31	VARobs	0.31
Nash-Sutcliffe Efficiency	NSE	-1.391	NSE	0.805
LN Nash-Sutcliffe Efficiency	LNSE	-1.522	LNSE	0.560
Adapted Nash-Sutcliffe Efficiency	ANSE	-1.280	ANSE	0.817

AVERAGE DAILY LOADS (kg/day)

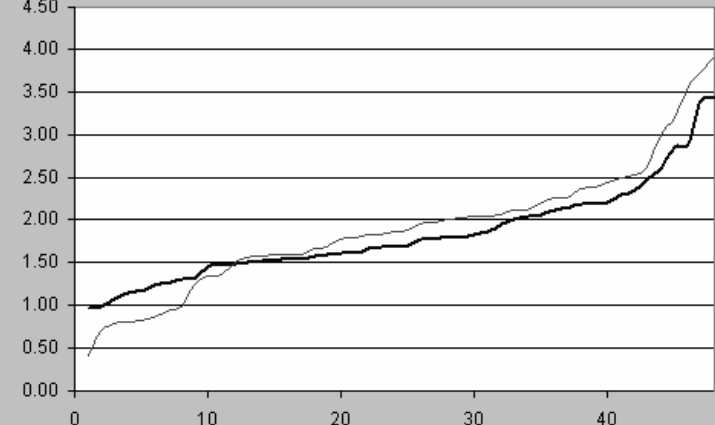
SEDIM	ORGN	ORGP	NO3	NH3	NO2	MINP	CBOD	KJN	TOT N	TOT P
9.26E+03	3.35E+02	9.60E+01	8.17E+02	2.02E+02	1.84E+01	5.71E+01	1.06E+03	5.37E+02	1.37E+03	1.53E+02

GRAPHS

SEQUENTIAL



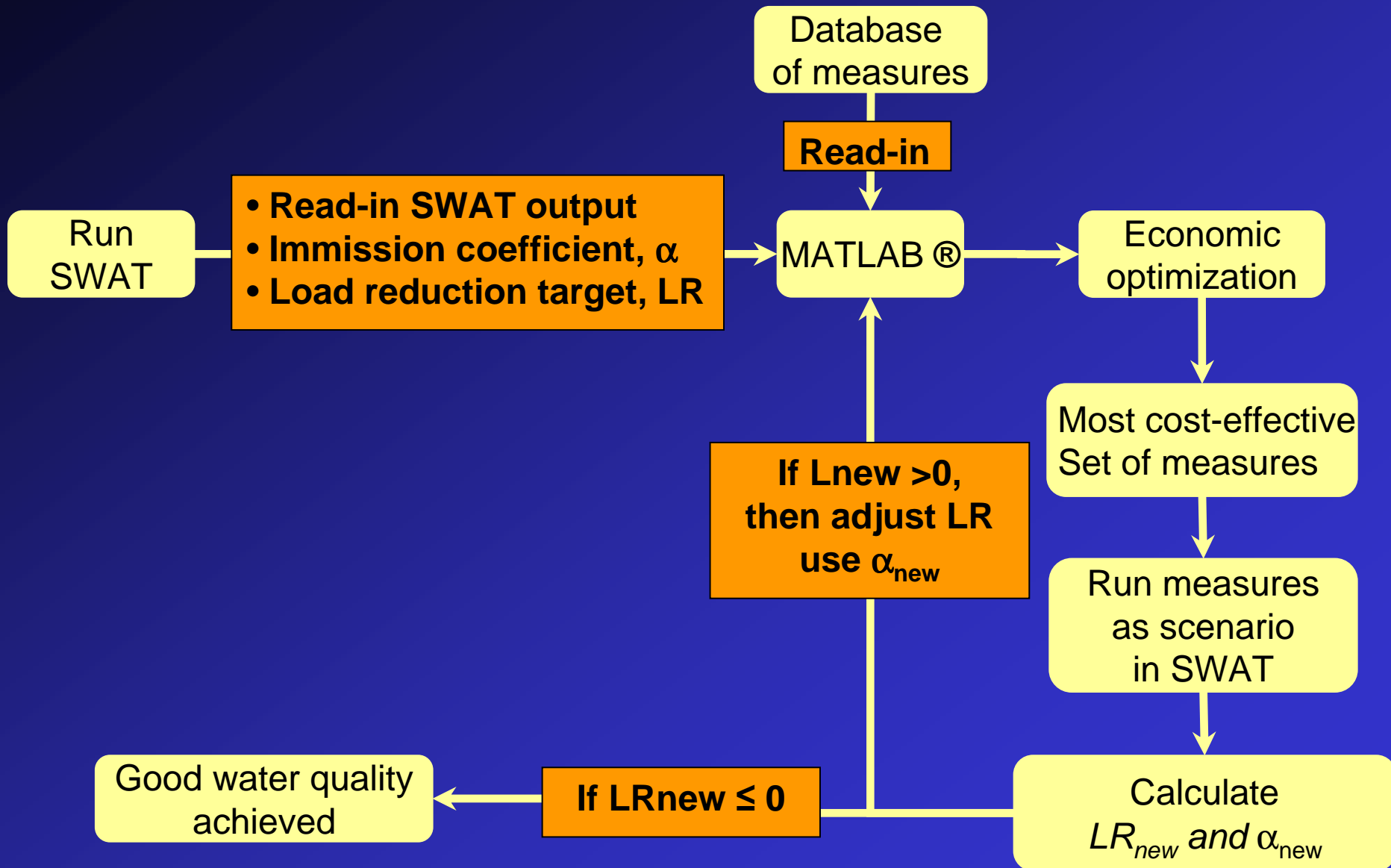
RANKED



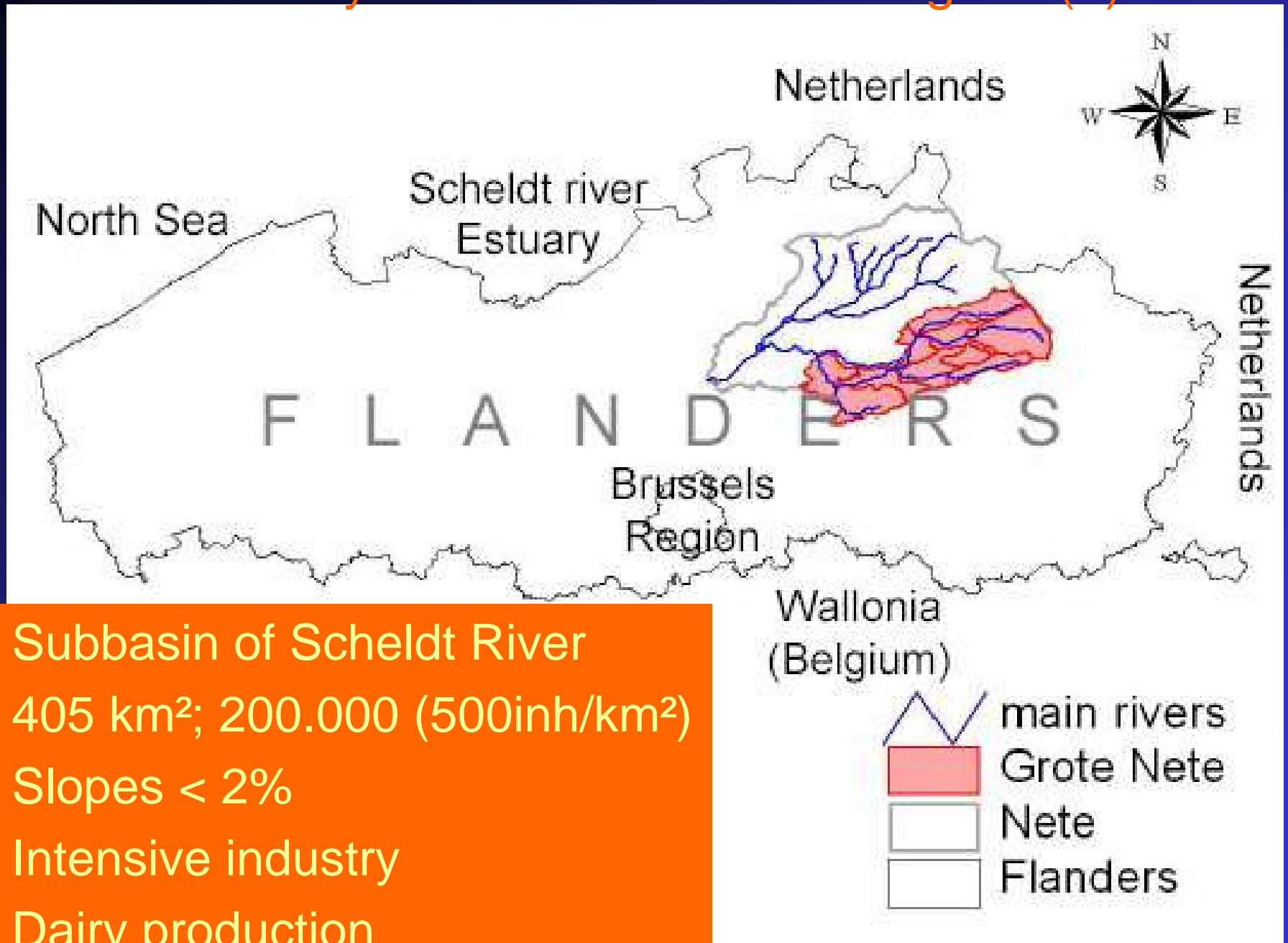
Export All Graphs

Copy to clipboard

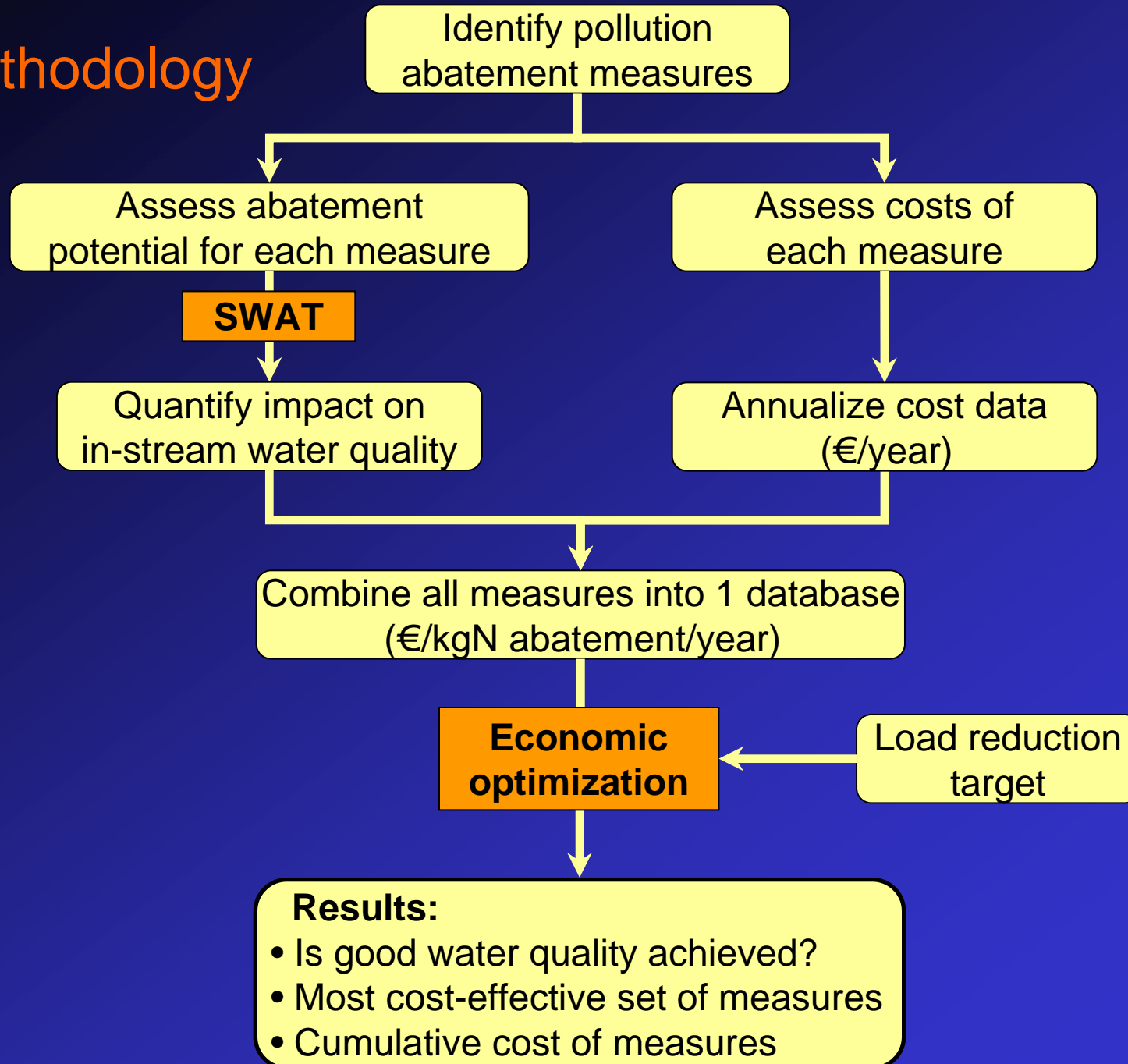
Link SWAT2005 – Matlab – Economic tool



Case study: Nete river basin in Belgium (1)



Methodology

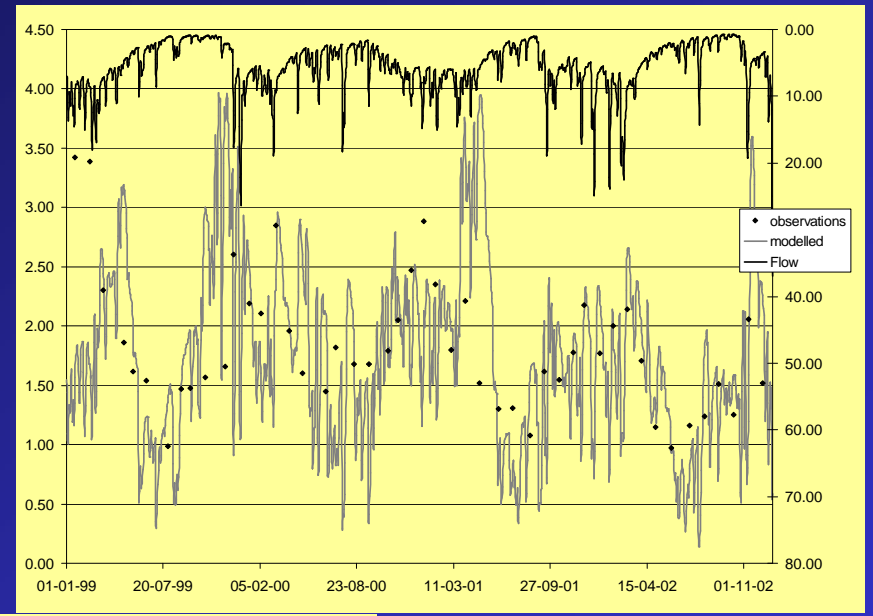
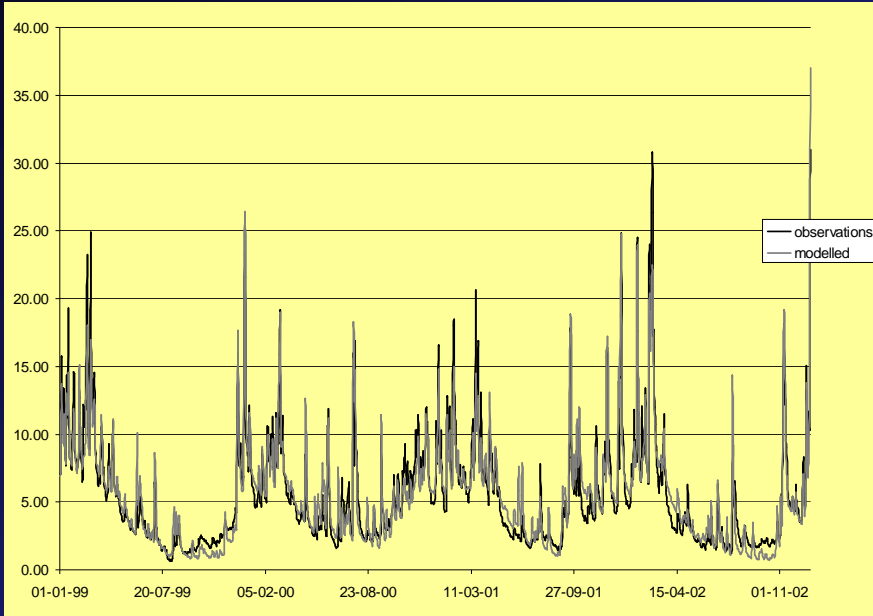




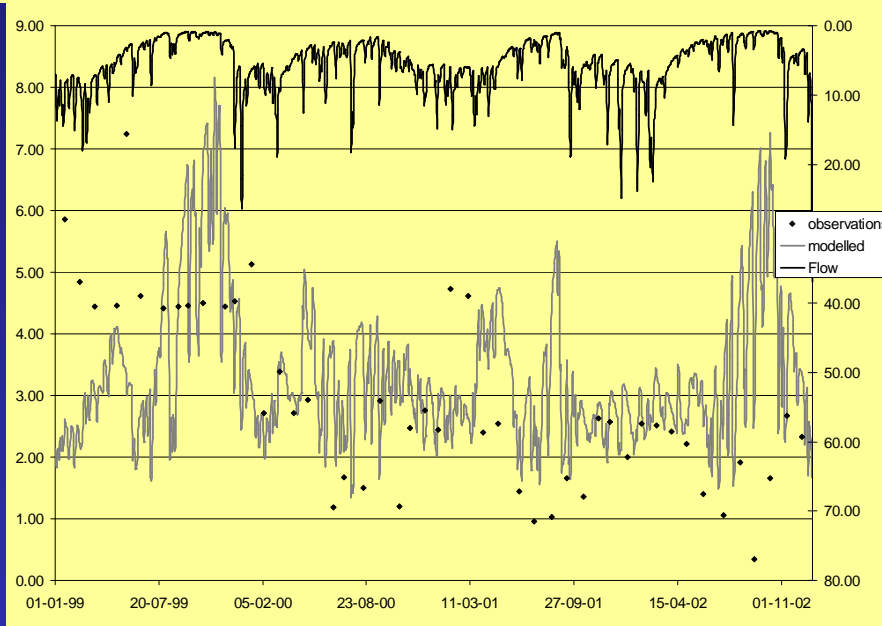
Case Study: SWAT results (2)

FLOW: NSE 0.87

NO3



Nt





Case Study: Results from CEA (4)

1) CE ratios

CE = Cost / Effectiveness
(in x € /kgN abatement)

measure	CE ratio (€/kgN abatement)	Rank
Connect to WWTP*	52.8	3
reduce pigs	11.8	2
manure processing	9.6	1

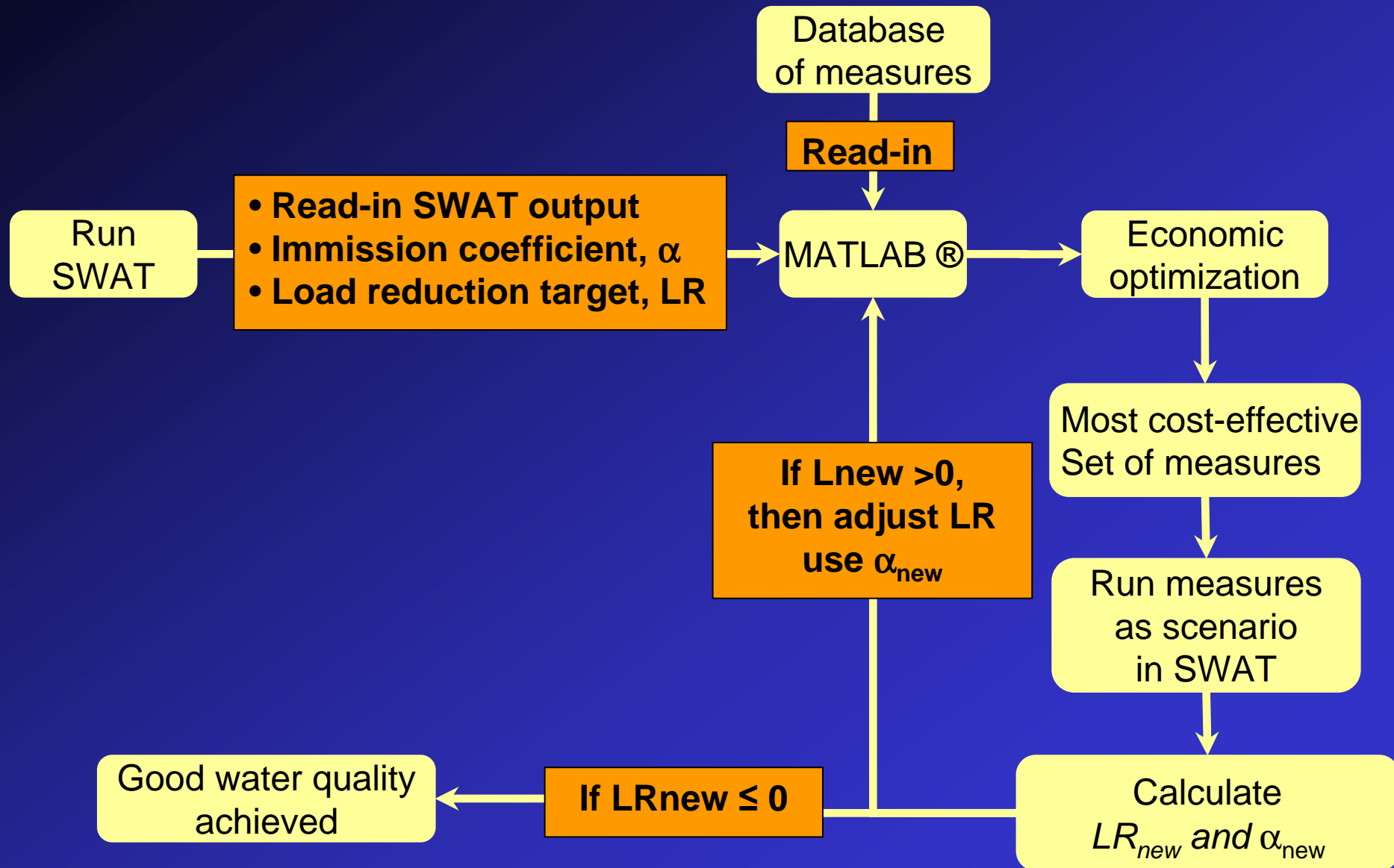
* Cost of WWTP itself ~ 9 Euro/kg N

Case Study: Results from CEA (5)

2) Location and selection of abatement actions

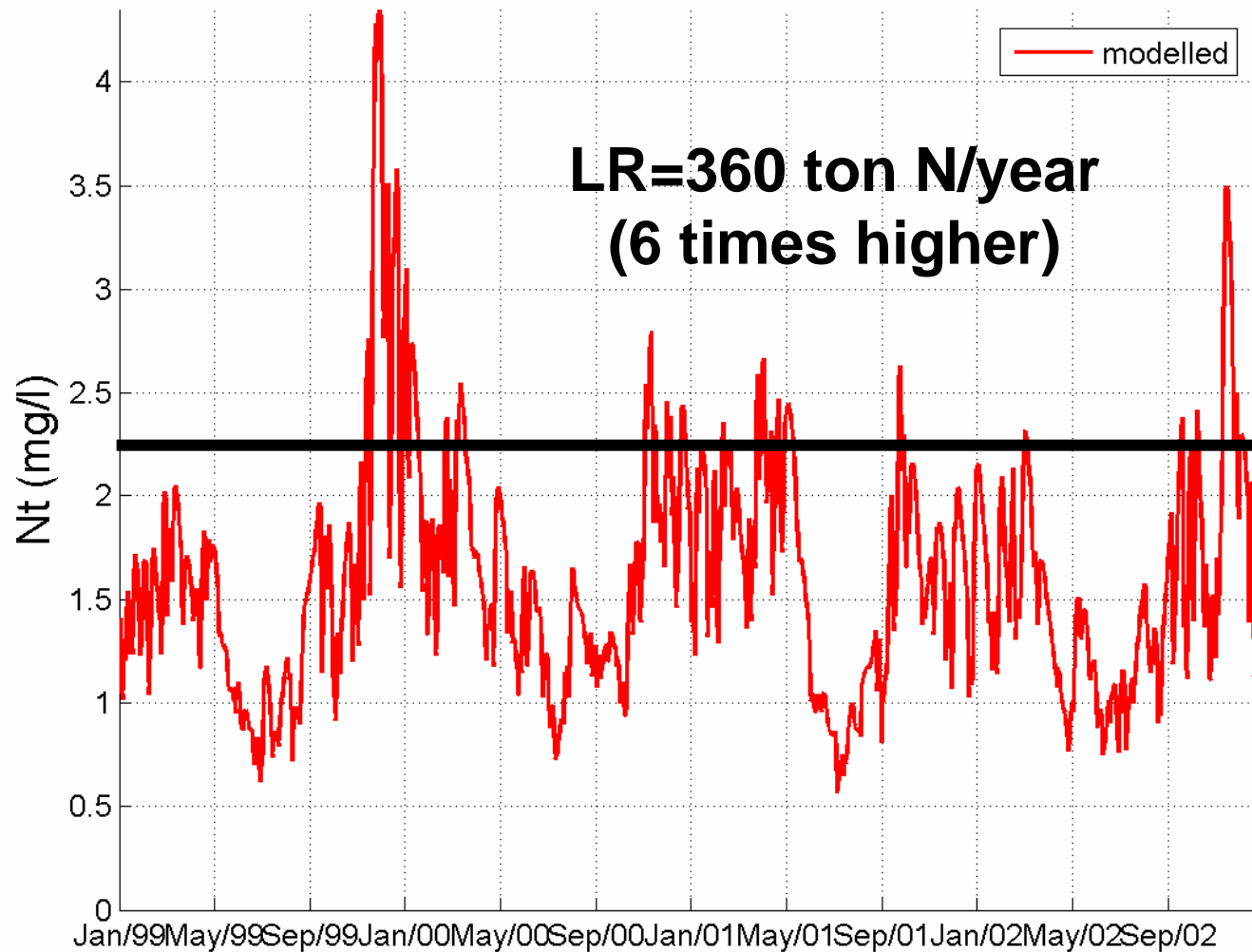
Subbasin	Best measures
1	2 manure processing
2	3 manure processing
3	2 manure processing
4	2 manure processing
Total cost	720 000 Euro/year

Link SWAT2005 – Matlab – Economic tool



Case Study: Results from CEA (6)

Good water quality reached: NO



Conclusion

- Economic tool for SWAT2005 developed
- Pre- and postprocessing tools developed for SWAT2005 in Excel and in Matlab
- For water quality modelling

- Better load reduction target needed
- Optimization technique needed
- For each subbasin: load reduction target and immission coefficient
- Cost and effectiveness values uncertain