



Soil, land-use, nutrients and water – experience from the Water4All project

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Water4All Project:

Sustainable Groundwater Management

Aim:

- **Significantly improve the groundwater quality by preventing the continuing contamination of groundwater in the North Sea Region**
- **Integrate groundwater protection in the context of spatial planning and the implementation of the Water Framework Directive**

Development of a *Guidance Handbook* through the combination of results of small-scale implementation schemes and concrete measures to evaluate the value of land use change to catalyse sustainable land use in the North Sea Region



Coordinated by Kirsten Klaassen & Christina Aue (D)



Introduction to the *Handbook*



EU Water Framework Directive

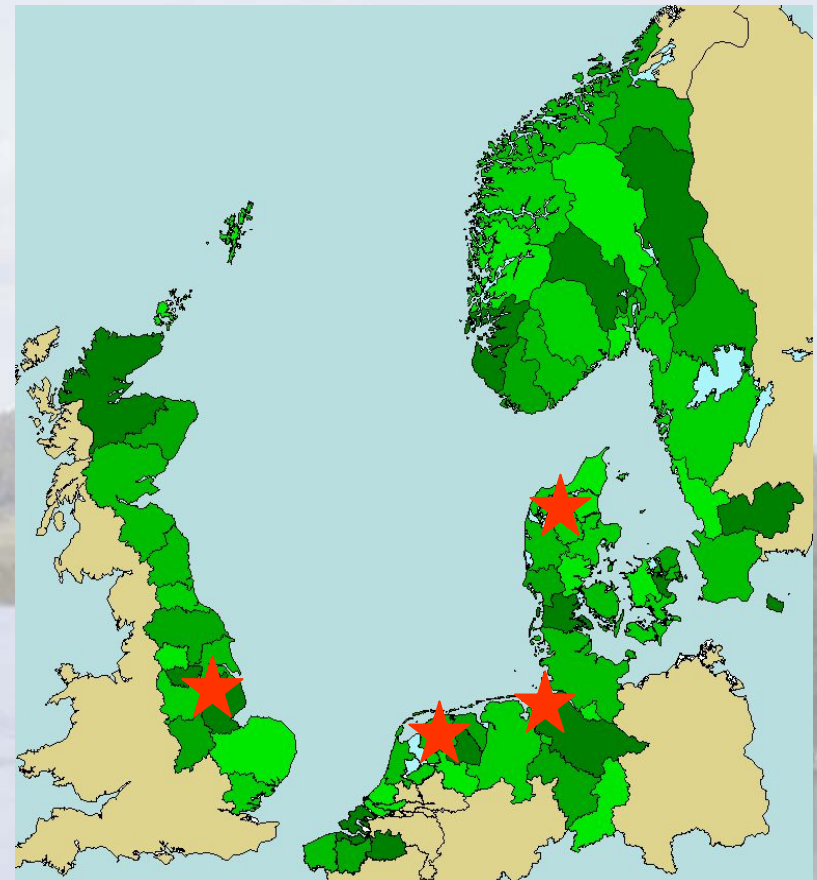
Water4All project partners:

Denmark: Aalborg Municipality

The Netherlands: Provincie Drenthe

Germany: Water Management, Coastal Defence and Nature Conservation Agency of Lower Saxony (NLWKN) & Water Board of Oldenburg and Ostfriesland (OOWV)

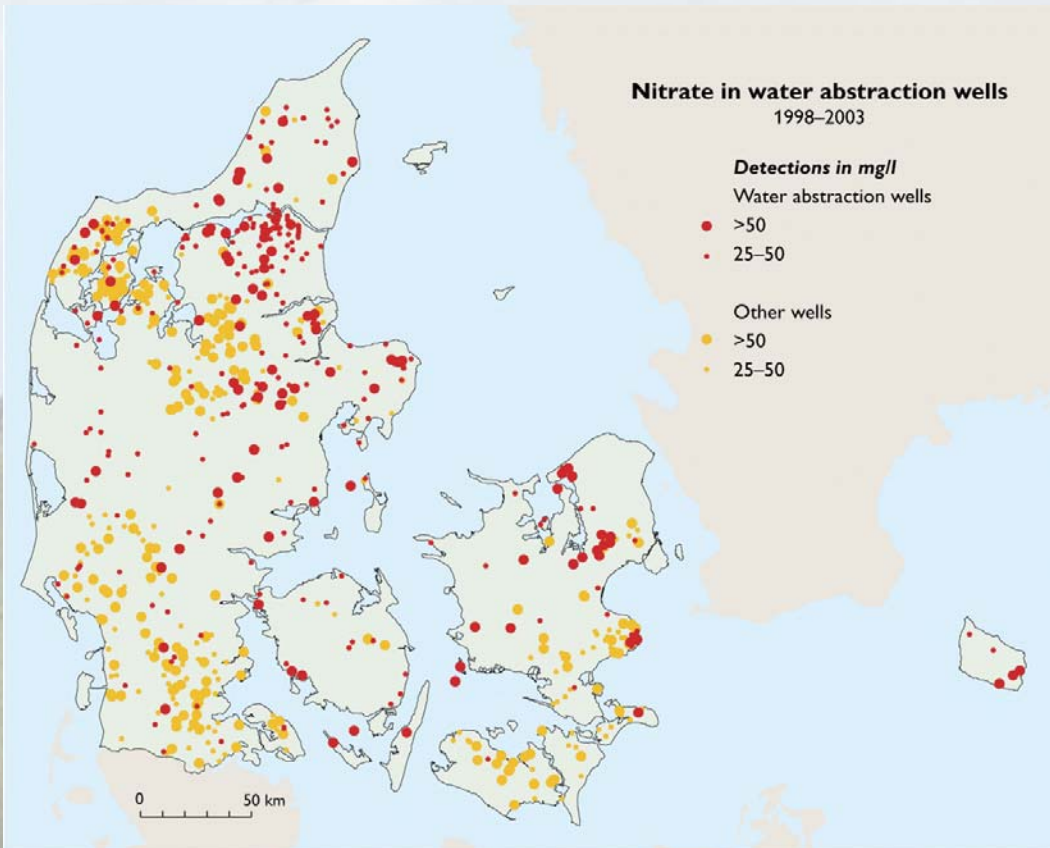
United Kingdom: Environment Agency with University of East Anglia



Statement of the problem



Temporal trend in nitrate concentrations in Denmark, Netherlands, Lower Saxony (D), East Anglia (UK)



Nitrate content in the modern groundwater is declining but average concentrations are above the *maximum admissible concentration* (MAC) for drinking water (50 mg/L) at 16% of monitoring sites

75 % of abstraction wells do not contain nitrate (less than 1 mg/L)

Selected measures to protect groundwater



Matrix of groundwater protection measures compiled from the experience of the four partner countries (total = 51)

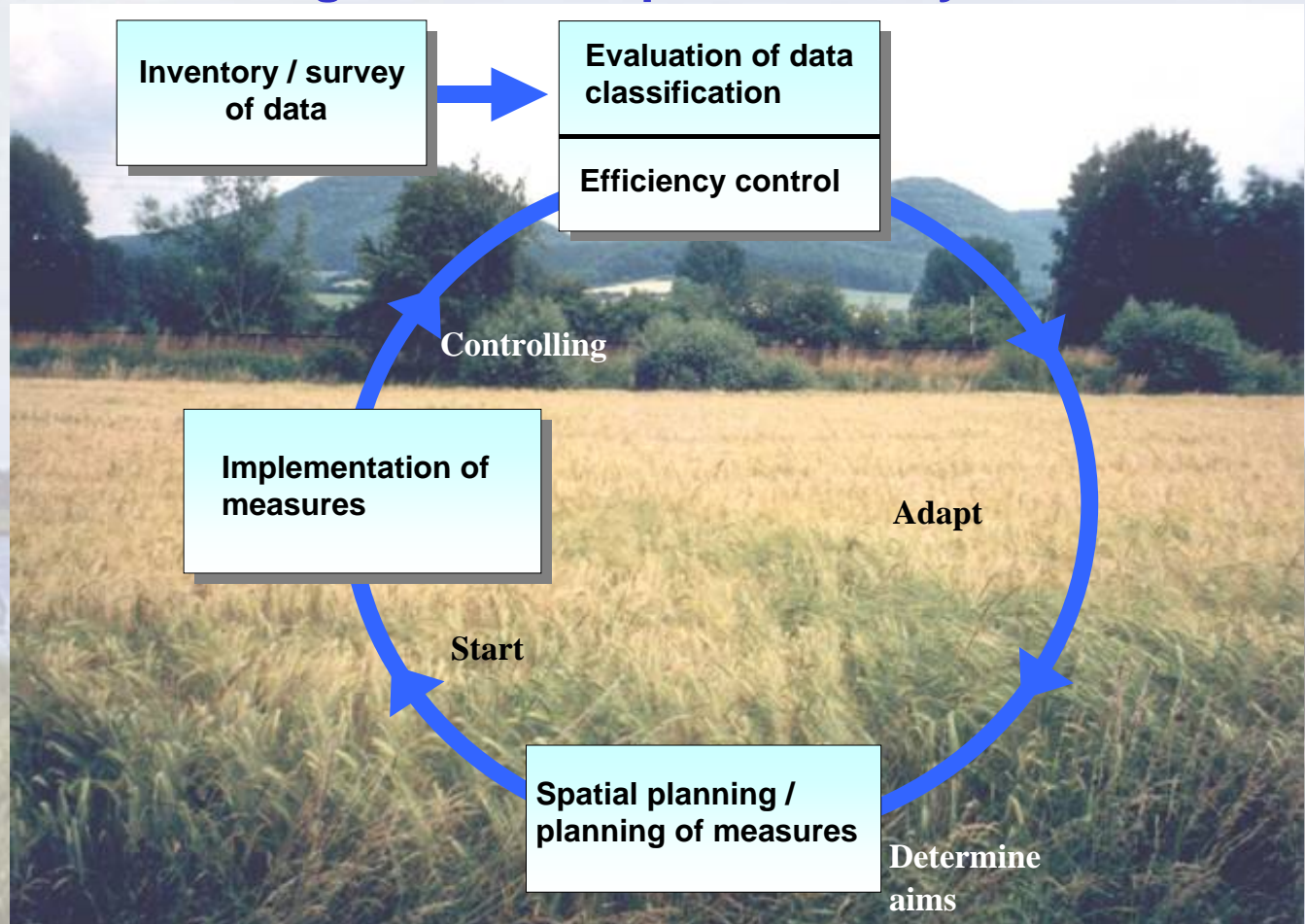
Categories of measures	Sub-category of measures	Compensated	Non-compensated
A Information & advice	Passive information		3
	Active information		5
B Cooperation & voluntary agreements (change of farming practice)	National agri-environmental schemes	3	
	Local/regional voluntary agreements	6	
C Planning & controlling instruments	Technical & scientific solutions		5
	Changing land use activities	9	
D Legal instruments	EU level		-
	National level		16
	Regional/local level		4

Selected measures expanded in the *Annex* giving details of:

- Country
- Institution
- Definition
- Field of impact
- Constraints
- Availability
- Efficiency
- Time period
- Compliance
- Costs
- Results
- Remarks



The groundwater protection cycle





Examples of measures

Compensated, local/regional voluntary agreements, change of farming practice

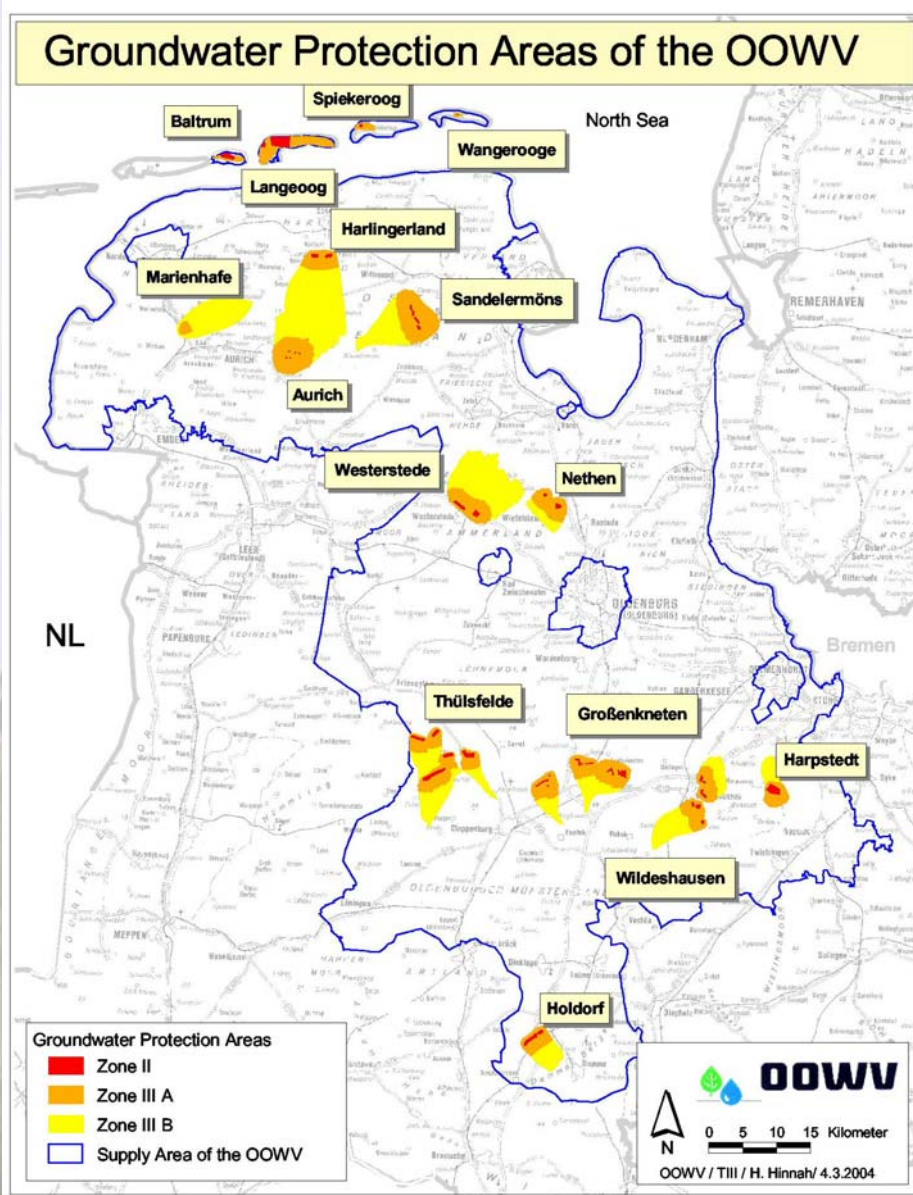
B.II.2 Voluntary agreements in Germany

Compensated, changing land use, planning and controlling instruments

C.II.5 Organic farming in Germany

C.II.2 Afforestation in Denmark

B.II.2 & C.II.5 Voluntary agreements and organic farming in Germany



Supply areas and drinking water protection areas in Lower Saxony

1 million customers

Initiatives financed by the Water Abstraction Charge (WAC) in Lower Saxony: the “water penny”



Each federal state in Germany handles the charge differently

In Lower Saxony water law:

Since 1992, 5 cent/m³ domestic water, <0.1 cent/m³ for power generation and industrial water raises 20,000,000 €p.a. for the purpose of groundwater protection

- free advice for farmers
- edict of cooperation
- contracts of voluntary agreements
- special projects



Financial aspects of water abstraction charge (all WPA`s of the OOWV)

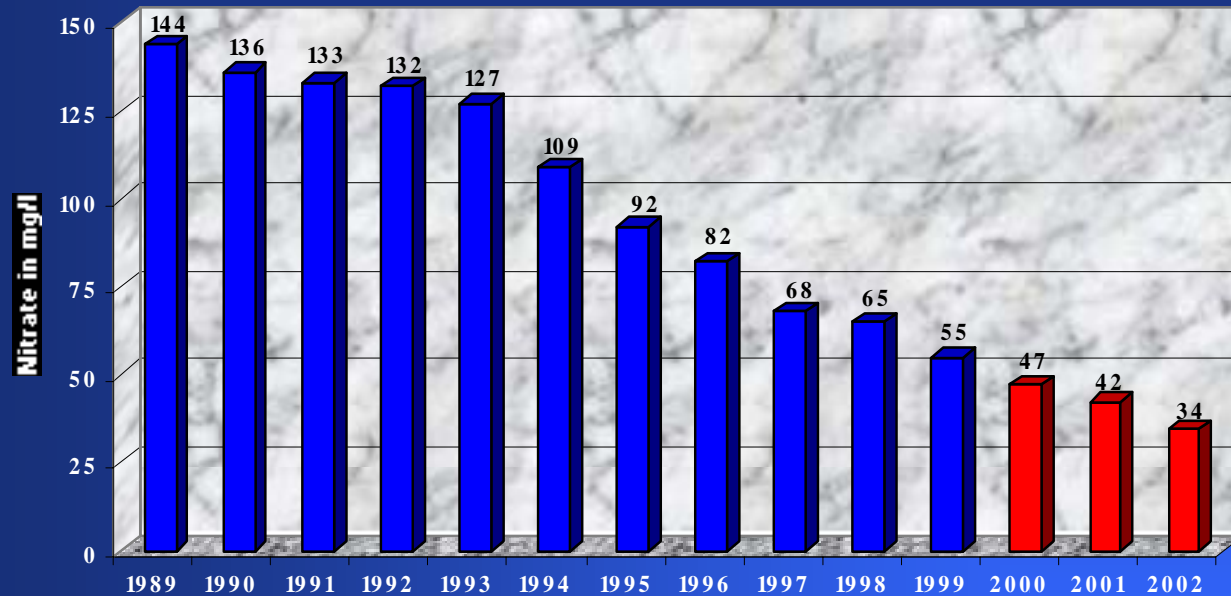
Full support by Lower Saxony's WAC:

- additional advice to farmers (8 consultants) 560,000 €p.a.
- voluntary agreements: 1,100,000 €p.a.
- compensation payments to farmers in groundwater protection areas: 140,000 €p.a.

Part-support by Lower Saxony's WAC:

- scientific investigations: 250,000 €p.a.
- purchase of land by state agency: about 200,000 €p.a.

Quality control: nitrate concentration in observation wells (1989 - 2002), waterworks Holdorf, under afforestation and best farming practice



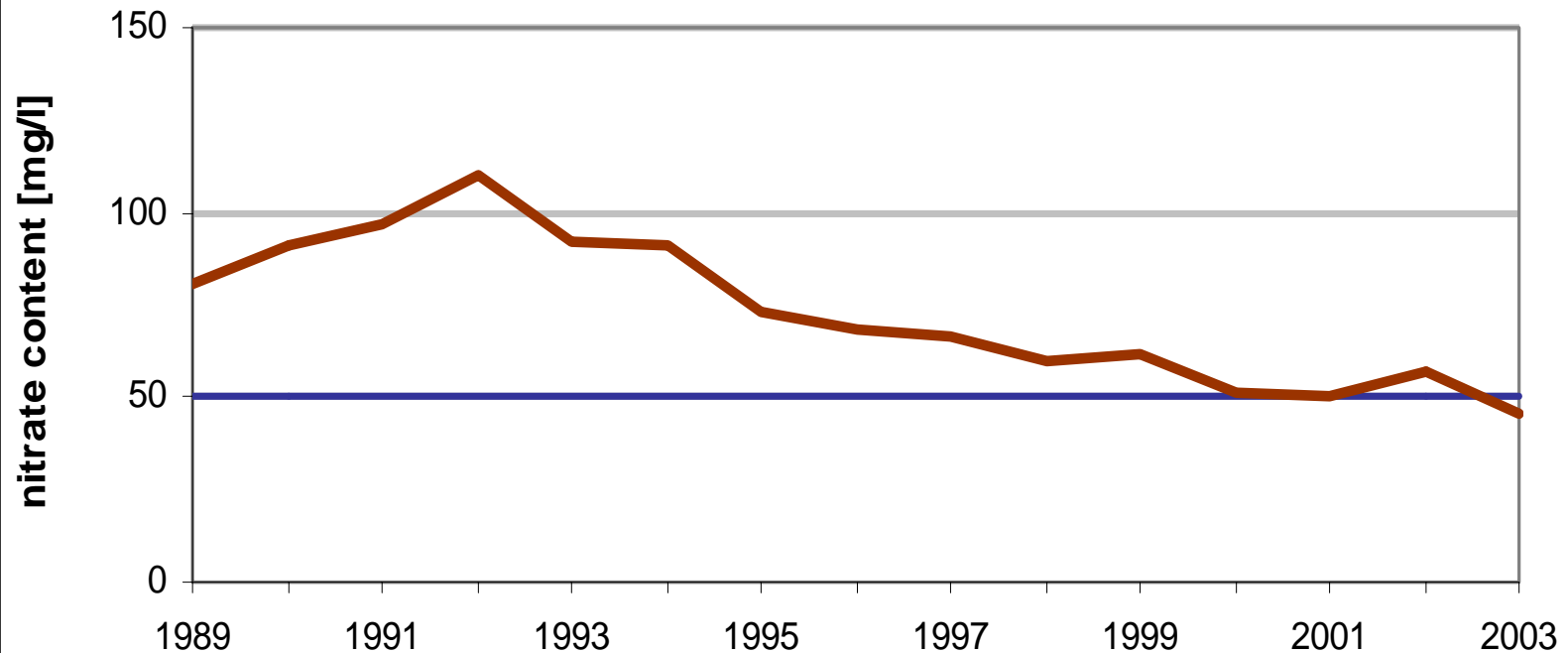
Waterworks "Holdorf"
Mean Value of Nitrate in Groundwater under Agricultural Use
21 Observation wells in Depth of <=15m



Quality control: nitrate concentration in observation wells (1989 – 2003) waterworks Thülsfelde



Average nitrate content in the lower groundwater under agricultural use (average of 29 observation wells)



C.II.5 Organic farming in Germany



Old waterworks Langeoog



Freshwater dune abstraction teaching trail, Nethen

Organic farm „Bakenhus“ in Großenkneten

Kaskade-information centre in Diekmannshausen

2000 ha land owned by OOWV
Information for public on how the WAC is applied for groundwater protection

Service centre in the T.A.Z. in Oldenburg



Tree and nature teaching trail in Holdorf

OOWV information centres

Bakenhus Organic Farm purchased by OOWV in 1995

200 ha (60 ha arable, 130 ha grass for 200 head of cattle)



Grossenkneten waterworks 15 Mm³/a



Zone II of groundwater protection zone planted with broadleaved woodland

Zone III low intensity cattle gazing in summer



Organic farming for groundwater protection in cooperation with farmers, financed by the “water penny”



Aim to balance nitrogen cycle within the farm, working to EC standards (regulation 27/5) without need for inorganic nitrogen

Free consultancy from water company offered to farmers to enhance productivity and find markets for produce. Operating within a “BIOPOOL” system. Eggs, milk and beef business now 10 million euros per year

3000 ha of holdings now in BIOPOOL (25-30% of land in water protection areas; but <5% in arable areas)



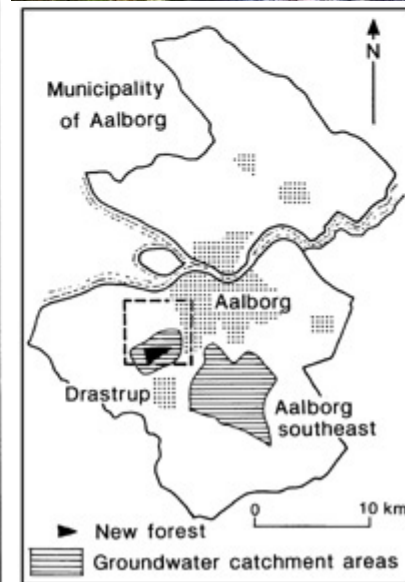
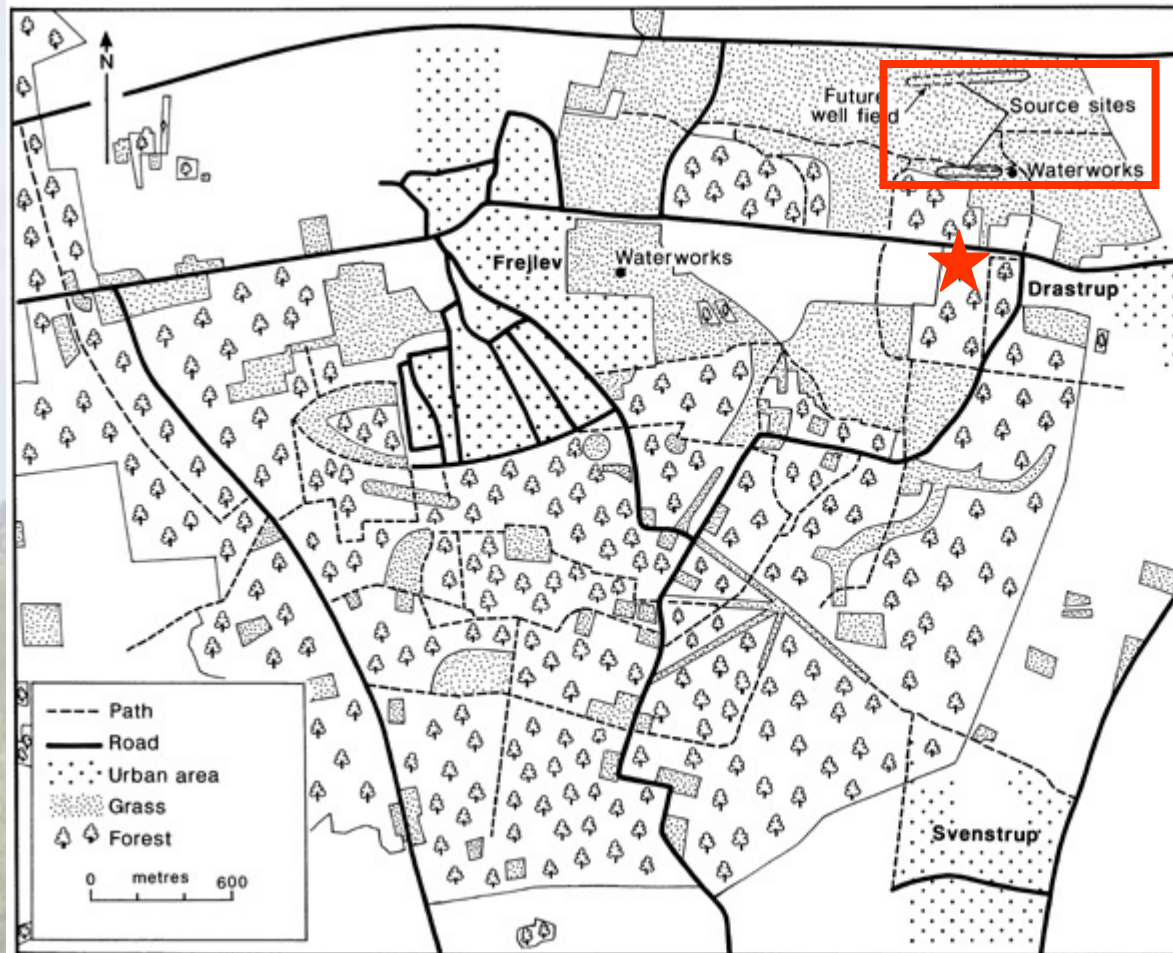
Does organic farming work?

Data from 50 holdings in last 6 years shows losses of 30-40 kg N/ha/a

Compare with conventional farms losing 17-150 kg N/ha/a with a mean value one-third higher than for organic farms

C.II.2 Afforestation in Denmark

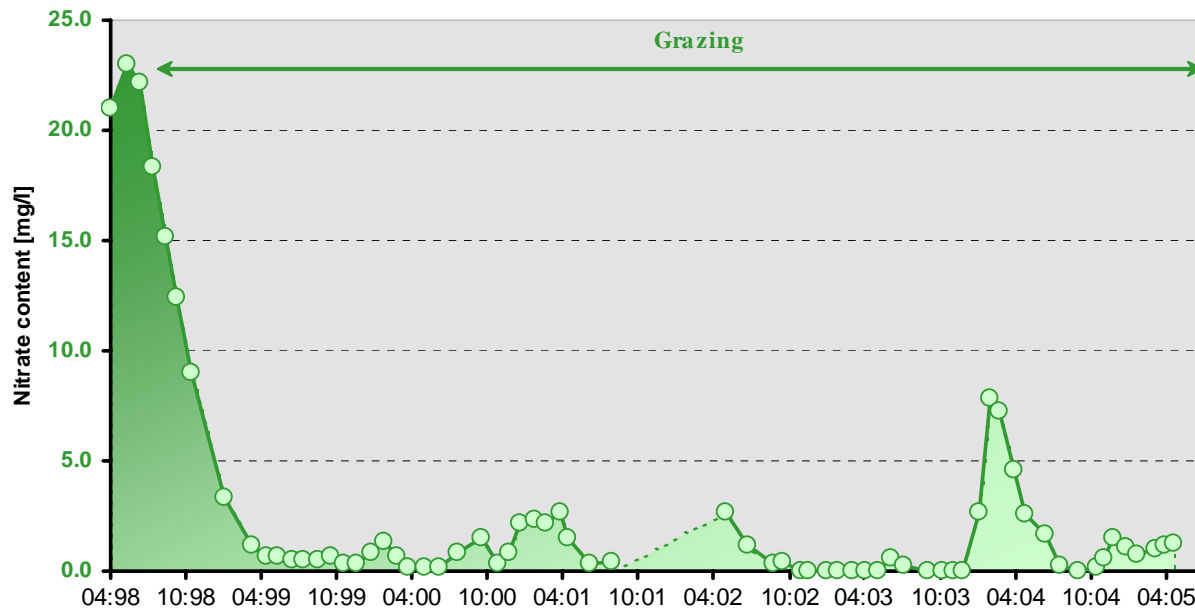
Drastrup Pilot Project: Municipal planning act to execute voluntary land distribution among farms in the groundwater catchment. 230-ha recreational forest of mixed age created with some permanent grass cover with low intensity grazing





Average nitrate content, April 1998 - May 2005

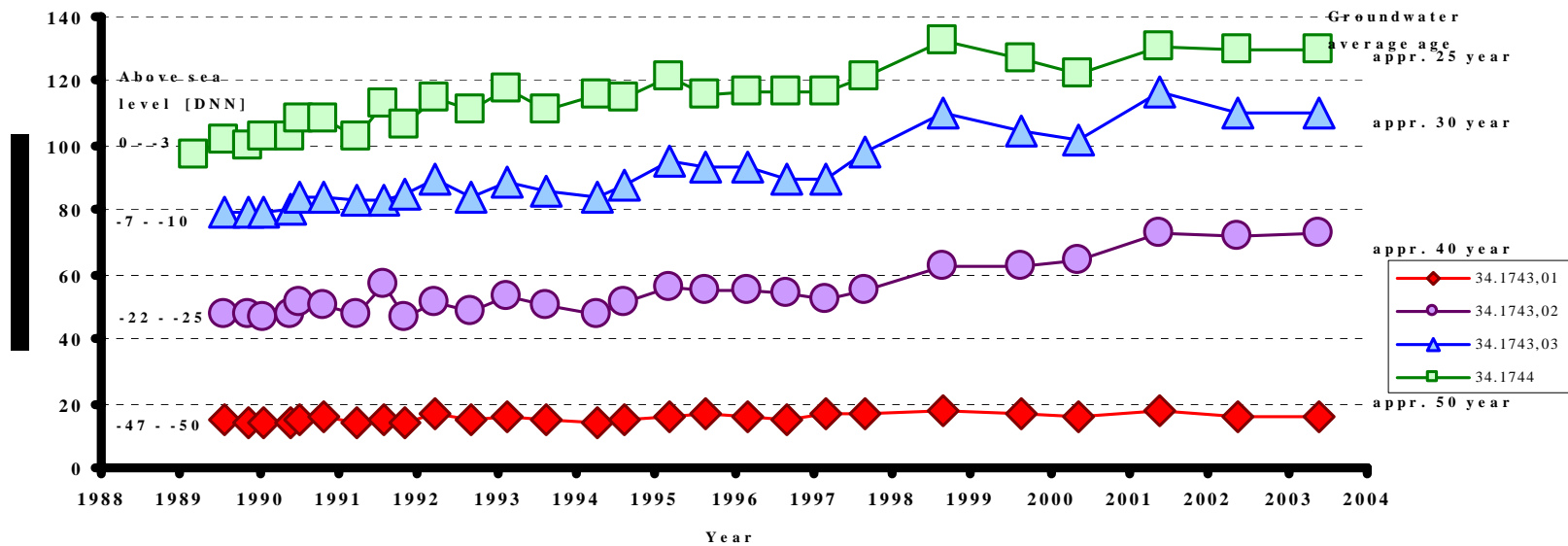
Grazing area



Nitrate in soil water at Drastrup beneath an area converted from arable to permanent grass



Nitrate content in 34.1743 og 34.1744
1988 - 2004



Nitrate in groundwater depth samples at Drastrup

Other benefits:



Increase in forest area



20% increase in land values



Biodiversity



Recreation



Conclusions from European experience

Water4All project proposes a 7-point strategy:

- **Understanding the problem in selected areas**
- **Develop a “package” of measures**
- **Combine functions**
- **Communication and negotiation**
- **Catchment management group and development plan**
- **Monitoring and reporting**
- **State benefits and revise process and measures**

UK Partner Project



Development and modelling of land use scenarios (1)

1. ***Recent Past:*** A continuation of existing measures (such as the Nitrate Vulnerable Zones)
2. ***Impact of Current Policy Reforms:*** Incorporate likely land use changes arising from CAP reforms, new agri-environment schemes etc.
3. ***Nitrate Best Practice:*** Supplement Scenario 2 with agricultural best practice measures (e.g. use of cover crops, avoidance of the 'leakiest' crops) that would have the effect of reducing nitrate leaching



Land Use Scenarios (2)

4. ***Region-wide NSA:*** Replicate the agricultural practices adopted under the 1990s Nitrate Sensitive Areas scheme across the limestone outcrop
5. ***Land Use Protection Zones:*** Investigate the effects of creating land use protection zones (e.g. low input grassland and/or woodland) in targeted areas (e.g. around well capture zones and the upper River Slea). These scenarios would also consider the scope for using such zones to provide public amenity or recreation facilities

Modelling approach



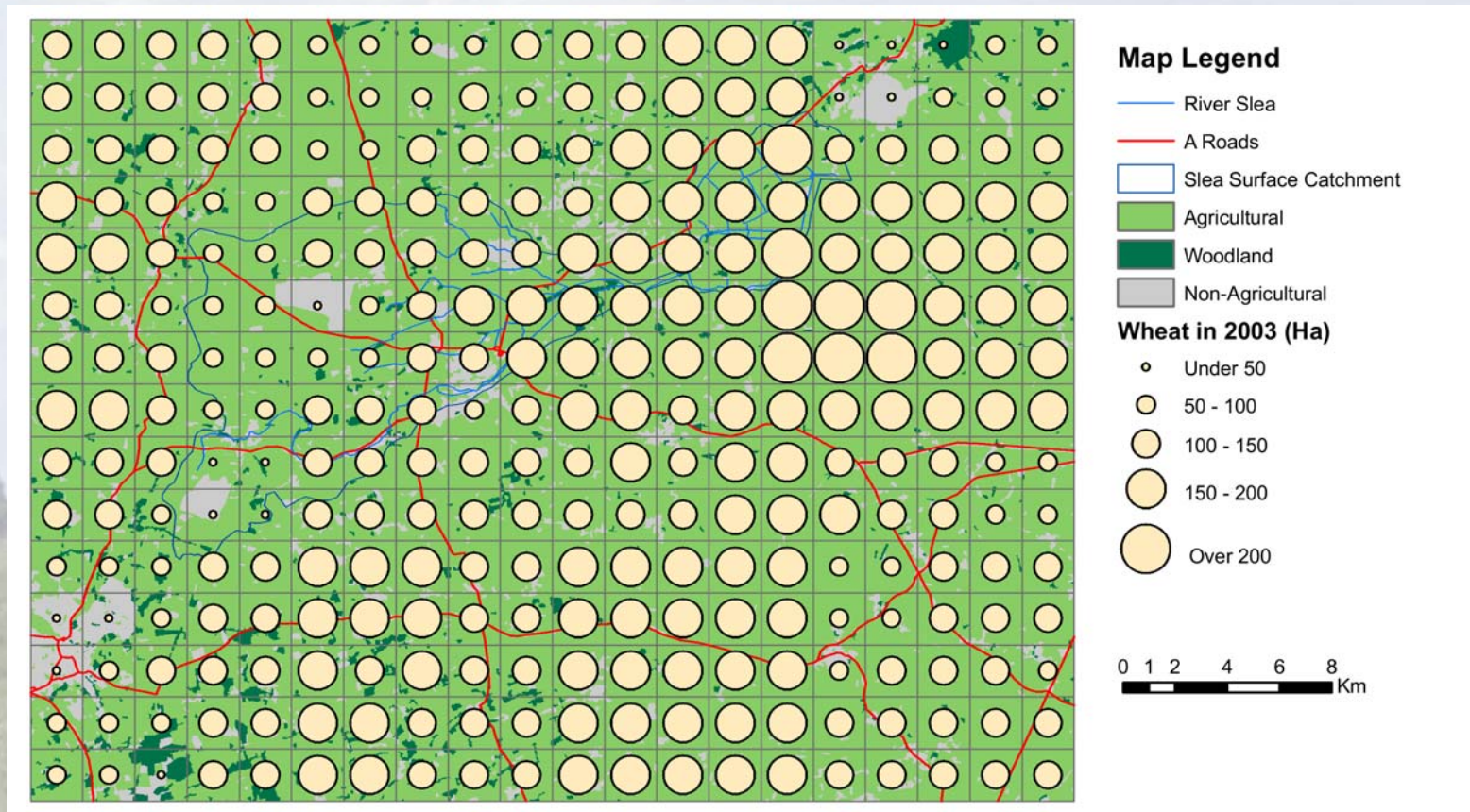
- Use export coefficient techniques to determine the nitrate entering the soil zone and a groundwater model to estimate changes over time in aquifer concentrations
- The initial calculations require data on the spatial distribution of sources (e.g. agricultural activities) and input/export information derived from field studies

	Baseline			NSA			Protective		
Crops	Input N kg/ha	Export Coefficient	Loading N kg/ha	Input N kg/ha	Export Coefficient	Loading N kg/ha	Input N kg/ha	Export Coefficient	Loading N kg/ha
Wheat	192.3	0.23	44.23	163.3	0.18	29.39	192.3	0.12	23.08
Potatoes	179.8	0.34	61.13	207.1	0.34	70.41	179.8	0.31	55.74
Sugar Beet	109.0	0.14	15.26	123.7	0.14	17.32	109.0	0.10	10.90
Oil Seed Rape	197.7	0.39	77.10	146.0	0.20	29.20	197.7	0.21	41.52

Source inventory

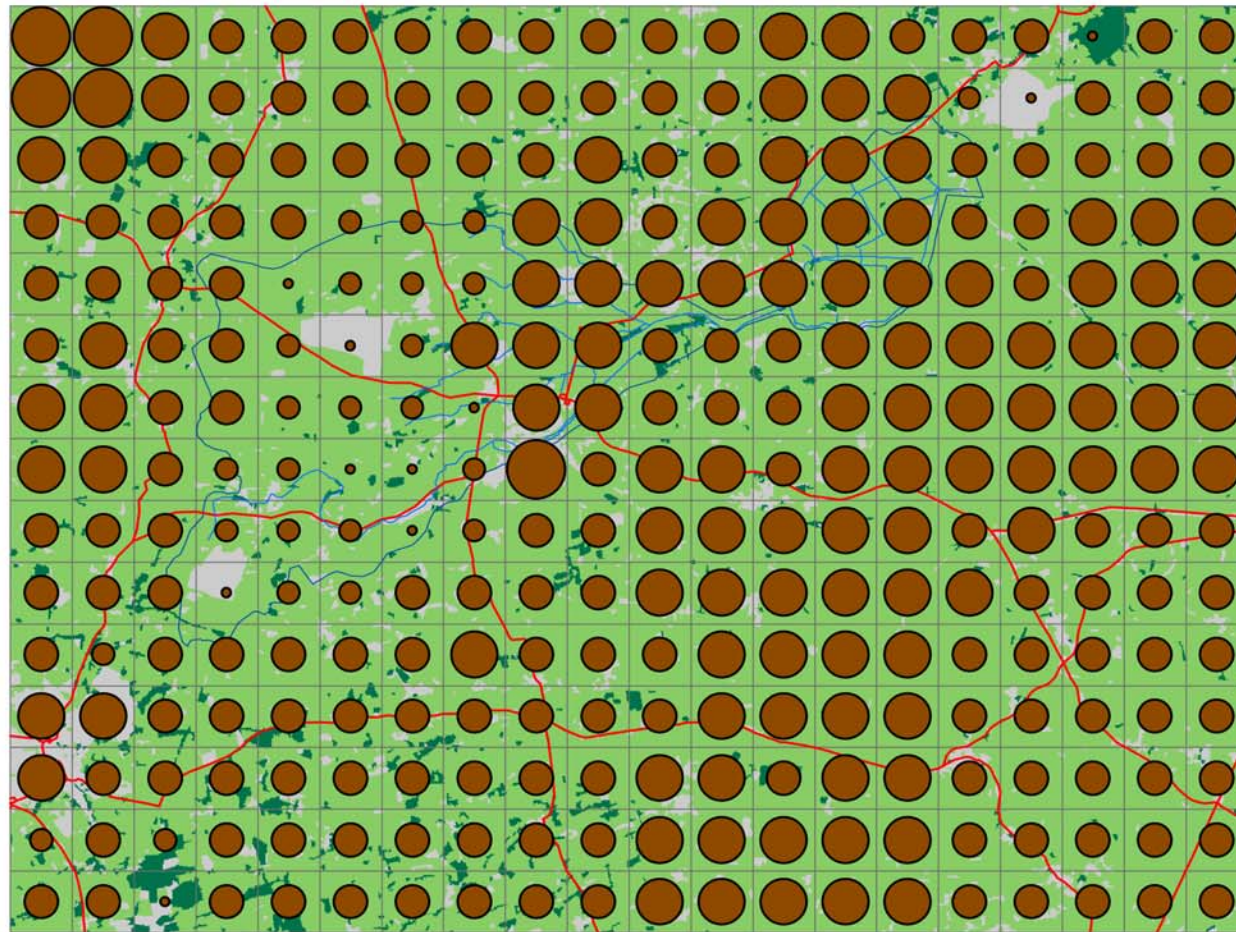


Data were compiled for 1988, 1994, 2000 and 2003



Scenario maps were generated from the 2003 baseline

Mapping nitrate export to soil



Scenario 5a

- River Slea
- A Roads
- Slea Surface Catchment
- Agricultural
- Woodland
- Non-Agricultural

Total N Exports (kg)

- < 8,000
- 8,000 - 12,000
- 12,000 - 16,000
- 16,000 - 20,000
- > 20,000

0 1 2 4 6 8 Km



Groundwater model

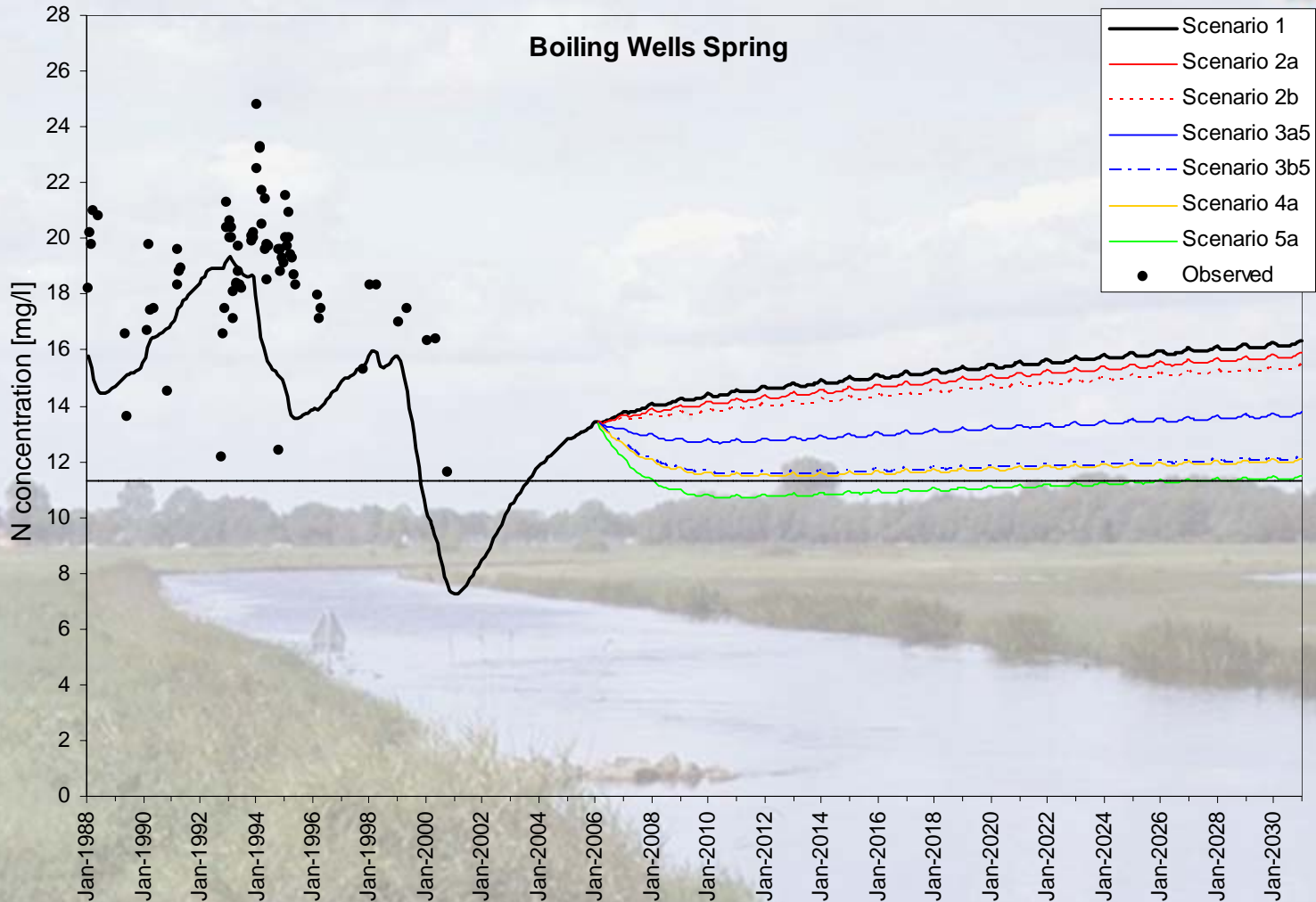
Constructed using Visual MODFLOW (v3.1)

Two layer conceptual model (Lincolnshire Limestone and overlying beds)

Transient state simulation with dual porosity mechanism allows diffusion exchange between the mobile fissure water and the relatively immobile pore water

The model was calibrated against groundwater nitrate levels at observation boreholes and then used to assess the impact of different scenario land use patterns

Model results for limestone spring



Conclusions from UK project to date



- In vulnerable catchments such as the Slea substantial changes in land use may be required to meet WFD objectives
- Involvement of (private) water companies will be limited without evidence of benefits that can be used to argue for alterations in existing regulatory arrangements
- In the Slea case there does appear to be some commonality of interest among stakeholders and it may be possible to identify a set of measures that would provide a 'win-win-win' situation in terms of protecting groundwater, supporting farm incomes and enhancing public amenity