Effectiveness of buffer strips in the Netherlands

International review report of the research project

Edited by Gert-Jan Noij

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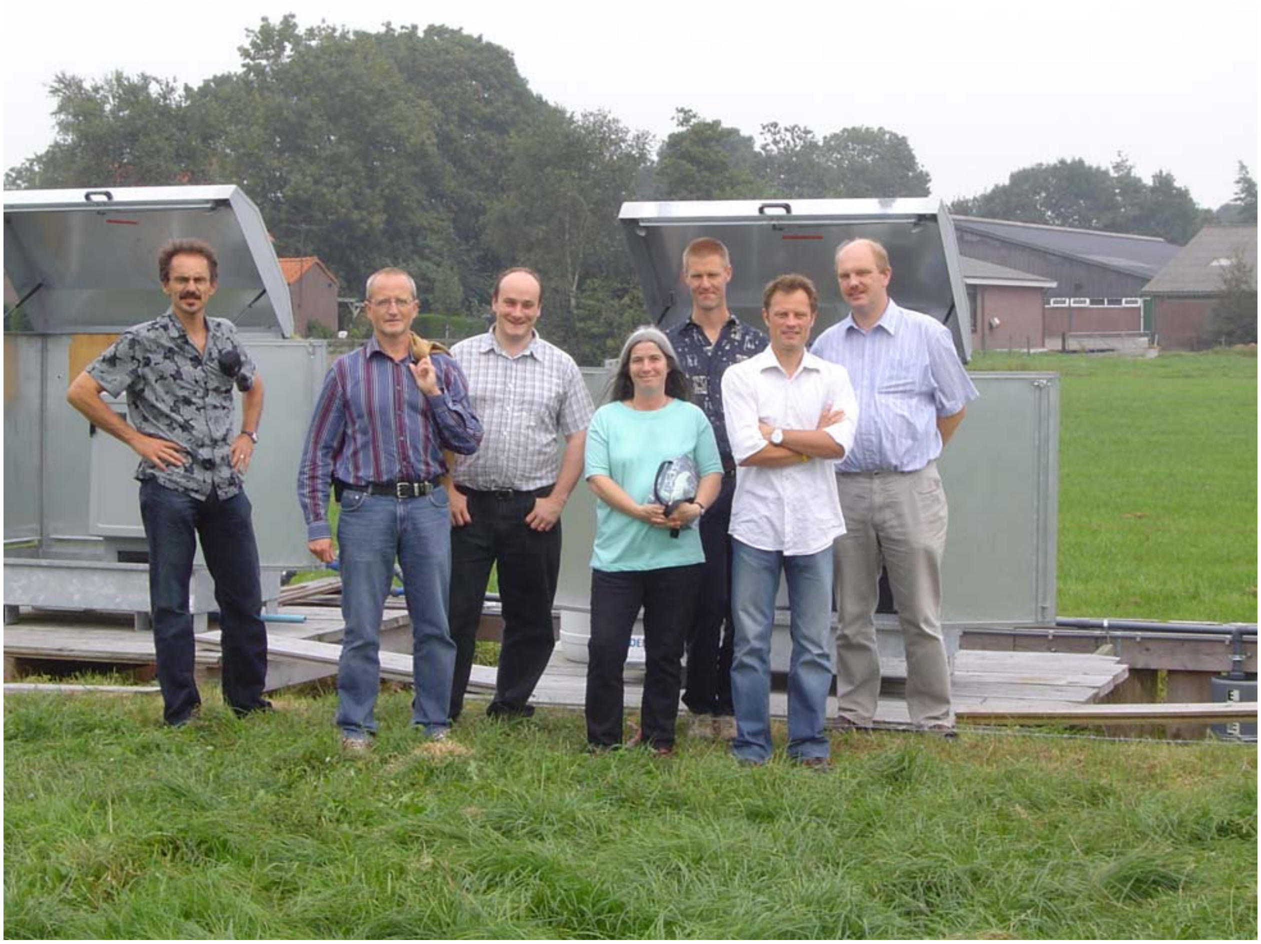
Effectiveness of buffer strips publication series

1. Noij, Gert-Jan, 2006. Effectiveness of buffer strips in the Netherlands. Research plan.
2. Noij, Gert-Jan, 2007. Effectiveness of buffer strips in the Netherlands. International review report of the research project
3. Noij, Gert-Jan, 2007. Effectiveness of buffer strips in the Netherlands. Revised research plan.
4. Bakel, Jan van, Harry Massop en Arie van Kekem. Locatiekeuze ten behoeve van het onderzoek naar bemestingvrije perceelsranden. Hydrologische en bodemkundige karakterisering van de proeflocaties. Alterra-rapport 1457, Wageningen.



From left to right: Gert-Jan Noij, Brian Kronvang, Martyn Silgram, Jane Hawkins, Marius Heinen, Pascal Boeckx and Piet Groenendijk at the Zegveld experimental site on September 18, 2006. The picture was taken by our colleague Antonie van den Toorn (see also p. 19).

Acknowledgements

We are very grateful to the participating peer reviewers for travelling a long way to meet us in Wageningen and Zegveld, and for sharing their expertise with us.

Thank you, Elly Verschoor, for the administration, and for arranging the accommodation.

We acknowledge Karel van Houwelingen (WUR-Animal Science Group) of the Zegveld experimental station for hosting us during the afternoon, and Antonie van den Toorn of our Alterra project team for explaining the experimental instrumentation (see p. 19).

Thanks to the Dutch Ministry of Agriculture, Nature and Food Quality (LNV), and the Dutch Ministry of Housing, Spatial Planning, and the Environment (VROM), we will be able to extend the original project by more than 40% to meet the recommendations of the review group. Off course, the additional funding took some time and this is the reason why the publication of this review report was somewhat delayed.

Gert-Jan Noij
Project leader

Wageningen, February 2007

Contents

Summarized conclusions and recommendations

- Closed bullets refer to conclusions
- o Open bullets refer to recommendations

REPLICATES

- There is a lack of replication, both within and between sites. Without replicates the field experiments as such will probably not be accepted by a peer reviewed journal as a scientific proof for the (in)effectiveness of buffers strips in the NL. Expected differences in nutrient load between the two treatments[1] lie in the order of 2.5 kg/ha/y N and 0.2 kg/ha/y P, corresponding with about 0.9 mg/l N and 0.06 mg/l P, only twice the detection limits. Even smaller differences may be expected during the first years of measurements, due to the expected time lag in the effect of treatment. These small differences may well be caused by variability in the fields and thus replicates are needed to check this and to test the significance of the differences. Replicates will increase the scientific value of the experiments manifoldly.
  Heterogeneity alongside the ditches should be assessed to support the selection of sites for replication.
- Replicates will also be needed to calibrate and validate the field model (FUSSIM2/ ANIMO). Without replicates you cannot tell whether a difference between model result and measurement is due to variation in the field, incorrect parameterization, or an inadequate model concept. This argument is even more important when insufficient measurements on part processes are available for validation, such as N and P in upper ground water (see Groundwater quality).

This leads to the following recommendations:

- o At least three replicates are needed. In case the budget is insufficient to realise this, it is recommended to concentrate on less sites, for instance two or three sites but with replicates.
- o Selection of sites for replication should be based on the variability alongside the ditches in the factors soil physics and/or Electromagnetic Induction (appendix 5). The measured variation in loads between replicate sites on fields with replication can then be correlated to these factors and allow an estimation of the expected variation in loads on the fields without replication, as based on the correlation with the measured factors (soil physics and/or EMI).
- o Replication on a field location is considered more important for a scientifically sound proof, than replication of locations (geohydrology). The expected small differences require focussing on the more vulnerable sites (arable>grass; slope>flat; shallow>deep drainage). See table 1. The greyish cells represent the actual field locations. From this table skipping Loon-op-Zand and Lelystad (pipe drains) could possibly be recommended.

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[1] Assuming a load twice the limit for surface waters in the NL 2 x 2.2 mg/l N and 2 x 0.15mg/l P x 300 mm precipitation surplus yields 13 kg/ha/y N and 1 kg/ha P and a possible effectiveness of buffer strips of around 20% yields differences of 2.5 kg/ha/y N and 0.2 kg/ha/y P

Table 1: expected buffer strip effectiveness (BSE[2]) for the five selected locations based on soil type, slope, geohydrology and land use.

Location	Beltrum	Lelystad	Loon op zand	Zegveld	Woold
Soil type	sand = -	clay = +	sand = -	peat = +	sand = -
Slope	<1% = +	0 = -	0 = -	0 = -	>1% = ++
Hydrology	deeply drained -	pipe drains -	loamy subsoil +	low permeabilit +	impermeable subsoil ++
Land use	arable = +	arable = +	grass = -	grass = -	grass = -
Exp. BSE	-+-+	+--+	--+-	+-+-	-++++-

- o The representativeness of locations should not only be assessed in terms of geohydrotypes but also in terms of management history, slope, soil N and P status and organic matter.
- o To save money it is suggested not to measure replicates in all years. This possibly leaves room for extension in time (+2 years; next item).

DURATION

There are two arguments to extend the experiments in time (with another two years):

- To avoid the time lag effects of the implemented measure;
- To get a longer data record for separate calibration and validation, and for extrapolation of model results in time.

GROUNDWATER QUALITY

- o It is recommended to measure upper groundwater quality on all sites (not only at Beltrum) because it is an important indicator for BSE, especially for N. Much denitrification is expected in the ditch slope and this might possibly overrule differences in N-load to the reservoirs. If so, an important conclusion for policy making may be drawn, namely that good management of the ditch slope is more important than a buffer strip. It is suggested to use the cores that already have been drilled for ground water level measurements. In case budget is insufficient cut down on sampling frequency.

RUNOFF

- o It is recommended to measure runoff on sites where it is expected (arable and/or slope), as it may be important for the BSE. Runoff is a process that is not yet included in the modelling, so otherwise you cannot analyze the role of runoff in BSE at all, nor use it for extrapolation.

ORGANIC MATTER

- It is expected that the introduction of a buffer strip on grassland will hardly effect mineralization and denitrification, and therefore little BSE is expected for nitrogen on grassland. Off course, in arable fields grass buffer strips will immobilize N and P and cause a higher BSE at the beginning.

[2] Buffer strip effectiveness = nutrient load with / load without buffer strip

- It is recommended to analyze “young” or labile organic matter at the start and the end of the experiment to find out whether the treatments have caused differences in organic matter dynamics. Pascal Boeckx referred to a method used at his department based on sieving out “free” organic matter, i.e. not bounded to the mineral soil matrix, particles or aggregates, which has shown good correlation with mineralization potential and alike (Six, et al. (including Frits Meiboom), 2002; contact Caroline Denef).

BIODIVERSITY AND MASS BALANCE

- It is recommended to monitor changes in biodiversity and species composition both in the strips on the field and in the reservoirs, to check if differences will occur that might influence BSE, such as preferential grazing, rooting depth, internal nutrient cycling, and biochemistry in the reservoirs.
- Sedimentation in the reservoirs may be assessed by installing sieves a few cm above the ditch bottom and measure weight and N/P-content, e.g. twice a year. It will help to complete the balance for the two treatments (differences in storage at the bottom).

MODEL VALIDATION

- It is recommended to develop a validation protocol, to prevent circular arguments. E.g. calibrate reference treatment and apply calibrated model to buffer treatment or calibrate first years and validate with latter years. Therefore a longer data record, i.e. extension of the field work in time is necessary. Different scenarios will have to be developed, depending on the final experimental design in the field. Replicates in the field are crucial for validation, especially when ground water measurements are lacking.

MULTIGOAL COST-EFFECTIVENESS

- In general, the information on the cost-effectiveness study was too limited and time was too short for a proper judgement of this part of the project.
- It was suggested to widen the scope of the cost-effectiveness study, as buffer strips may have several societal objectives, alternative to water quality, such as ecological corridors, increase in floristic biodiversity, creation of (bird) breeding habitats, etc.

Summarized judgement of the study

The judgement by the reviewers of the original project plan can be found in table 2. For more information see paragraph 5.7.

Table 2: Summarized judgement of the original project parts (marks ranging 0-5).

Criteria	Project part	mark
	Over-all	average 3.5
	Part 1: Field experiments	average 3.1
Contribution to the project objectives		3.25
Scientific and technical quality:		
	Theoretical presuppositions, hypothesis	3.5
	Adequacy of chosen approach, lay-out, design	3.25
	Observations, indicators, parameters, monitoring	3.5
	Reproducibility, replicates, statistics, bias, representative	**2**
	Part 2: Model study	average 3.3
Contribution to the project objectives		3.75
Scientific and technical quality		3.3
Models review		3.4
	Part 3: Cost-effectiveness	average 3.6
Contribution to the research objective		--[3]
Scientific and technical quality		
	Adequacy modelling approach and method	4.33
	Chosen alternative measures	--[3]
Farm models review		
	Relevance	4
	Scientific basis	--[3]
	Applicability	3.66
	Input data soil, hydrology, crops	2.83
	Complexity	--[3]
	Alternatives	--[3]
	Setup of the project	average 4
Contribution to the research objective		4
Scientific and technical quality		4

[3] Minimum response 3 out of 4 reviewers

Summarized revisions

The revisions that were decided based on this review will be described more extensively in a revised research plan (Noij, 2007, Effectiveness of buffer strips publication series 3). This summary is restricted to a list of decided activities.

REPLICATES

- o Three replicates (i.e. two extra) will be installed on two locations.
- o The selection of strips for replication alongside the ditches will be based on the following measurements to record spatial variability:
    - Electromagnetic induction (see appendix 5, will be executed by TNO);
    - Ground radar (by TNO);
    - Extended soil profile description along the ditch;
    - Auger hole method to determine hydraulic conductivity.
- o We selected the Beltrum and the Zegveld locations for replication based on the considerations in table 3
- o The locations will be assessed in terms of management history through interviews with the farmers and by studying soil N and P status (for organic matter, see below).

Table 3: judgement of criteria for the selection of locations for replication of load measurements

Altitude	Below sea level					Above sea level							
Soil type	Clay				Peat	Sand							
Hydrology	+ pipe drains		-drains		Holland[4]	Deeply drained		Loamy subsoil		Shallow soil		+drains	
Land use	Arable	Grass	A	G	G	A	G	A	G	A	G	A	G
Exp. BSE[2]	Low		High		H	L	L	Medium		H		L	
Area	High	Medium	VL[1]	Low	H	M	H	L	L	VL[1]	L	M	M
Code	a	B	c	d	E	F	g	h	i	J	k	l	m
Location	Lelystad				Zegveld	Beltrum			LoZ		Woold		
Priority	2	3	3	3	1	1	3	3	3	3	2	3	3
Explanation	High area but less useful because of pipe drains	Lower area and lower BSE than a)	Hardly exists	Low area, high BSE	High area, high BSE	Substantial area, low BSE	High area, situation taken into account via f)	Low area, average BSE	Low area, BSE lower than h)	Hardly exists, highest BSE	Low area, high BSE	Substantial area, low BSE, effect of pipe drains via a)	

[1] Very Low

[4] "Holland" profile, see footnote 4, page 11

DURATION

- o Budget is available for measuring three years. This means that the original replicates will be measured for the leaching seasons 2006/7-2008/9 and the new replicates for the leaching seasons 2007/8-2009/10. Off course, we will try to find budget for measuring the original replicates also in the leaching season 2009/10, at least for the two locations with replicates.

- First deuterium analysis already show increased deuterium concentration in surface water samples at Zegveld and Woold. These are indeed the locations were we expected the fastest reaction due to relatively superficial drainage. This indicates that we are on the right track concerning hydrological time lag effects.

GROUNDWATER QUALITY

- We will execute groundwater measurements (N, P) on all replicates in Zegveld and Beltrum. See also organic matter.

RUNOFF

- According to the original research plan we will pay some extra attention to modelling runoff, but we still need measurements for validation.
- Runoff is a badly understood process under Dutch circumstances. A separate hydrological research project is being initiated to measure runoff from a flat field to the ditch. The concerned researchers will select 1 or 2 locations from our project, but have not decided yet. Runoff measurement equipment will be installed on the same field, but not on the same plots, to prevent interference with our discharge measurements. Their measurements can therefore not be applied directly.
- On 3 separate locations in the Province of Limburg (1 grass and 2 arable fields on deeply drained sandy soil) P and N-runoff from field to ditch will be measured for the next three years. Hopefully these measurements can play a role in the validation of our models.

ORGANIC MATTER

- We will suggest our colleagues of Wageningen University and Research centre to do soil organic matter analyses for both treatments, for instance by students.
- We are seeking cooperation with Mathieu Sebilo form BIOEMCO in Paris, France, to execute isotope analyses (N^{15}, O^{18}) on groundwater and surface water samples in order to assess denitrification “en route”.

BIODIVERSITY AND MASS BALANCE

- We will suggest our colleagues of Wageningen University and Research centre, to monitor the following parameters for both treatments, for instance by students:
  - biodiversity and species composition in the strips on the field;
  - biodiversity and species composition in the reservoirs;
  - Sedimentation in the reservoirs.

MODEL VALIDATION

- We will develop a validation protocol for model validation.

MULTIGOAL COST-EFFECTIVENESS

- We will certainly include remarks on the possible multiple goals of buffer strips in the planned cost-effectiveness study, but extension of the study for the purpose of societal goals will depend on our clients, the Ministries of Agriculture (LNV) and Environment (VROM).

1 Introduction to the project

In October 2005 ALTERRA started a large-scale study on the effectiveness of unfertilized buffer strips along waterways in the Netherlands. We are investigating if such buffer strips can contribute to better surface water quality. The study was initiated in response to an agreement between the Netherlands and the European Union. Brussels wants the Netherlands to install buffer strips of at least 5 m wide along waterways, like in other countries of the EU. The Netherlands, however, has doubts about the effectiveness of buffer strips under flat conditions with little runoff. On the other hand, it does not want to exclude the possibility of implementing this measure with an eye to the water quality targets specified in the EU water framework directive. Buffer strips might be cheaper than alternatives such as reducing fertilizer rates, installing helophyte filters, removal of phosphates through crops, deeper pipe drainage and higher water levels (retention). The study is being paid for by the Dutch Ministries of Agriculture, Nature and Food Quality (LNV), and Housing, Spatial Planning, and the Environment (VROM), and will last at least until 2008.
Research into buffer zones has already been carried out in various countries, where in most cases the landscape is sloping, subsoils are relatively impermeable and the buffer zones are wide riparian wetland zones with natural vegetation. Under these circumstances, there will be a lot of runoff from the agricultural land surface containing nitrogen and phosphate, either in soil particles (esp. P) or in soluble form (esp. N). Soil particles in this run-off can be filtered out by the vegetation in the buffer zones, soluble N and P may to some extent be taken up by the vegetation and in wet buffer zones nitrates can be removed through denitrification. On the contrary, the Netherlands has mainly deeply permeable (or pipe drained) soils in a flat landscape, with little surface run-off. This means, that most of the discharge passes underneath the buffer strip.

In order to take the effects of soil, hydrology, and land use into account, we selected 5 locations for field experiments (table 4). At the first four locations, two collection reservoirs were placed in the banks of the ditch to collect the discharge from the fields. This allows us to measure the flow and take regular samples to determine the nitrogen and phosphate load. Next to one of the two reservoirs at each site, a 5 m unfertilized grass buffer strip was created. The other collection reservoir does not have a buffer strip and is used for comparison. At the fifth location a third reservoir was installed with a 3 m

Table 4: Overview of research in the field

Location	***Crop***	***Soil type***	***Hydrology***
Zegveld	grass	peat	“Holland” profile[4]
Lelystad	maize	clay	“Holland” profile[4] with subsurface drain pipes
Loon op Zand	grass	sand	loamy subsoil with low permeability
Woold	grass	sand	sloping, shallow soil on impermeable boulder clay
Beltrum	maize	sand	deeply permeable subsoil

[4] The typical “Holland” profile consists of an aquitard on top of an aquifer

buffer strip to study the effect of varying width. An additional buffer strip treatment of 10 m was applied there without measurement equipment for the time being. The study is supported by measurements of the groundwater, soil and crop. We are also using "tracers" to estimate how long it will take before the buffers are fully effective.

Modelling research will be conducted as well as farming systems research (together with other institutes) to be able to draw conclusions about the cost effectiveness of buffer strips on a national scale (extrapolation).

For further information we refer to the appendices 2-4 (presentations used during the review meeting) and to the research plan (Noij, 2006. Effectiveness of buffer strips in the Netherlands. Research plan. Effectiveness of buffer strips publication series 1, Alterra, Wageningen, the Netherlands).

2 Introduction to the review

The research plan text reads (Noij, 2006, paragraph 3.1, organization): *"As it is important that the study is widely supported, a (Dutch, ed.) reference group will be installed by the contracting ministries for advice on scientific aspects, planning options and communication of the results. This group will consist of representatives from the Ministries of LNV and VROM and the Dutch research institutes/universities RIVM, RIZA and UU. Moreover we suggest two external international reviews with scientific representatives from surrounding EU countries and a representation from the European Commission" (underlined by ed.)* This opportunity was offered to the EU by the Dutch officials, but they were satisfied with the setup of the research as it is now, including this review by peer researchers. A second review will be organized at the end of the research period.

2.1 Target group of the review

- Clients: officials of the Ministries of VROM (Environment) and LNV (Agriculture);
- Officials of the relevant EU-departments, in particular those responsible for EU-Nitrates Directive;
- Dutch reference group;
- Project team.

2.2 Purpose of the review

- To judge the setup of the research. Is the project plan adequate to get the required results for the project objectives:
  - ***over-all:*** to supply a scientifically based estimate of the efficiency of buffer strips (BS) in reducing nutrient loads from agriculture to surface waters in the Netherlands;
  - ***part 1, experiments:*** to provide experimentally based estimates for the three major Dutch soil types sand (/loam), clay and peat, for both grassland and arable land;
  - ***part 2, model study:*** to quantify variation due to soil and hydrology based on models (extrapolation and up scaling);
  - ***part 3, cost-effectiveness:*** to compare the cost-effectiveness of BS (buffer strips) with alternative measures that can be taken by farmers, taking in account the effect of buffer strip width.

  This scientific basis can be used for policy decisions on the application of buffer strips in the Netherlands.
- To gather relevant suggestions and/or information from peer researchers for improving the research plan:
  - to collect relevant references to the literature;
  - to collect relevant experiences from ongoing research on the topic;
  - to collect other relevant information or experience from the participants.
- To contribute to the exchange of information between the EU countries:
  - on measures to reduce nutrient loads to surface waters from agriculture;
  - on buffer strips in particular;
  - to contribute to the formation of a research network on buffer strips and other measures.

2.3 Criteria for the review

- Contribution to the project objectives
- Scientific and technical quality:
  - adequacy of chosen approach and methodology;
  - theoretical presuppositions, hypothesis;
  - reproducibility, representativeness (for NL), bias, replicates, statistics;
  - observations, indicators, parameters, monitoring;
  - any other criterion considered important by the participant.

2.4 Approach of the review:

- Meeting with peer researchers (see app. 1 for program and 6 for list of participants).
  - Presentations:
    - overall setup, including cost-effectiveness;
    - field experiments;
    - model research.
  - Excursion to one of the experimental locations.
  - Discussion.
- Afterward written enquiry (see chapter 5).
- Reporting (after reviewing the concept).

3 Results of the morning session

3.1 Over-all project and cost-efficiency

Nearly all comments and questions raised during and after the presentation by Gert-Jan Noij, see appendix 2 were informative. We discussed the following points of interest.

- Why not use more combinations: 3 soils X 2 land uses X yes/not drained (= 12 situations)? Why not more farm types?

We state that some combinations are not realistic or occur only rarely. The five chosen situations are common situations that occur in the five main geohydrotypes. Chosen farm types may be considered representative for these situations.

- The buffer strips are not fenced off. Therefore it will be hard to predict what effect installation of buffer strips this will have in the future on grazing + excretion inside the BS. Cows may prefer certain species that will develop in the BS vegetation, and thus relatively more excretion may occur along the ditch (compared to the remainder of the field). In that case the BS is not a truly unfertilized BS. Background information: in DK fencing ditches is obligatory, and also in the UK within some NVZ (nitrate vulnerable zones).

We explained that the layout without fencing is based on the assumption by Ministry officials that the possible introduction of buffer strips in the NL would not be accompanied by an obligatory fencing. Thus fencing would overestimate BSE compared to the expected future practice.

- Consider to include the total added value of BS in the final report of the cost effectiveness study (use data on societal benefits from literature)

We accepted this recommendation.

3.2 Field experiment

Discussion points during the presentation of the field work by Marius Heinen (Appendix 3)

- Why so small buffer strips? Brian tells us about the history of the buffer strip width in Denmark. A considerable part of the agricultural area is abandoned there nowadays. Apparently, in Holland the size of the buffer strip is more determined by political interests than by scientific preferences. In the case of Beltrum, an additional strip width has been chosen of 3 m. From a scientific point of view you would prefer to find the maximum effect and thus an additional strip should be chosen of 10 m width. Then, it corresponds better with the Danish situation.

On the other hand 10 m would imply waiting longer for complete expression of the effect.

- Has a detailed preliminary soil sampling been performed to gain insight in the variability and representativeness of the fields? Spatial variability of solute patterns due to fertilization should be quantified, as well as the soil properties along the field ditch.

We did soil sampling perpendicular to the ditch to characterize the strips and the field, but not parallel to the ditch. Pascal suggests making use of the experience of Prof. Marc van Meirvenne by using Electromagnetic induction scanning equipment (Appendix 5). This equipment may scan up the 150 cm deep. It doesn't give particular insight in the parameters that cause the variability but it shows where the differences occur.

- The field ditches seem to be quite variable in width.

The shape of the cross-section of a field ditch will influence the hydraulic properties and the discharge capacity of the ditch, but will hardly influence the load from soil to the surface water itself.

- Has some preliminary modelling been performed to estimate a priori discharges, time lags, etc?

Only HYDRUS2D has been applied to Beltrum to estimate the amount of deuterium to be inserted in the soil in the tracer experiment. Some rough estimates of the discharge from the precipitation excess, the spacing of the fields and the 90% extreme situations have been made by hand.

- Is the spacing between the catching reservoirs large enough to prevent interference?

A minimum spacing of 5 m has been chosen between the treatments to be able to inject the slurry in a correct way in the experimental plots. We have ideas on monitoring surface runoff patterns during peak precipitation, but these have not been worked out yet

- How many pipe drains are connected in the catching reservoirs in Lelystad?

Two drain tubes discharge into each reservoir. In the light of spatial variability, it is a weak basis for estimating field averaged loads and thus for making a distinction in loads between the fertilized and unfertilized strip. However it can make sense, if you are sure that the point of departure concerning the soil nutrient status of both plots is equal.

- Historically buried organic matter can play an important role in denitrification and mineralization. The question is raised whether soil organic matter and soil organic nitrogen are sampled in detail.

Samples are taken in quite a number of soil layers, but statistical significance is not assured a priori.

- What is happening with the water in the catching reservoirs? Processes as plant uptake, denitrification and sedimentation will influence the load estimates. It is recommended to perform measurements to quantify the impact of the residence of the discharged water in the catching reservoir.

We are very well aware of this point. Visual observations are done on the vegetation in the catching reservoirs and we intend to harvest excess biomass for sampling if necessary.

- What is the rationale of the bounding streamline philosophy, used as a basis for the tracer experiments?
- It is recommended to measure the internal N-production (mineralization) in the soil in the buffer strip and in the untreated reference plot. It is expected that the internal N-production will remain at the same level in the untreated and the treated plots for a number of years. After that a distinction between the internal N-production levels may be expected. If this phenomenon is not taken into account, a wrong conclusion on the effectiveness of buffer strips may be drawn. It might give you a false idea that the buffer strips are not working. It is recommended to carry out mineralization experiments at the start and at the end of the project. Pascal suggests using a free organic matter analysis for this (Six, et al. (including Frits Meiboom), 2002; contact Caroline Denef). The fraction analyzed by this method is well correlated with mineralization.
- Are the parcels of land upstream of the strips fertilized?

The management of the rest of the field and upstream fields is “business as usual”

- What type of tracer do you want to use for the “inflow at the gate estimation” experiments? It is recommended to use bromide, because background concentrations of chloride and variations in these background concentrations due to fertilization events may interfere too much with the tracer injected in the experiment.

We accept this recommendation.

- Are rooting depths of the crops measured during the season and at different locations? The idea is the plant roots in the unfertilized strip may intercept nutrients entering from upstream parts of the field.

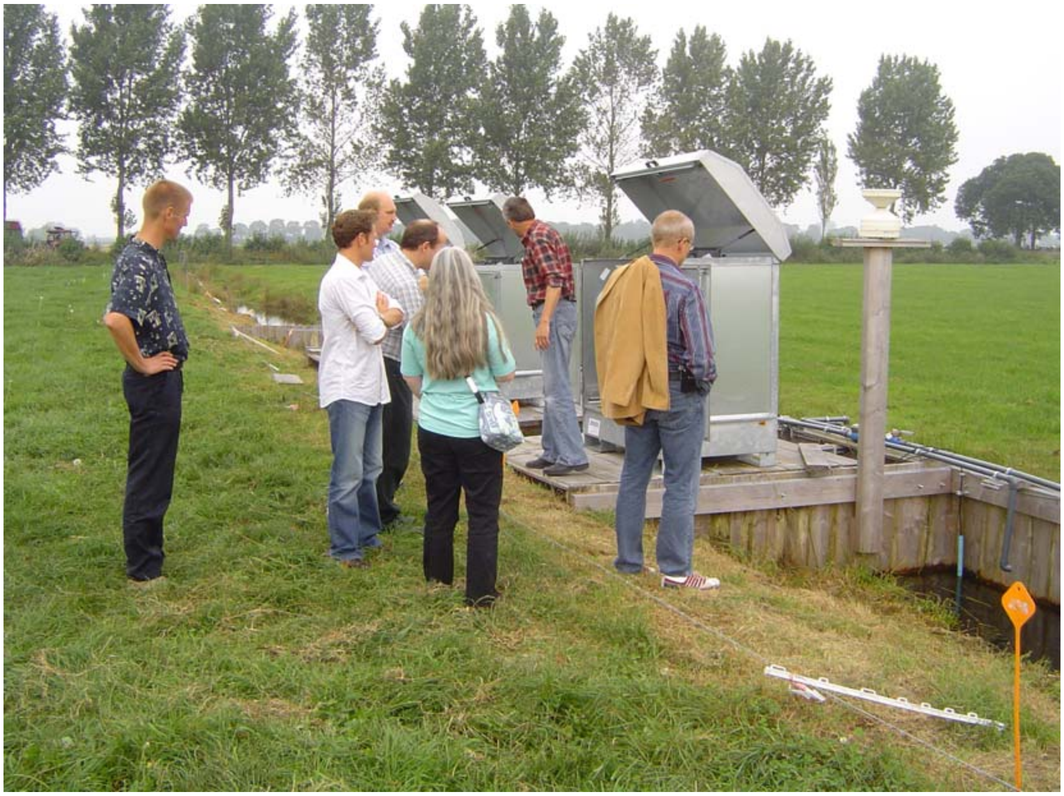
We accept this recommendation.

- Remaining remarks:
  - o Brian Kronvang expects only a so-called area-effect. The loads will decrease proportionally to the reduced fertilization rates induced by implementing the measure.
  - o Highest effects may be expected with a grass strip adjacent to a maize field as a result of immobilisation in organic matter and possible interception of runoff.
  - o Denitrification will predominantly occur in the bank of the field ditch. It is recommended to quantify this process in the field ditch bank by measurements.
  - o It is recommended to analyse nitrate and other nitrogen species in the upper groundwater zone not only at one location but in all flied locations.
  - o The research aims at quantifying small differences between loads from untreated and loads from treated fields. It is highly recommended to apply replicates (threefold is minimum)

3.3 Modelling study

The additional remarks during and after the presentation by Piet Groenendijk (Appendix 4) were the following.

- o Possible usefulness of hydraulic head measurements for field model calibration and validation were discussed.
- o Concepts for surface runoff may/might come from other projects, but are not yet included in this project.
- o Extrapolation by models into the future is considered important also because of several "laggy" effects (both hydrological residence time and organic matter dynamics).
- o Jane Hawkins suggests taking retention in the ditch system into account, direction of the ditch stream and the retarding effect of the reservoirs in the ditch. We argue that the reservoirs are separated from the ditch system and that the effect of water level in the ditch is overcome by the levelling system (pumping in and out if necessary every 1 cm level difference).


Marius Heinen, Pascal Boeckx, Piet Groenendijk, Martyn Silgram, Jane Hawkins, Antonie van den Toorn and Brian Kronvang at the Zegveld experimental site. Photo taken by Gert-Jan Noij


Marius Heinen, Jane Hawkins, Pascal Boeckx, Brian Kronvang, , Martyn Silgram, Antonie van den Toorn and Piet Groenendijk at the Zegveld experimental site. Photo taken by Gert-Jan Noij.

4 Results of the afternoon session

4.1 Visit to the Zegveld experimental site

The participants highly appreciated the visit to one of the experimental sites (see picture on the other page). Antonie van den Toorn of our Alterra field project team explained the experimental instrumentation and participated in the discussion in the field. Several suggestions were discussed, that will be reported in the next section.

4.2 Final discussion

General
Remember that at all locations the fertilization rate is the maximum allowable rate. So, we will look at the maximum possible BSE.

Replicates

- Time is probably not a good pseudo-replicate, because it will take a few years for any difference (if there is any) to develop; after that we need to go on an extra few years in which case we could consider time as a pseudo-replicate; but, for now, the project doesn't last long enough.
- Replicates are more important if you expect only small differences. For example, if current concentration in the ditch is say 5 mg/L and the BS comprises 10% of the field, we may expect some 10% difference in load, only 0.5 mg/L. The lower the current concentration levels are in the ditches, the more difficult it will be to observe differences in loads. If differences are to be shown, replicates are needed, at least a triplicate.
- You need a high signal-to-noise ration in your measurements.
- Consider several options for doing replications (in order to save on the budget)
  - less locations with replicates
  - less measurements at all locations (only first and last year; every other year, …)
  - circulate equipment from location to location
- If only 1 site is to be replicated: consider Beltrum, because differences there are expected to be low, and thus you need replicates to verify any differences.
- Or, you might want to do replications at the site were you expect the highest differences.
- Or, choose the two most extreme situations for replications
  - a) Woold and Beltrum (disadvantage: different land use)
  - b) Woold and Zegveld (same land use)

Denitrification

- Pascal Boeckx argued that reduction in nitrate concentration of the soil solution may continue at high rates in the ditch bank. So high concentrations in upper groundwater next to the ditch can still be lowered drastically in the ditch bank before the water actually enters the ditch. This potential in denitrification will not change due to the BS treatment. Or, in other words, you may not find differences in loads but you may find differences in the upper groundwater only. This may serve as an argument to do sampling of the upper groundwater at all locations.

Runoff

- Will be difficult; long gullies required; outside the reservoirs.

Labile organic matter

- During presentation of Piet this item was already discussed: Pascal Boeckx will send some references and a name of the PhD student who works with the proposed method.

Multi-goal cost effectiveness

- During presentation of Gert Jan this item was already discussed: consider including the added value of BS in the final report of the cost effectiveness study (use data from literature).

Calibration and Validation

- A protocol is needed where these two steps are written out. Make several for different options: either with or without replications, either with or without sampling of upper groundwater.
- Clearly, the reference object must serve as the calibration object, and the BS object must serve as the validation object.
- You may consider splitting up the time series as well.
- Calibration of the soil models require more information of the status in the soil (as a function of time) in order to be able to calibrate sub-processes in the models. Thus, it would be worthwhile to do sampling of upper groundwater at all locations (minimum package of concentration, e.g. $N\text{-}NO_3$, N-Nts, $P\text{-}PO_4$), and do some mineral N content measurements in time (e.g. 2 times per year).

Sediment traps

- Brian Kronvang suggested installing 2 to 3 sediment traps inside each reservoir, a few cm above the bottom, and analysing these twice a year. Determine if there are differences in sediment loads (mineral, org. matter, Nt, Pt) between the 2 objects per location. This will contribute to completion of the N and P balance. (At Zegveld it is very difficult to find differences in “soil” storage at the bottom, because of the diffuse transition from water, via sludge or mud to soil.)

Is current experimental set up good enough to measure possible differences?

- See replicates.

5 Afterward written enquiry

5.1 Introduction

We supposed that it would be hard to collect all relevant information during a one-day meeting. Therefore we considered it useful to use an additional written enquiry, in order to:

- serve in advance as an introductory tool for the participants;
- have a guiding tool during the discussions;
- save remarks during and add remarks after the meeting;
- get a completer picture of the participants' judgment of the research project;
- to structure the review report.

Depending on the questions several qualifications may be possible, such as the ones in table 5. We used marks as much as possible.

Table 5: some examples of possible qualifications

Marks	**1**	**2**	**3**	**4**	**5**
Grades	E	D	C	B	A
Bad-good	no good	insufficient	sufficient	good	very good
Useful	no use	inadequate	adequate	useful	very useful
Chance	nil	low	moderate	high	almost certain
Sense	nonsense	unnecessary	helpful	necessary	indispensable essential
Scope	far too narrow far too wide	too narrow too wide	sufficient	good	very good

etc…

We asked to fill in a written enquiry during and/or after the meeting and send it back to us. If participants had too little information on a specific question, they left it unanswered.

We choose to start with the separate project parts and conclude with the over-all setup of the project, in order to prevent doubles. Any general or personal remarks were placed at the end of the written enquiry.

5.2 Part 1: Field experiments

Reminder: according to the project plan the objectives of the field experiments are:
..."to supply a scientifically based estimate of the efficiency of buffer strips in reducing nutrient loads from agriculture to surface waters in the Netherlands" and
..."to provide experimentally based estimates for the three major Dutch soil types sand (including loam), clay and peat, for both grassland and arable land".

- Contribution to the project objectives
  - *experimentally based estimates (3 soil groups; 2 land-uses)*

Mark	**1**	**2BK MS**	**3**	**4 JH**	**5 PB**

Remarks PB:
- The most important land uses and soil types are included in the set-up.
- The focus is on reducing loads. However, nutrient concentration measurements in the piëzometers installed in the buffer strips could provide additional information. If the nutrient concentrations are below the thresholds (even in the control buffer strip), than it could be deduced that no additional measures are needed.
- I wonder why grasslands are included as land use. Only to prove that buffer strips on grasslands do not have a function to reduce nutrient loads?

Remarks JH:
- The selection of sites appears appropriate in order to investigate the major Geohydrology types of the Netherlands.

Remarks BK:
- The experimentally based estimates may be met by the design as you cover the different combinations of soil groups and land-uses – but again this is only done once without any use of replicates so you may very well end with results that might not be sufficient for your objective of providing experimentally based estimates .... etc., as your experiments are not replicated (see below).

Remarks MS
- Principle of different soil groups/land uses is good, with arable and grassland, and sands, clays and peat soils all represented as major Dutch soil types. However, this concept of "geohydrotypes" requires some pragmatism to focus on the most vulnerable situations only (the experiment currently tries to achieve too many land/soil combinations with insufficient replication).
- More evidence is required to demonstrate that the experimental sites chosen are indeed representative of these "geohydrotypes" in terms of management history, soil nutrient (N, P) and organic matter status, slope, climate, land use. This information may have been developed already by the project team *(not yet, ed.),* but was not included in sufficient detail in the review.
- There are some benefits of using a closed environment (ditch chamber) system. However, some concerns remain over the extent to which this methodology unduly alters the abiotic and biotic factors in the ditch environment (temperature, mixing, flow rate, chlorophyll a). An alternative would have been to monitor entire unconfined ditches instead. (*ed.:This was indeed considered during the preparation of the project, but discarded for two reasons. It would have been hard to find a series of comparable ditches and fields for applying the treatments and find enough farmers willing to cooperate. I must admit, at that time we still considered replicates!*

- *scientifically based estimate*

Mark	1	2 BK MS	3	4 PB	5 JH

Remarks PB:
- It is really excellent that the buffer strips will be followed for 3 years.
- The lack of spatial replicates will have some constraints (see also further).

Remarks JH:
- The choice of models & approach are well suited to the production of estimates.
- ANIMO is a well established & published model in particular.

Remarks BK:
- The scientific research design at the five locations is not at all adequate as no replicates exist at each location. I strongly urge that replicates of both the control and the buffer strip are introduced. At least three replicates are needed at each site for scientifically to be able to do any statistics on the final effects of introducing buffer strips. It most be foreseen that a natural variance in the soil physics may simply override any effects of introducing buffer strips.

Remarks MS:
- Lack of replication severely undermines the scientific robustness of results; severely limits the ability for peer review and ultimate publication; and raises the question of whether unreplicated results can reasonably be extrapolated to draw general conclusions about the impact of buffer strips across the whole of the Netherlands. It is doubtful if unreplicated results such as these will be sufficient to demonstrate a convincing case to prove an effect (or as hypothesized, the lack of an effect), to the European Commission.
- The modelling approach is generally plausible, but it is hindered by the inclusion of a rather complicated mixture of different models, the lack of sufficient monitoring data for calibration and validation, and the absence of a detailed protocol describing the modelling approach and methodology in detail. The validity of the assumptions to be developed for the up scaling activities is of great importance in terms of generalizing results to Dutch agricultural systems.

- Scientific and technical quality:
  - Theoretical presuppositions, hypothesis;

Mark	1	2	3 JH MS	4 PB BK	5

Remarks PB:
- I wonder which results will be measured: the effect of installing an unfertilized buffer strip or the effect of the reduced fertilization on this strip?

Remark JH:
- No hypotheses have been explicitly stated, though assumptions are made that there will be differences in loading from the different treatments imposed.

Remarks BK:
- The presuppositions and general working hypothesis of the project is valid as creating dry buffer strips (in this case 5 m) without changes in the soil hydrology and flow patterns will surely only increases nutrient (N,P) retention in the case that you have surface runoff from agricultural fields sloping towards the watercourse. The value of creating buffer strips in such environments has been proven for P reduction in many studies and will also to some extent help to reduce losses of organic N. The effect of this should surely be studied at least at the study sites with sloping fields towards the ditches (is not done at the moment). An increase in the capture of nitrate and subsequent denitrification under the buffer strip is doubtful as no changes in hydrology are introduced. Added values for the project in gains in biodiversity in the buffer strips could be important for the Habitat Directive and may also influence the nitrogen input to soils (fixation, changes in grazing) – so I find it important that

this is incorporated in the project to follow the development in plant species and cover.
Remarks MS:
- The hypothesis proposed is a null one i.e. that there is no significant effect of increased buffer strip width on nutrient pollution. Although this is a plausible hypothesis, it is not clear how the results will enable the hypothesis to be tested i.e. when are differences in measurements between a control and a contrasting treatment considered "significant"? It is not clear how this difference will be tested statistically e.g. t-test, LSD etc. The lack of replication makes testing any such hypothesis much more difficult.

o Adequacy of chosen approach, methodology, lay-out, design

Mark	**1**	**2 MS**	**3 BK**	**4 PB JH**	**5**

Remarks PB:
- The approach and lay-out are well developed.
- The lack of replicates may (seriously) constrain to statistically proof that there exists a difference between the buffer strips and the control plots.
- The within field heterogeneity should be assessed to allow a verification that the buffer strips are installed at a representative plot in the selected field. Within field heterogeneity can be assessed using electromagnetic induction measurements.
- The project has limited attention for geo-morphological features as "buried C" which could aid to explain nutrient loads, especially nitrate.
- It is recommended to use Br^- tracer instead of Cl^- (Cl^- is also present in manure).

Remarks JH:
- Approach & methodologies are appropriate for the investigation.

Remarks BK:
- The approach and methodology chosen in the project is a very comprehensive and new one as you try to capture the load of the nutrients originating in the surface waters trying to do use a mass-balance approach. Our experience in Denmark looking on the effect of restoration of wetlands have often been on using both a mass-balance approach and a more experimentally one following the water and nutrients in transects along the wetlands. I believe that you should also try to implement such an approach following not only the groundwater hydrology but also look on changes in groundwater quality along the transects on the fields where piëzometers are already installed. You may foresee that problems in setting up the mass-balance for water and nutrients in the reservoirs will appear as sedimentation conditions may differ between the control and the experimental site; the biological uptake may differ and also may the denitrification in the reservoirs due to differences in the available surfaces (plants).

Remarks MS:
- The short duration of the project is concerning, given the time taken for environmental systems to respond to management change and reach a new stable condition. A minimum of a further two years of monitoring is required for results to be sufficiently robust to support generalization of conclusions and upscale modelling activities.
- This is of course early stages in the project, but overall the explicit links between field data and modelling, and modelling assumptions, need further more detailed study as the project progresses.

- Observations, indicators, parameters, monitoring. A priori discussion items:
  - No separate surface runoff measurements yet
  - Analysis of undissolved N and P in discharge samples
  - Biomass growth in containers and slope of the ditch

Mark	**1**	**2**	**3 JH BK MS**	**4**	**5 PB**

General remarks PB:

- Surface runoff would only be a problem in the arable maize fields. I would suggest to focus the attention on these fields also seen the limited slope of all the fields studied.

General remarks JH:

- Frequency of sampling seems adequate.
- There is a need to access the heterogeneity of the soil alongside the ditches.

General remarks BK:

- Generally your programme of sampling and analysis is of good quality also the sampling frequency, etc. is of very good quality.

General remarks MS:

- Surface runoff monitoring is essential, as under some circumstances this can be significant even on modest (e.g. 2 degree) slopes (focus on arable sites). This could be implemented at a site such as Woold.
- Monitoring of chlorophyll a in the ditch waters both inside and outside the closed tank system is required to demonstrate that the experimental method is not unduly altering the biological and biochemical parameters in the environmental system which it seeks to monitor.
- There would be value in seeking evidence for any auxiliary biodiversity benefits associated with the buffer strip and fertilisation treatments (e.g. different vegetation species; clover versus grass rich swards etc). This should be assessed at the end of the experiment.
- Baseline groundwater piëzometer concentrations should be taken in each experimental plot, focusing on those areas where concentrations are highest. Such concentrations may respond to the contrasting fertilization and grazing patterns in the experimental treatments.

Specific (re)marks PB:

- An important comment is to make on the analysis of total dissolved N (TDN) and via difference dissolved organic N (DON). This is scientifically very interesting since this pool might make up a significant part of the bio-available N load to the rivers. The same holds for dissolved organic P. However, for TDN measurements there are serious limitations with respect to the current TN analyzers on the market. The problem is that the combustion efficiency for the various N species that make op the TDN pool is not equal. Moreover the formed NO and NO_2 is not produced in the same ratios for standards and samples. All of this seriously hampers the reliability of such measurements. More information can be obtained from the reviewer.
  (*ed.: As a matter of fact we are combining analyses of filtered and unfiltered samples. In the unfiltered samples we analyze for TN (solid + dissolved), in the filtered samples for TDN and mineral N. Subtraction should yield solid N, dissolved organic N and mineral N. We did experiments to find out if the destruction with persulphate is complete*.)

Specific (re)marks JH:

- It would be preferable to have groundwater measurement for all the sites which could be from occasional soil extraction samples.
- Concern about the build up of P in the sediment in the reservoirs.
- Possible biodiversity charges (e.g. sward composition) could provide some added value to the project.

Specific (re)marks BK:

- You need to analyse also total fractions (TN, TP) in water samples taken from the reservoirs in order to include any transformations of N and P in your mass-balances. (See first item PB) Moreover, you could very simply measure the sedimentation of N and P in the reservoirs by deploying sediment traps hanging in the wall of the reservoirs. I will also suggest making a regular monitoring of plants in the reservoirs (coverage) and maybe once a year an estimate of the biomass. I find it very important that you include in your regular monthly monitoring a monitoring of the quality in upper groundwater by installing new piëzometers that is emptied (some hours) before doing the water sampling.

- o Reproducibility, replicates, statistics, bias, representativeness (for NL), size of the experiment (5 locations, size of containers and buffer strips). A priori discussion item:
  - "No replicates" is considered an important weakness of the experimental design. Do you consider this weakness insurmountable or do you think it is nevertheless possible to publish results in a peer reviewed scientific journal?

Mark	1 BK	2 JH MS	3 PB	4	5

Remarks PB:
- I think that the lack of spatial replicates will seriously hamper to detect statistical differences (no SD's can be calculated) between the buffer strips and the control plots. Moreover, I am afraid that publication in peer reviewed, quality journals will be a problem.
- I was surprised that buffer strips are so small (5 m). However, I understand this comes along with the experimental lay-out and the load approach that has been chosen.
- The selected sites are clearly representative for the Netherlands. Personally I would have left the grasslands out of the experiment. However, if it was the intention to proof that buffer strips do not function on this land use to reduce nutrient loads than I understand.

Remarks JH:
- There is a lack of replication, both within and between sites. Problems may particularly arise from accounting for the range of variation during the modelling phase.
- The lack of replication will probably be heavily criticized when trying to publish the data in a peer reviewed quality scientific journal.

Remarks BK:
- You need to introduce replicates may be at 2 of your experimental sites. You may then use the findings from these replicates to the other sites if you can argue that you covered the sites with highest variability in soil physics, etc. So you need to carefully evaluate which sites you introduce replicates on if you have the resources needed. A mapping of soil physics along the ditches investigated at all five sites is crucial in this aspect.

Remarks MS:
- Yes, the lack of replication is the single most serious “negative” aspect of the project’s approach. Research budgets are always limited, but it would be preferable to reduce the number of sites (e.g. by two) and instead increase the replication (minimum 3 replicates) in order to have scientific confidence in these results; facilitate peer review and publication; and ensure the results are robust enough to be presented to EC in support of Dutch environmental policy.
- Closed tanks in ditches are of limited size and could unduly modify biochemistry and abiotic factors.
- Essentially, the project is looking to detect a very small potential effect against a high background noise (“signal / noise ratio”), and without replication it is possible to reach an erroneous conclusion simply because of this environmental variability.
- Without replication, no assessment of uncertainty or variability in system response is possible. As a result, publication of results in a credible scientific journal will be extremely difficult (although conference proceedings may be possible). Peer review is important for such results if they are to be used as a key factor influencing Dutch policy under the Nitrates Directive.

- Other criteria, such as ……

Mark	1	2	3	4 PB	5

Remarks PB:
- I wonder whether it could be possible to measure denitrification capacities in the river banks of the ditches. Potentially these could be a hotspot for denitrification.
- I recommend to measure nutrient concentrations along a transect of piëzometers installed in the buffer strips and the control plots.
- I recommend measuring the mineral N and P delivery from the unfertilized buffer strips. This would allow you to estimate how much of the nutrients are formed in the buffers strips. As such the lag phase of the unfertilized buffer strips to deliver nutrients can be assessed and the effect of the control plot can be verified.
  (*Ed. don't you think that the crop uptake suffices for this?)*

Remarks JH:
- If there is a change in sward species on the buffer stripes compared into non-buffers, there may be preferential grazing of the areas (on the grassland treatments) and this would affect the nutrient status of these soils.

Other comments MS:
- Biodiversity issues have not been considered. This could include changes in vegetation composition in the buffer strips due to contrasts in fertilization or grazing access; biogeochemical and biological changes in the closed tanks in the ditches.
- Any potential confounding effect of livestock access to ditch banks (bank erosion due to drinking water access) should be considered. *Ed. We excluded this effect from the experiment by fencing, meaning that BSE is underestimated for regions where this happens.*
- The rooting depth and vegetation density of the vegetation in different experimental treatments should be assessed, to demonstrate the presence or absence of an effect, and to provide parameters to support modelling (N uptake etc).

5.3 Part 2: Model study

Reminder: according to the project plan the objective is:
…."to quantify variation due to soil and hydrology." We intend to do so by:
…."developing and applying a model instrument for extrapolation of the results in time (future) and space (to cover the Netherlands)."

- Contribution to the research objectives
  - assessment of the model study to quantify variation due to soil and hydrology

Mark	1	2	3 MS	4 JH BK	5 PB

Remarks PB:
- I believe this approach is the only option to really upscale the experiment.

Remarks JH:
- It is useful to have the modelling phase built in this project though there is some concern about the calibration/validation of the models given the lack of replication in the experiments.

Remarks BK:
- The model study will be a very important part of the study as it can help you to look deeper into the processes in the soil that may or may not be responsible for the observed changes in nutrient loads between the control and the treatments. However, the model has to be calibrated to all sites and for that reason sufficient input data is needed from the soil monitoring of hydrology and water quality. Moreover, it is very important to be able to validate the applied models and this procedure can only be conducted if you at some sites

(suggested two) have replicates of the control and treatment – and you may choose to only calibrate the model on one and reserve the other two controls and treatments for validation.

Remarks MS:

- Main soil types and hydrological regimes appear to have been covered adequately in the experimental design

  - value of the development and application a model instrument for extrapolation of the results in time (future) and space (to cover the Netherlands)."

Mark	**1**	**2**	**3 BK MS**	**4 PB JH**	**5**

Remarks PB:

- difficult to asses the "future" aspect of the modelling.

Remarks BK:

- It will be difficult to extrapolate the findings to entire Netherlands using a model as you are only covering at least some of the spatial variation found in the country. However, it might be possible to undertake such a calculation simply using metamodels.

Remarks MS:

- The development of a detailed protocol outlining the main steps in the modelling methodology is required with some urgency. The modelling approach appears to use a complicated mixture of different modelling tools with contrasting histories, validation status, modelled variables, and temporal/spatial scales.
- In particular, the limited length of the experimental dataset will seriously constrain the robustness of modelling work (e.g. due to seasonal and annual variations in weather, crop management, system response etc). This short record and lack of replication means it is extremely difficult to separate data into a calibration and validation phase of the modelling, yet it is well known that the models proposed require considerable calibration prior to their use "in anger". This problem is especially acute due to the "spin-up" time required by some of the models chosen.
- This therefore supports the case for the project duration to be extended for minimum of a further two years – which is essential to provide the length of data record to allow separate calibration and validation activities, and allow sufficient time for the system itself to respond to the experimental management change (buffer strip width).

- Scientific and technical quality:
  - Theoretical presuppositions, hypothesis;

Mark	**1**	**2**	**3 MS**	**4PB JH BK**	**5**

Remarks PB:

- As always, I hope there will be some room for uncertainty assessment of the obtained modelling results.

Remarks BK:

- I find that more emphasize should be given to the important steps of doing the model calibration and validation in the project. A calibration and validation manual should be drafted very early in the project to assist in analysing if sufficient data is collected at the different sites both for model calibration and for the very important subsequent model validation on independent data. The validation protocol should also include descriptions of the statistical measures used for evaluation the performance of the model (sub-models).

Remarks MS:

- Surface runoff and erosion not included in ANIMO. Although the very shallow slopes mean this will not be an issue in many Dutch environments, it may be relevant for some locations with slopes of 2 degrees of more. Other projects already underway in NL should be reviewed to provide evidence to decide whether runoff monitoring is required.

- o Adequacy of chosen modelling approach and methodology;
  - choice for mechanistic modelling;
  - couple a detailed physical 2D plot model FUSSIM2 with 1D hydrology and nutrients plot models SWAP/ANIMO;
  - determine the hydrological boundary conditions for the plot models with a regional model SIMGRO;
  - calibrate plot models with field experimental results;
  - derive simplified so called metamodels, geared to available national spatial data;
  - use the metamodel and the spatial schematization of the national STONE-model for national application

Mark	**1**	**2**	**3 MS**	**4 PB JH BK**	**5 PB**

General remarks: PB

- Due to time limitations no detailed information could be given on the models. However the selection and coupling of the different models seems logic to me. Although I have to admit that I am not a modeller.

General remarks BK:

- I find that the models and model concept chosen (2D FUSSIM coupled with a 1D hydrology and nutrient) is sufficient for solving the tasks and hypothesis given that sufficient emphasize is devoted to calibration and validation of the models including that the necessary input data for both calibration and validation exists.

Specific (re)marks BK:

- Implementation of surface runoff measurements is crucial for the model calibration and validation at least on sites where surface runoff can be foreseen to happen (Sloping fields).
- Monitoring upper groundwater quality is also needed for calibration of the models (boundary conditions).
- Monitoring sedimentation and plant biomass in the reservoirs is also needed for final validation of the models.
- Total nutrient fractions should also be monitored.

Remarks MS:

- It is unclear why STONE, with a time step of decades, has been selected for this study. A shorter time step model would have been more appropriate, given the other unknown economic and climatic variables which could have an effect over such long time periods. I assume funders are primarily interested in effects over a time period of 2006-2015?
- Other models appear broadly suitable, although the proposed method appears to couple many different approaches (SIMGRO, FUSSIM, HYDRUS etc) which has the potential to cause difficulties in terms of model assumptions, boundary conditions, species modelled, and temporal and spatial time step. Some of the chosen models have a long pedigree (e.g. FUSSIM), but the validation status of others needs to be considered.
- The meta-modelling approach is sensible as a way of simplifying the chosen existing complex models which are being implemented. However, the limited experimental data (no replicates, short time period) will severely hinder the modelling process in terms of validation and predictive uncertainty. A sensitivity analysis of the meta-model would help target field monitoring to ensure all the most sensitive parameters are measured.

- Models review:
  - Summarized overview of the models

	STONE spatial schem.+animo+swap	ANIMO	SWAP	FUSSIM2	SIMGRO
Scope	Entire Netherlands	Field plot	Field plot	ditch-field transect	region
Dimensions	quasi 2D	1D	1D	2D	quasi 3D
Spatial schematization	6405 uniq. plots of 25-20,000 ha	Soil layers 1-50 cm	Soil layers 1-50 cm	vertical finite elements	layers+ horiz. finite elements
Time step	decade	1-10d	h	h	d (gw) <h (sw)
Processes	hydrology nutrients	Nutrients	hydrology	hydrology nutrients	ground-&surf.-water hydrology
hydrology	Forced	Forced	calculated	calculated	calculated
lateral fluxes	calculated	Forced	calculated	calculated	calculated
crop uptake	Forced	arable forced grass calc.	-	calculated	-
P-sorption	calculated	Calculated	-	-	-
N-cycle	calculated	Calculated	-	calculated	-

  - criteria for models review

Relevance of chosen processes for the research objectives
Theoretical or **scientific basis** for process descriptions.
Applicability of the model related to domain, presuppositions, boundary conditions
Availability and quality of **input data**
Complexity as related to available data and objective
Possible **alternatives** for the chosen models (many – no alternatives)

Criteria	models review				
↓ qualification→	1	2	3	4	5
relevance			MS	PB JH BK	PB
scientific basis		BK	JH		PB
applicability			BK	PB JH	PB
input data	no	insufficient	Moderate	Enough	a lot of
soil			JH BK MS	PB	
hydrology			JH BK MS	PB	
crops			JH BK MS	PB	
complexity	too c.	very c.	PB JH BK MS	fairly	just right
alternatives	many	quite some MS	Little BK	one	no
Remarks JH: I am unable to provide information or alternatives as this is out of my range of knowledge.					

5.4 Part 3: Cost-effectiveness

Reminder: according to the project plan the objective is:
…." to compare the cost efficiency of buffer strips with alternative measures that can be taken by farmers, taking in account the effect of buffer strip width."
Method: …"apply available farm models to calculate the costs of implementation of buffer strips and alternative measures. Use the metamodels from the model study to estimate effectiveness.

- Contribution to the research objective
  - o assessment of the farm model study to calculate costs of buffer strips (with varying width) and alternative measures for the Netherlands

Mark	**1**	**2**	**3**	**4**	**5 PB JH**

Remarks PB:
- This would provide very relevant data for policy makers.
- The so called "added value" of buffer strips could be included here. Buffer strips have other functions than reducing nutrient loads. Other functions might be: ecological corridors, increase in floristic biodiversity, creation of (bird) breeding habitats, etc.

Remarks BK:
- To do at more proper review more specific information is needed on this part of the project.

Remarks MS:
- Actual project cost (€ 4M) appears expensive given the limited number of individual monitoring locations (ditch chambers) and short monitoring period currently implemented.

- Scientific and technical quality:
  - o Adequacy of chosen modelling approach and methodology;
    - ▪ estimate costs of measures with integrated farm models for different farm types;
    - ▪ choose representative farm types for the three main soil groups of the NL;
    - ▪ estimate effectiveness of buffer strips with the metamodels from the model study;
    - ▪ estimate effectiveness of alternative measures with available literature and models.

Mark	**1**	**2**	**3 MS**	**4**	**5 PB JH**

General remarks PB:
- The information on the integrated farm models was unclear.
- The farm types are representative, I believe.
- The alternative measures are representative.

General remarks BK:
- To do at more proper review more specific information is needed on this part of the project.

Remarks MS:
- -A more detailed protocol describing the assumptions and methodology for this task is required.

- o chosen alternative measures
  - ▪ blocking transport routes
    - blocking surface runoff
    - deep drainage
    - bio-filters (marsh, ponds, and alike)
  - ▪ reducing nutrient surplus/residues
    - reduce fertilizer rates
    - remove crop residues (esp. sugar beet leaves)
    - ….

Mark	**1**	**2**	**3 MS**	**4 JH**	**5**
General remarks PB: - Not so much information was given on how wide spread the alternative measures are or will be implemented in The Netherlands. - Is, e.g. for deep drainage sub soil denitrification considered? - Are the bio-filters so called constructed wetlands? General remarks BK: - The choice of alternative measures is very interesting also for other countries like Denmark as we are also discussing the value of some of them for the WFD. Specific (re)marks PB: - In general, the information provided here during the meeting was rather limited.					

- o Review of chosen farm types and models

On the next page you find a summarized overview of the farm models, below the judgement by the participants.

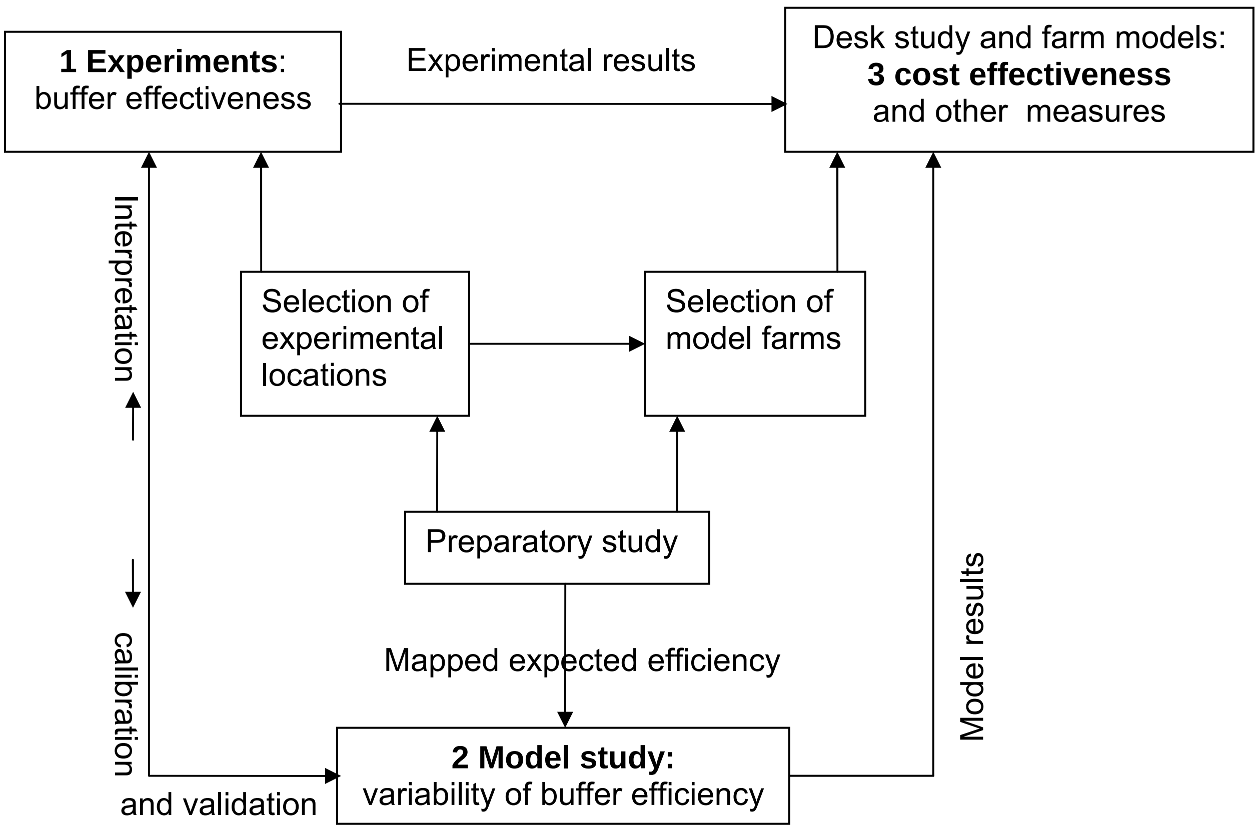
Criteria	farm types and models review				
↓ qualification→	1	2	3	4	5
relevance			MS	JH	PB
scientific basis				PB JH	
applicability			MS	PB JH	
input data					
o soil/Gt[5]		MS		PB JH	
o management parameters			MS	PB JH	
o crop parameters				PB JH	
o cow parameters			?	PB JH	
o economic parameters			?	PB JH	
Remark: a rather quick review was given, not enough detail to assess this thoroughly.					
Complexity				JH	PB
Alternatives			PB		

[5] Groundwater table

Summarized overview of the farm models								
	BBPR, dairy farms			arable farms model				
typology	sand	clay	peat	sandy soils		clay soils		
name milk prod. %maize % vegetables	intensive >14 Mg/ha/y 30%	moderate 12.5 Mg/ha/y 15%	extensive 11.5 Mg/ha/y 0 %	south high	Northeast: starch potato low	Southwest moderate	Centre high	Northwest low
time	models calculate results for an average year							
abstract	the model integrates grass production, cow nutrition and excretion, and the necessary feed-backs to describe nutrient recycling (excreta) and losses			*not available*				
soil and Gt[5]	3 sandy, 4 clay, 3 peat soil types, 9 Gt's moisture supply; wetness damage according to HELP-method							
management	effective N-fertilizer level; stocking rate, potential cow production level, fodder regime, ….			effective N-fertilizer level; rotation; sowing and harvest date, tillage,…				
grassland utilization	grazing-mowing, rotational-continuous supplemental feeding,…							
cow nutrition, production and excretion	COW-model							
farm economy	attributable costs, costs of labour and ground area, surpluses			attributable costs, costs of labour and ground area, surpluses				

5.5 Over-all setup of the project

We chose to start with the separate project parts and conclude with the over-all setup of the project, in order to prevent doubles. Comments on the over-all project were restricted to the added value of the integration of the separate parts.



- contribution to the objectives of the research project
  - adequacy of the setup
  - Missing items; suggestions for widening the scope
  - Redundancies; suggestions for narrowing the scope
  - suggestions for improvement

<table>
<tr><th>Mark</th><th>1</th><th>2</th><th>3 MS</th><th>4 JH</th><th>5 PB</th></tr>
<tr><td colspan="6">Remarks PB:
- The overall concept and approach of the project is very good
- I would include some repetitions (3), preferably on the most contrasting sides.
- I would not have included grassland as land use.
- Besides measuring the nutrient loads I would also measure the nutrient concentration in the ground water in the buffer strips.
- Be aware of the analytical difficulties by measuring TDN.
- Use a Br tracer instead of Cl.
Remarks JH:</td></tr>
</table>

- Addition of some form of replication would strengthen the findings of this project. Also the addition of surface runoff measurements could be useful. Remarks MS: - Biodiversity and chlorophyll a should be monitored (see earlier comments).

- scientific
  - added value of the over-all setup to the separate parts 1,2,3

Mark	**1**	**2**	**3 MS**	**4 JH**	**5 PB**
Remarks PB: - The chosen approach allows to work at different scales (plot, landscape and country); - Inclusion of cost effectiveness study will be highly valuable. Remarks MS: - As stated earlier, replication is essential, even if limited budgets mean that this requires a reduction in the number of experimental sites. - There is a strong case for extending the duration of the study to ensure that the system's response has been fully captured in monitoring data, and to provide a sufficiently long monitoring record to allow proper calibration and validation of modelling activities.					

5.6 Concluding remarks.

<u>Martyn Silgram</u>
Please find my review notes on your buffers project attached. Apologies for the delay in returning them. I hope my comments are not too critical. The project has some good potential, providing that you can secure some additional funding to <u>extend the duration by a further two years, and introduce replication</u>. Good luck in your research. Kind regards

<u>Brian Kronvang</u>
Thank you for hosting me at your meeting on the Dutch Buffer strip project. I was very impressed with your experimental set-up for the project and the very good link between the experimental setup and the use in models for up scaling via a metamodel. I believe that you are on the right track when trying to investigate the effects of buffer strips for both N and P in situations with relatively flat terrain and without changing the hydrology.
As expressed at the meeting and in the field I have my doubt on especially the scientific part of the project as you will be in a situation at the end where you really regret that you did not have <u>replicates</u> of your controls and experiments at least for some of the sites. If you allow for this to be implemented you <u>will increase the value of your experiments 5-fold</u> for the international scientific community and help yourself in strengthening your modelling efforts at the sites for understanding the processes behind.
You may need also to change and include a bit extra in your monitoring design - surface runoff, sedimentation, biomass, etc. but this is by no means as important and costly as the introduction of replicates (three preferably).
I attach my written review and hope that is useable for your future work in the project.
Best wishes and I am looking forward to hear more on the project in the future.

5.7 Summarized judgement

Criteria	1	2	3	4	5	average	Marks
Part 1: Field experiments						**3.1**	
Contribution to the project objectives						3.25	
…. to supply scientifically based estimates for BSE		2		1	1		3.25
….to provide exp. based est. for 3 soils and 2 crops		2		1	1		3.25
Scientific and technical quality:						3.06	
Theoretical presuppositions, hypothesis			2	2			3.5
Adequacy of chosen approach, lay-out, design		1	1	2			3.25
Observations, indicators, parameters, monitoring			3		1		3.5
Reproducibility, replicates, statistics, bias, representative	1	2	1				2
Other criteria				1			--
Part 2: Model study						**3.3**	
Contribution to the project objectives						3.75	
…to quantify variation due to soil and hydrology			1	2	1		4
value of an instrument for extrapolation			2	2			3.5
Scientific and technical quality:						3.32	
Theoretical presuppositions, hypothesis			1	3			3.25
Adequacy of chosen approach, lay-out, design			1	3	1		3.38
Models review						3.39	
relevance			1	3	1		3.38
scientific basis		1	1		1		3.33
applicability			1	2	1		4
input data soil, hydrology, crops			3	1			3.25
complexity			4				3
alternatives		1	1				--
Part 3: Cost-effectiveness						**3.6**	
Contribution to the research objective						--	
farm model study					2		--
Scientific and technical quality						--	
Adequacy modelling approach and method			1		2		4.33
Chosen alternative measures			1	1			--
Farm models review						3.50	
relevance			1	1	1		4
scientific basis				2			--
applicability			1	2			3.66
input data soil, hydrology, crops		1	1	2			2.83
complexity				1	1		--
alternatives			1				--
Over-all setup of the project						**4**	
Contribution to the research objective			1	1	1		4
Scientific and technical quality			1	1	1		4
Over-all average judgement						**3.5**	

Appendix 1: program of the review meeting

Alterra, Wageningen, 18th of September 2006

9.00 collecting participants at WICC (accommodation)

9.10 welcome at Alterra, lumen 1
acquaintance round

9.30 presentations and discussion (*50/50%)*
- o 9.30 overall setup, including cost-efficiency (Gert-Jan Noij)
- o 10.30 field experiments (Marius Heinen)
- o 11.15 model research (Piet Groenendijk)

12.00 Inventory of remaining discussion items

12.10 Transportation to Zegveld experimental farm

13.00 Lunch at Zegveld

14.00 excursion to the grassland-on-peat-soil location.

15.15 Inventory of additional discussion items

15.30 General discussion

16.30 Transportation to Wageningen

17.45 Arrival at WICC

18.30 Dinner in Wageningen

Appendix 2: presentation over-all study and cost-efficiency

Appendix 3: presentation field study

Appendix 4: presentation modelling study

Appendix 5: field electromagnetic induction and electrical conductivity

Field variability parallel to the ditch can easily be assessed for different depths by electromagnetic induction measurements. It will cost only about half a day per field to measure. It doesn't give a clue about the cause of the variability (moisture content, texture, organic matter and alike) but it will show you where to look. This should be done in the first place to show whether the actual strips are representative for the fields. See following references.

<table>
<tr><td>Dept of Soil Management,
Coupure 653, 9000 Gent,
Belgium

marc.vanmeirvenne@ugent.be</td><td>interested in the following topics:

Mapping of soil pollutants
Digital and traditional soil mapping
Plant nutrition and soil management
Spatio-temporal monitoring of soils
Precision agriculture
Soil information databases
Development of new statistical techniques</td></tr>
<tr><td colspan="2">COCKX L., GHYSELS G., VAN MEIRVENNE M. & HEYSE I., 2006. Prospecting frost-wedge pseudomorphs and their polygonal outline using electromagnetic induction. Permafrost and Periglacial Processes. doi: 10.1002/ppp.546 (upcoming)</td></tr>
<tr><td colspan="2">DOUAIK A., VAN MEIRVENNE M. & TOTH T., 2006. Temporal stability of spatial patterns of soil salinity determined from laboratory and field electrical conductivity. Arid Land Research and Management. 20:1-13.</td></tr>
<tr><td colspan="2">COCKX L., VAN MEIRVENNE M. & HOFMAN G., 2005. Characterization of nitrogen dynamics in a pasture soil by electromagnetic induction. Biology and Fertility of Soil, 42: 24-30.</td></tr>
<tr><td colspan="2">VAN MEIRVENNE M., 2003. Is the soil variability within the small fields of Flanders structured enough to allow precision agriculture? Precision Agriculture, 4: 193-201.</td></tr>
</table>

Appendix 6: list of participants and CV's

Prof. Pascal Boeckx
Laboratory of Applied Physical Chemistry - ISOFYS
Faculty of Bioscience Engineering
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Dr. Martyn Silgram
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Curriculum Vitae Prof. Dr. Ir. Pascal Boeckx

1. Personal information

Nationality:	Belgian	
Address:	Sluiskouter 33	
	9800 Petegem-aan-de-Leie	
Phone:	Private:	+32 9 381 92 67
	Office:	+32 9 264 60 00
Date of birth:	February 1, 1968	
Place of birth:	Turnhout	
Civil status:	not married	

Current position

Docent at Ghent University, Faculty of Biosciences Engineering, Department of Applied Analytical and Physical Chemistry

Coupure 653, B-9000 Gent, Belgium

Tel.:	+32 9 264 60 00
Fax:	+32 9 264 62 30
E-mail:	pascal.boeckx@ugent.be
URL:	http://www.isofys.ugent.be

2. Diplomas

- PhD in Applied Biological Sciences (10/11/1998)
- MSc in Environmental Sanitation (1992)
- Bio-engineer (MSc): Chemistry (1991)

3. Publications

<u>Total</u>: 282 (80 are peer reviewed)

- ISI journals with international peer review: 65
- Non-ISI journals with international peer review: 7
- Chapters in books with international peer review: 8
- Chapters in books: 25
- Proceedings: 25
- Publications in journals without peer review: 10
- Editor of journals: 4
- Abstracts of congress communications: 113
- Reports: 14
- Generalising publications: 12

Science citation index: 344 (June 2006)

4. Scientific activities

- Presentations at international workshops or conferences: 86 (of which 31 were invited contributions)
- Co-organiser of 3 advanced study courses, 2 national workshops, 7 international workshops and 3 international symposia, 1 Benelux meeting
- Scientific missions as project member: 23
- Scientific missions as expert: 18
- (Co-)promoter of research projects: 21
- Promoter of MSc's: 21
- Promoter of PhD's: 5

5. International services

- Expert for the *Intergovernmental Panel on Climate Change* (IPCC), since 1999
- Member of the Editorial Board of *Emission Factor Database of the IPCC*
- Greenhouse gas inventory review expert for the *United Nations Framework Convention on Climate Change* (UNFCCC, Bonn, Germany) and IPCC, since 2001
- Co-chair of workgroup 2 of COST action 627 (2000-2005): *Carbon sequestration in European Grasslands*
- Member of the management committee of COST action 639: *Greenhouse gas budget of soils under changing climate and land use (BurnOut)*
- Frequent reviewer for scientific Journals: *Plant and Soil, Canadian Journal of Soil Science*, *Geoderma*, *Journal of Environmental Quality, European Journal of Soil Science, Global Change Biology Soil* and *Tillage Research*
- Review of project or fellowship proposals for: INTAS (EU), DEFRA (UK) Research Grant Council (Hong Kong), Chambre d'agriculture Bourgogne (France)
- Member of the examination committee of the 15 PhD 's

6. Memberships

- Secretary of BASIS: Benelux Association for Stable Isotope Scientists, since June 13, 2006
- Association member of the European Science Foundation
- Member of the International Union of Soil Sciences
- Member of the executive board of the Belgian Society of Soil Sciences

7. Research interests

- Emission and sorption (e.g. C sequestration) of greenhouse gases (N_2O, CO_2, CH_4) from terrestrial ecosystems
- Stable isotope ecology and biogeochemistry
- Environmental biogeochemistry
- Link between microbial community structure and biogeochemical processes
- Tropical soil fertility

Curriculum Vitae Dr. Jane Hawkins

Date of Birth:	14th March 1961
Nationality:	British
Email:	jane.hawkins@bbsrc.ac.uk

Academic Record:

1998-2005	University of Plymouth Faculty of Science The School of Earth, Ocean and Environmental Science Devon.	Ph.D. Title: 'Amino acids as diagnostics of soil and soil water quality.'
1989-1996	Open University Walton Hall, Milton Keynes, Buckinghamshire.	B.Sc. Hons Psychology (2:1).
1981-1984	Writtle Agricultural College Chelmsford, Essex.	OND Agriculture (credit).

Current Employment:

Mar 1985-present	BBSRC Institute of Grassland and Environmental Research Research Scientist (Band 6 PD). Nutrient Flows and Systems Modelling. North Wyke, Okehampton, Devon, EX20 2SB, UK.

Specific Research Interests:

- ❖ Biofilters for reducing air and water pollution from agriculture.
- ❖ The potential of farm ponds as nutrient traps.
- ❖ Inorganic nitrogen and phosphorus losses from soils.
- ❖ Characterisation of dissolved organic N and C and in soil waters.
- ❖ Agronomic and drainage effects on organic N and C leaching.
- ❖ Factors affecting nitrous oxide/di-nitrogen production and losses from soils.
- ❖ Design and development of a novel laboratory based technique for the measurement of nitrous oxide/di-nitrogen.
- ❖ Design, construction and management of an interactive nutrient management website for farmers.

Publications:

1 **Hawkins, J. M. B.,** Scholefield, D. and Braven, J., (2006). Dissolved free and combined amino acids in surface runoff and drainage waters from drained and undrained grassland under different fertilizer management. Environmental Science and Technology, 40, (16), 4887-4893.

2 Caneiro, J. , Cardenas, L. ,Hatch, D. , Trindad, H. , **Hawkins, J.** , Scholefield, D. , Chadwick, D. (2005) Cattle slurry amended with nitrification inhibitors: effects on nitrous oxide, dinitrogen and methane emissions. IGC Satellite Conference, Dublin, July 2005.

3 Hatch , D., Trindade, H. Cardenas, L., Carneiro, J. **Hawkins, J.** , Scholefield, D. and Chadwick, D. (2005) Laboratory study of the effects of two nitrification inhibitors on greenhouse gas emissions from a slurry-treated arable soil: impact of diurnal temperature cycle. Biology and Fertility of Soils, 41, 225-232.

4 **Hawkins, J. M. B., (2005).** Amino acids as diagnostics of soil and soil water quality. PhD Thesis. The School of Earth, Ocean and Environmental Science, Faculty of Science, University of Plymouth, Devon, UK, 310 pages.

5 Ganzeveld, L. , Li, C. , Cardenas, L. , **Hawkins, J.** , Kirkman, G. (2004) Nitrogen Emissions from Soils. In: Emissions of Atmospheric Trace Compounds. Advances in Global Change Research Volume 18. (Eds. Granier, C., Artaxo, P. Reeves, C. E.). Kluwer Academic Publishers, Dordrecht, Netherlands.

6 **Hawkins, J. M. B.** and Scholefield, D. S. (2004) Scoping the potential of farm ponds to provide environmental benefits. Defra Final Report. 60 pages.

7 Bol, R. , Toyoda, S. , Yamulki, S. , **Hawkins, J. M. B.** , Cardenas, L. M. , Yoshida, N. (2003) Dual isotope and isotopomer ratios of N_2O emitted from a temperate grassland soil after fertiliser application. Rapid Communications in Mass Spectroscopy, 17, (22) 2550-2556.

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9 Cardenas, L.M., **Hawkins, J.M.B.**, Chadwick, D. Scholefield, D. (2003) Use of a 2-pool model to evaluate the effect of fertiliser application on nitrogen emissions from grassland soils, Proceedings of the 12th Nitrogen Workshop, Exeter, September 2003.

10 Cardenas, L. M. , **Hawkins, J. M. B.** , Martinez, J. , Chadwick, D. , Scholefield, D. (2002) Effect of carbon availability on N2 and N2O emissions. Workshop, CEMAGREF, Rennes, France, 10-12 June 2001.

11 Cardenas, L. M. , **Hawkins, J. M. B.** , Chadwick, D. , Scholefield, D. (2002) Study of denitrification in grassland soils in relation to carbon application. BIOGEMON 2002. 4th International Symposium on Ecosystem Behaviour, University of Reading, 17-21 August 2002.

12 Cardenas, L. M. , **Hawkins, J. M. B.** , Chadwick, D. , Scholefield, D. (2003) Biogenic gas emissions from soils measured using a new automated laboratory incubation system. Soil Biology and Biochemistry, 35, (6), 867-870.

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15 **Hawkins, J. M. B.** , Scholefield, D. (1999) Dissolved free amino acids in surface lateral drainage from grazed grassland. Proceedings of the 10th Nitrogen Workshop, Copenhagen, Denmark, 1999.

16 Scholefield, D. , Chadwick, D. R. , **Hawkins, J. M. B**. (1999) Use of a novel incubation technique to measure N_2O/N_2 following surface or injected application of slurry. Grasslands 2000, Proceedings of the XVIII International Grassland Congress, Winnipeg, Manitoba, Saskatoon, Saskatchewan, Canada, 8-17 June, 1997 (Vol 2) (Eds. Buchanan-Smith, J. G. , Bailey, L. D. , and McCaughey, P), Can. Forage Council, Can. Soc. Agron., Can. Soc. Anim Sci.

17 **Hawkins, J. M. B.** , Scholefield, D., and Bol, R. (1998) The potential of amino acid distributions as diagnostics of soil quality. Ecological Aspects of Grassland Management, Proceedings of the 17th General Meeting of the European Grassland Federation, Debrecen Agricultural University, Debrecen, Hungary, 18-21 May, 1998 (Eds. Nagy, G. , Peto, K.,). 555-558 BGS, Reading, UK.

18 Scholefield, D. , **Hawkins, J. M. B.** , Jackson, S. M. (1997) Use of a flowing helium atmosphere incubation technique to measure the effects of denitrification controls applied to intact cores of a clay soil. Soil Biology and Biochemistry, 29, (9-10), 1337-1344.

19 Scholefield, D. , **Hawkins, J. M. B**. , Jackson, S. M. (1997) Development of a helium atmosphere soil incubation technique for direct measurement of nitrous oxide and dinitrogen fluxes during denitrification. Soil Biology and Biochemistry, 29, (9-10), 1345-1352.

20 **Hawkins, J. M. B.** , Scholefield, D. (1997) The extent and pathways of transfer of organic N from fertilised and unfertilised grassland. Proceedings of the 5th British Grassland Society (BGS) Research Conference, Seale Hayne Faculty of Agriculture Food & Land Use, University of Plymouth, Newton Abbot, Devon, 8-10 September, 1997. BGS, Reading.

21 Scholefield, D. , **Hawkins, J. M. B.** (1997) Determination of controls over denitrification using a flowing helium atmosphere system. Gaseous Nitrogen Emissions from Grasslands (Eds. Jarvis, S. C. , Pain, B. F.), 27-36 (Chapter 3), CAB International, Wallingford.
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25 **Hawkins, J. M. B.** , Haygarth, P. M. , Jarvis, S. C. , Scholefield, D. (1996) Long-term study on the transfer of phosphorus from grassland soil to surface waters. Proceedings of Diffuse Pollution and Agriculture (Eds. Petchey, A. M. , D'Arcy, B. J. , Trust, C. A.,). 252-254 Scottish Agricultural College, Nevisprint Ltd.
26 Scholefield, D. , **Hawkins, J. M. B.** , Jackson, S. M. (1994) Use of a `flow-over' incubation technique without acetylene blocking to measure the effect of the factors controlling denitrification in a grassland soil Progress in Nitrogen Cycling, the 8th Nitrogen Cycling Workshop, University of Ghent, Belgium, 5-9 September 1994.
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31 Tyson, K. C. , **Hawkins, J. M. B.** , Stone, A. C. (1993) Final report on the AFRC-ADAS Drainage Experiment 1982-1992. North Wyke Research Station, IGER.
32 Tyson, K. C. , **Hawkins, J. M. B.** , Stone, A. C. (1992) The North Wyke grassland drainage experiment. Grass Farmer, 42, 21-23.
33 Scholefield, D. , **Hawkins, J. M. B.** , Blantern, P. J. (1991) Development of a soil core incubation technique for the measurement of denitrification. 3rd AFRC Meeting on Plant and Soil Nitrogen Metabolism, AFRC IGER, Aberystwyth.
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35 Scholefield, D. , **Hawkins, J. M. B.** , Tyson, K. C. , Elliot, P. (1987) Better estimation of the losses of N through denitrification from pasture grazed beef cattle. Meeting on Plant and Soil Nitrogen Metabolism, Sussex, September 1987, Agricultural and Food Research Council, London.

Curriculum Vitae

Name	***Knud Brian Kronvang***
Profession	Geologist, Hydrologist, Geomorphologist
Date of birth	November 9, 1955
Nationality	Danish
Education	PhD
Position	Senior scientist

Key Qualifications

Research experience in hydrology and delivery, transport and fate of sediment, nutrients and pesticides in watersheds including catchment modelling. Additional experience in ecological effects of river restoration with emphasis on hydrology, geomorphology, sediment and nutrients. Monitoring of freshwater and agriculture within catchments regarding methods, data analysis and reporting. Extensive experience in project planning, implementation and monitoring from more than 50 research, monitoring and feasibility projects conducted since 1986, both in Denmark and for EU-institutions.

3-5 relevant International peer reviewed publications

Laubel, A.R., Kronvang, B., Hald, A.B. & Jensen, C. 2003. Hydromorphological and biological factors influencing sediment and phopshorus loss via bank erosion in small lowland rural streams in Denmark. - Hydrological Processes 17: 3443-3463.

Kronvang, B., Bechmann, M., Pedersen, M.L. & Flynn, N. 2003. Phosphorus dynamics and export in streams draining micro-catchments. Development of empirical models . - Journal of Plant Nutrition and Soil Science 166: 469-474.

Andersen, H.E. & Kronvang, B. 2006: Modifying and evaluating a P index for Denmark. - Water, Air and Soil Pollution 174: 341-353.

Kronvang, B., Laubel, A.R., Larsen, S.E., Andersen, H.E. & Djurhuus, J. 2005: Buffer zones as a sink for sediment and phosphorus between the field and stream. Danish field experiences. - Water Science & Technology 51(3-4): 55-62.

Andersen, H.E., Kronvang, B., Larsen, S.E., Hoffmann, C.C., Jensen, T.S. & Rasmussen, E.K. 2006: Climate-change impacts on hydrology and nutrients in a Danish lowland river basin. - Science of the Total Environment 365: 223-237.

Andersen, H.E., Kronvang, B. & Larsen, S.E. 2005: Development, validation and application of Danish empirical phosphorus models. - Journal of Hydrology 304: 355-365.

Kronvang, B., Bechman, M., Lundekvam, H., Behrendt, H., Rubæk, G.H., Schoumans, O.F., Syversen, N., Andersen, H.E. & Hoffmann, C.C. 2005: Phosphorus Losses from Agricultural Areas in River Basins: Effects and Uncertainties of Targeted Mitigation Measures. - Journal of Environmental Quality 34: 2129-2144.

Kronvang, B., Jeppesen, E., Conley, D.J., Søndergaard, M., Larsen, S.E., Ovesen, N.B. & Carstensen, J. 2005: Nutrient pressures and ecological responses to nutrient loading reductions in Danish streams, lakes and coastal waters. - Journal of Hydrology 304: 274-288

Education

- M.Sc., Department of Earth Science, University of Aarhus, 1985
- Ph.D. Department of Earth Science, University of Aarhus, 1996.

Employment record

1986-88. Researcher at Freshwater Laboratory, Danish Environmental Protection Agency.

1989-95. Researcher at NERI, Dept. of Streams and Riparian Areas.

1995- Senior scientist at NERI, Dept. of Freshwater Ecology.

Number of publications

International scientific publications:	**70**
Ph.D. theses:	**1**
Other scientific publications and reports:	**125**
Popular articles	**28**
Presentations	**81**

Curriculum Vitae Dr. Martyn Silgram

Personal Information

Name	Martyn Silgram
Date of Birth	23 October 1968
Nationality	British
Present Position	Senior Researcher: Soils, Land Use and Water Quality

Key Attributes

- Soil Science; Hydrology; Modelling; Policy advice to government and their agencies
- Primary focus is the impact of land use management on nutrient pollution to water (Defra WQD, MWD, and NRRA)
- Research and/or scientific policy support to DEFRA, Welsh Assembly government, EA, EEA and EC (e.g. Nitrates Directive, Water Framework Directive)

Personal Profile

• Strong scientific background in soil science, hydrology and modelling; experience in data management (QC), analysis of monitoring and modelling data; and strong involvement in policy support work to DEFRA and EC (including NSAs and NVZs)
• Competent scientist with considerable experience managing projects worth £1M for DEFRA, EA, and EC
• Expertise at European level through (i) Concerted Actions (ii) as lead scientific adviser to EC DG Environment on implementation of the Nitrates Directive in Member States (2000-2005); (iii) EEA indicators of sustainability project; (iv) EUROHARP – Framework V project evaluating catchment models for implementing the Water Framework Directive; (v) as official UK delegate (on behalf of DEFRA) on OSPAR committees and working groups (NEUT; HARP-NUT; EUC) focusing on nutrient losses from land to water bodies
• Experience designing, planning and managing field experiments studying soil nutrient cycling (N, P, sediment), including the impacts of land use management on hydrological and biochemical processes (*e.g.* mineralisation) & fluxes in arable, grassland & forest ecosystems.
• Expertise scrutinising the performance of models (supported by process-based experiments) simulating hydrological & biochemical systems & their response to environmental or management change.
• Providing support for users of IRRIGUIDE, our in-house water balance model

Work experience in the Last Five Years

Projects studying nutrient cycling and losses (N, P, sediment) in arable & grassland systems:
• One of five senior staff co-ordinating work under a £3M Nitrate Vulnerable Zone monitoring / modelling project on behalf of DEFRA.
• Lead scientific adviser to EC DG Environment on the implementation of the Nitrates Directive in Member States (2000-2004) (including analysis of Action Programmes, NVZ designations etc.)
• Defra scientific adviser on OSPAR Eutrophication Committee (EUC) 1999-2006; reporting of nutrient pollution from catchments to marine environment (for Defra reporting to OSPAR)
• Lead UK scientist in EUROHARP, a €8M Framework 5 project with 21 partners evaluating catchment models of nutrient pollution for policy support (Water Framework Directive) across 17 European catchments
• Leading DEFRA projects on P mobilisation, transport, loss and mitigation at field and farm scale to support policy tools (e.g. agri-environment schemes) and model development (e.g. PSYCHIC) – including £500K Defra project “Mitigation options for phosphorus and sediment” (2005-2008).
• Lead adviser to the Welsh Assembly government on consultation regarding proposed revisions to the NVZ Action Programme

• Management, analysis, and reporting of Nitrate Sensitive Areas scheme data to DEFRA, in addition to ad hoc advice to aid policy decisions
• Management and delivery of consultancy contracts with DEFRA on “Assessment & modelling of nutrient losses, including development of nutrient loss indicators” and “Specific tasks in support of policy advice”
• BNSC LINK study assessing the potential of Earth Observation data on crop type & fractional ground cover as inputs into catchment modelling of N, sediment & P loss
• Impact of CAP Agenda 2000 proposals on nitrate leaching and economic implications for farmers
• Multi-site study measuring & modelling losses of nitrate from heavier-textured soils
• Comprehensive study examining the mobilisation & retention of P at field & catchment scale via measurements & modelling
• Large-scale study on seasonal soil mineral nitrogen supply & soluble organic N at 30 sites over a range of crop / soil / management scenarios (to help guide fertiliser advice)
• Multi-site experiment quantifying the mineralisation of cover crop residues & impacts on N supply to succeeding crops & nitrate leaching
• Published reviews on the mineralisation of cover crop residues & the effects of cultivation on soil physical, hydrological and biochemical processes and fertiliser recommendations
• Large multi-site experiment examining the impact of straw incorporation on soil nitrogen supply, soil fertility and nitrate leaching.
• Establishing modelling relationships between soil organic matter levels, land management and nutrient supply in a study on crop nutrient management.

Education and Qualifications

1988-92 BSc (Hons) Soil Science (Soils & the Environment), Reading University
Dissertation on the biochemistry of heavy metal mobilisation and plant uptake from sewage sludgeapplied to arable farmland

1992-95 PhD “Hydrological & biochemical controls on nitrate leaching in a forested hillslope: an integrated field & modelling study”
Imperial College (London) / Institute of Terrestrial Ecology (Bangor)

Membership of Professional Bodies

British Society of Soil Science (1992)
British Hydrological Society (1992)
Member of the Institute of Professional Soil Scientists (M.I.Soil Sci.) (1997)
Chartered Scientist (C.Sci.) (2005)

Other Skills and Courses Attended

• Project Management skills: accredited PRINCE 2 Practitioner (2005)
• Effective communicator, with demonstrable experience in project management, experimental design, dataanalysis, model testing and evaluation, reporting and literature reviews, and presenting research results to awider audience (via conference/journal papers, lectures & the farming press)
• Strong team-working skills gained via experience at CEH, ADAS Boxworth and ADAS Wolverhampton as part of multi-disciplinary research teams

Languages

English Fluent , French Basic

Employment History

Date: 04/1998 -
Details: Senior Researcher: soils, land use and water quality
- ADAS Environment Systems, Wolverhampton
Date: 01/1996 - 03/1998
Details: Soil Science Research Consultant

- ADAS Boxworth, Cambridge
Date: 12/1995 - 01/1996
Details: Scientific Officer: application/evaluation of SOIL/SOILN models for estimating nitrate leaching fluxes
- Institute of Terrestrial Ecology (now Centre for Ecology and Hydrology), Bangor

Overseas Experience

Date: 01/2002 – 03/2006
Details: Work Package 4 (nitrogen) leader, EUROHARP EU Framework V project – Project meetings with European partners from 17 countries and associated catchment visits (Norway, Italy etc).
Date: 10/1990 – 09/1991
Details: Research Officer: 35S cycling in arable systems and the organic fractionation of S compounds
- Lincoln University, New Zealand

Publications

Silgram, M., Wheater, H.S., Reynolds, B. & Beck, M.B. 1995. Hydrological controls on nitrate leaching in a forested hillslope. *Proceedings of the British Hydrological Society 5th National Symposium, Edinburgh, September 1995*. British Hydrological Society/Institute of Hydrology: 9.19-9.23.

Emmett, B., Liversage, C., Silgram, M., Kennedy, V., Sleep, D., Brittain, A., Hughes, S., Norris, D. & Reynolds, B. 1996. *Annual Report for the Aber Nitrogen Manipulation Experiment 1995/6*. Project T07072a5 National Power/ PowerGen Joint Environment Programme/NERC contract LC/5/0004. Institute of Terrestrial Ecology, Bangor, Wales.

Harrison, R., Bennett, G., Wiltshire, J.J.J. & Silgram, M. 1996. Mineralisation and uptake of nitrogen from cover crop residues. *Transactions of the 9th Nitrogen Workshop, Braunsweig, Germany,* pp 235-238.

Williams, J.R., Harrison, R., Silgram, M. & Chambers, B.J. 1996. Soil nitrogen supply in arable cropping rotations. *Aspects of Applied Biology* **47,** 59-66.

Silgram, M. & Chambers, B. 1997. Seasonal soil mineral nitrogen survey. In *ADAS Research Review 1996/7:* 13-14.

Emmett, B.A., Reynolds, B., Silgram, M., Sparks, T.H. & Woods, C. 1998. The consequences of chronic nitrogen additions on N cycling and soilwater chemistry in a Sitka spruce stand, N.Wales. *Forest Ecology & Management* **101** (1-3), 165-175.

Waring, R., Silgram, M. & Lord, E. 1998. Modelling phosphorus export potential for the Nene and Welland catchments. Report to Environment Agency/English Nature/Anglian Water Group.

Silgram, M. & Shepherd, M. 1999. The effects of cultivation on soil nitrogen mineralisation. *Advances in Agronomy* **65**, 267-311.

Silgram, M. & Lord. E.I. 1999. Large-scale control of nutrient loss: The UK Nitrate Sensitive Areas scheme and HARP-NUT Initiative. *Proceedings of the Warwick Conference: Agriculture & the Environment – Challenges and Conflicts for the new Millenium*. ISBN 1 899263 03 9, pp 101-107.

Hutchins, M., Silgram, M., Davenport, I., Settle, J., Robinson, S., Simmonds, L. & Veck, N. 2000. The role of earth observation techniques in improving field-scale predictions of runoff, erosion and pollutant fluxes Aspects of Applied Biology **60**, 219-224.

Silgram, M. 2000. National estimates of indirect losses of nitrous oxide from agriculture. *ADAS Research Review* 1998/9, pp 28-29.

SFT, 2000. Development of HARP guidelines: HArmonised quantification and Reporting Procedures for nutrients. Norwegian Pollution Control Authority, Oslo. pp 179. ISBN 82-7655-401-6.

Silgram, M., Hutchins, M., Robinson, S., Settle, J., Simmonds, L.P. & Veck, N. 2001. Using earth observation techniques for constraining uncertainty in sediment loss predictions. *Remote Sensing and Hydrology 2000 (Eds. M. Owe, K. Brubaker, J. Ritchie & A. Rango).* Publ. no. 267 (August 2001) IAHS Publication **267**, 501-503.

Silgram, M., Waring, R., Anthony, S. & Webb, J. 2001. Intercomparison of national and IPCC methods for estimating N loss from agricultural land. *Nutrient Cycling in Agroecosystems* **60 (1-3)**, 189-195.

Silgram, M., Hutchins, M., Hodgkinson, R. and Lord, E.I. 2001. *Processes and pathways influencing phosphorus retention within a farm catchment*. In Connecting phosphorus transfer from agriculture to impacts in surface waters. Proceedings of the International Phosphorus Transfer Conference, Plymouth, September 2001. p 85.

Dampney, P.M.R., Slater, J.A. and Silgram, M. 2002. Farmcrop and agri-environment end-user requirements for remote sensing. Proceedings of the 3rd international symposium “Retrieval of bio-and gophysical parameters from SAR data for land appliucations”, Sheffield, UK, 11-14 September 2001 (ESA SP-475, January 2002),

Hutchins, M.G., Price, L.E., Anthony, S.G., Silgram, M. and Shepherd, M. 2002. Development of national scale modelling of diffuse nutrient losses for policy support. Science for Water Policy (SWAP) – Implications for the Water Framework Directive (Eds. L. Ledoux and D. Burgess), pp 70-72.

Silgram, M., Borgvang, S., Bouraoui, F., Krongvang, B., Schoumans, O., Svenson, L. and Vagstad, N. 2002. EUROHARP: Evaluating methods for quantifying agricultural losses to water bodies. Science for Water Policy (SWAP) – Implications for the Water Framework Directive (Eds. L. Ledoux and D. Burgess), pp 113-147.

Silgram, M. & Chambers, B.J. 2002. The effects of repeated straw incorporation on soil mineral nitrogen supply, fertiliser N requirements and nitrate leaching losses. *Journal of Agricultural Science (Cambridge)* **139 (2)**, 115-127.

Davenport, I.J., Silgram, M., Robinson, J.S., Lamb, A., Settle, J.J. and Willig, A. 2003. "The use of earth observation techniques to improve catchment-scale pollution predictions". *Physics and Chemistry of the Earth* **28**, 1365-1376.

Williams, A., Barker, J., Silgram, M., Mansour, M., Neumann, I., Hughes, A. 2003. The use of flow modelling to assess the impact of agricultural control measures on abstracted groundwater quality. MODFLOW and more 2003: Understanding through modelling – Conference proceedings (Ed. Poeter, E. Zheng, C. & Hill, M. & Doherty, J.) International Groundwater Modelling Centre, Colorado. pp 446-450.

Schoumans, O. & Silgram, M. (Eds.) 2003. Review and literature evaluation of quantification tools for the assessment of nutrient losses at catchment scale. EUROHARP report 1-2003. ISBN 82-557-4411-5. NIVA report SNO 4739-2003, Oslo, Norway, 120 pp.

Davenport, I.J., Settle, J.J., Silgram, M., Robinson, J.S. and Lamb, A. 2004. (Derivation of Vegetation and Soil Endmembers, and Vegetation Fraction From Multispectral Imagery. *Remote Sensing of the Environment* (in press)

Silgram, M. & Schoumans, O. 2004. Modelling approaches: model parameterisation, calibration and performance assessment methods in the EUROHARP project. EUROHARP report 8-2004. ISBN 82-577-4491-3. NIVA report SNO 4740-2003, Oslo, Norway. 18pp.

Silgram, M., Williams, A., Waring, R., Neumann, I., Hughes, A. and Mansour, M. 2004. Effectiveness of the Nitrate Sensitive Areas Scheme in reducing groundwater concentrations. *Quarterly Journal of Environmental Geology and Hydrogeology* **38,** 117-127.

Schoumans, O.F., Silgram, M., Walvoort, D.J.J., Groenendijk, P., Bouraoui, F., Andersen, H.E., Lo Porto, A., Reisser, H., Le Gall, G., Anthony, S.G., Arheimer, B., Johnsson, H., Panagopoulos, Y., Mimikou, M., Zweynert, U., Behrendt, H. and Borgvang, S. 2006. Evaluation of the performance of nine quantification tools to assess diffuse annual nutrient losses from agricultural land. Hydrology and Earth Systems Sciences (in press).

Anthony, S.G., Silgram, M., Collins, A.L., Strőmqvist, J., Bouraoui, F., Schoumans, O., Lo Porto, A., Groenendijk, P., Arheimer, B., Mimikou, M. and Johnsson, H. 2006. Evaluation of diffuse pollution model applications in EUROHARP catchments with limited data. Hydrology and Earth Systems Sciences (in press).

Schoumans, O.F., Silgram, M., Groenendijk, P., Bouraoui, F., Andersen, H.E., Krongvang, B., Behrendt, H., Arheimer, B., Johnsson, H., Panagopoulos, Y., Mimikou, M., Lo Porto, A., Reisser, H., Le Gall, G and Anthony, S.G. 2006. Description of nine nutrient loss quantification tools: capabilities and suitability based on their characteristics. Hydrology and Earth Systems Sciences (in press).

Silgram, M., Schoumans, O., Walvoort, D., Anthony, S.G., Gronondijk, P., Stromqvist, J., Bouraoui, F., Arheimer, B., Kapetanaki, M., Lo Porto, A. and Mårtensson, K. 2006. Subannual models for catchment management: evaluating model performance on three test catchments. Hydrology and Earth Systems Sciences (in press).

Silgram, M., Davison, P. and Gooday, R. 2006. Nitrates Directive implementation: a case study of England and Wales. Nitrogen load in agro-ecosystems and its outflow to water bodies: analyses with monitoring and modelling. 3rd International workshop of the Japan-Korea Research Cooperation, Tsukuba, Japan, 15 March 2006. pp45-50