Stakeholder co-production of models in catchment management for water quality

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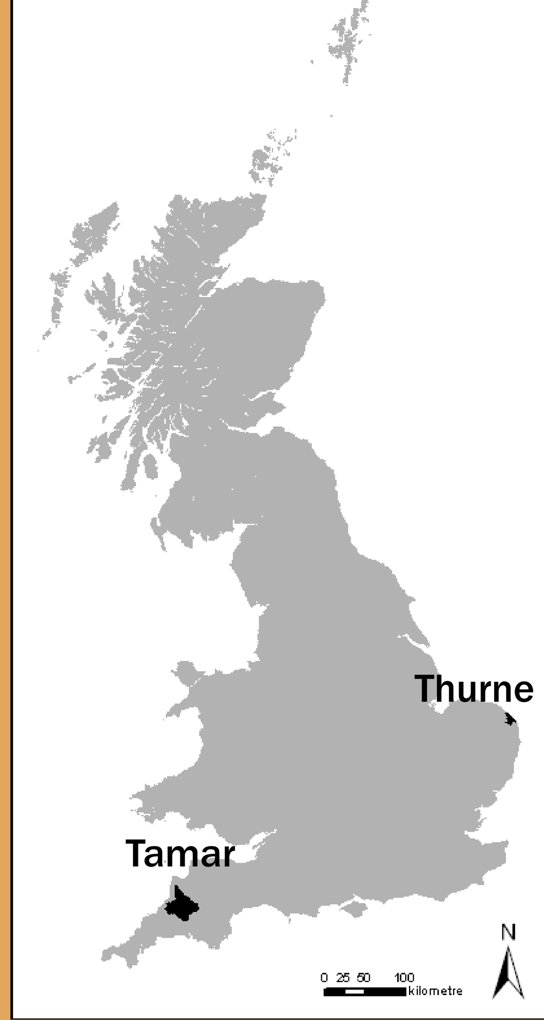
Rationale

- "Good" water quality may be delivered by a mix of regulations, incentives and voluntary actions. Hence successful catchment management requires strong partnerships and stakeholder engagement.
- Due to the complexity of catchments we also need models to help us characterise them, set water quality goals and identify the best mix of actions.
- Because decisions are then (partly) based on models, all involved must accept the model results if catchment management is to work effectively.
- One possible way of achieving model acceptance is stakeholder co-production of models which can take various forms.
- Here, against the background of catchment management for water quality in the UK, we report two case studies of taking stakeholders through the three main stages of model development (**perceptual**, **formal** and **procedural** modelling) at varying levels of depth.

Case studies



Wider project timeline & overall analytic-deliberative approach

Meeting with farmers, Feb 2010: land use data ground-truthing

3rd Thurne workshop, Dec 2009: testing model & interface, ground-truthing

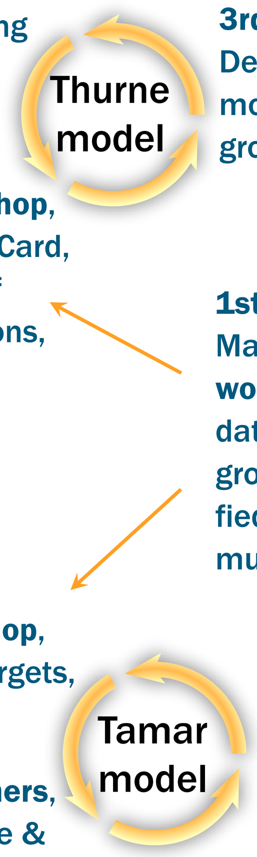
2nd Thurne workshop, Nov 2008: Report Card, graphical model of problems & solutions, WFD targets

1st Thurne workshop, May 2008 & **1st Tamar workshop**, Jun 2008: data presentation & ground-truthing, identified need for good communication tools

2nd Tamar workshop, Nov 2008: WFD targets, sceptical of model

Meeting with farmers, Mar 2010: land use & management data ground-truthing, testing model

3rd Tamar workshop, Apr 2010: testing model & interface, ground-truthing, scenarios

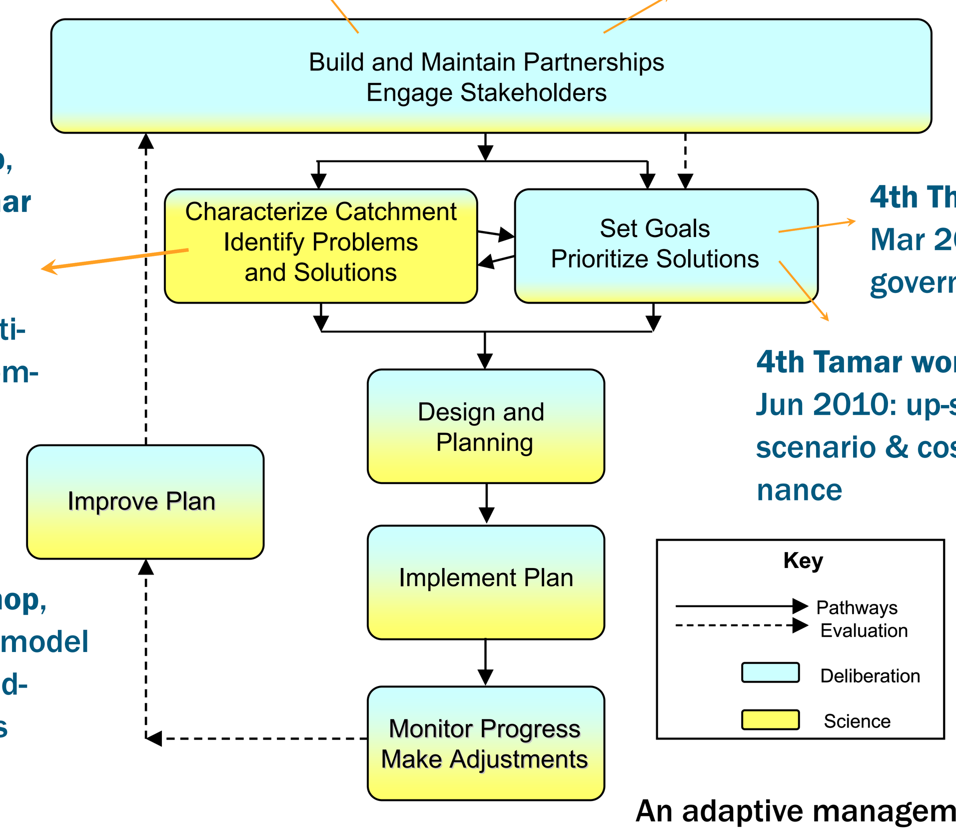


1st Thurne workshop, May 2008 & **1st Tamar workshop**, Jun 2008: problem framing, identified key issues

Interested citizens, conservation groups, farmers, tourism industry, water companies, local to national government, environment agencies, ...

4th Thurne workshop, Mar 2010: scenarios, governance

4th Tamar workshop, Jun 2010: up-scaling of scenario & cost, governance



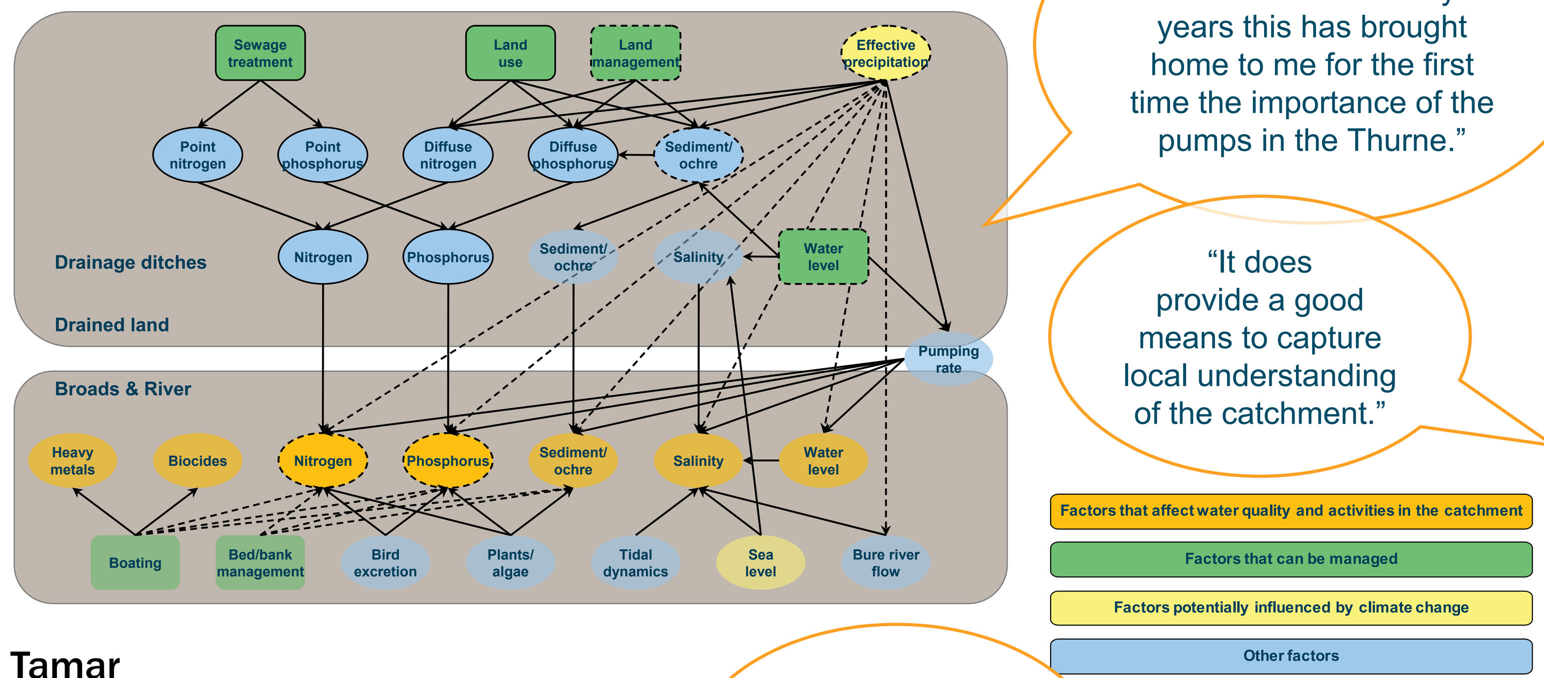
An adaptive management cycle
http://www.watergov.org/documents/Catchment_Template%204%20page.pdf

Conclusions

- This type of modelling provided a platform for stakeholders to collaboratively frame the scale and severity of the water quality problems, and develop a collective understanding of uncertainty.
- The stakeholders had the opportunity to model potential solutions to the problems in real time, stimulating highly dynamic and engaged discussion.
- The modelling also allowed an appreciation of trade-offs to be developed. The provision of indicative scenario costs provided all important economic reality to the debate.
- The model became an explicit vehicle for stakeholders to incorporate their knowledge within the problem solving process, thereby stimulating ownership and trust in the outcomes.
- There remain, however, issues of confidentiality which point to an "honest broker" to govern the model that is collectively produced.
- Finally, modelling will only add value to catchment management if it is adapted and refined as additional data become available and scientific theory advances. Ways must be found to make this as inexpensive as possible.

(1) Perceptual modelling stage

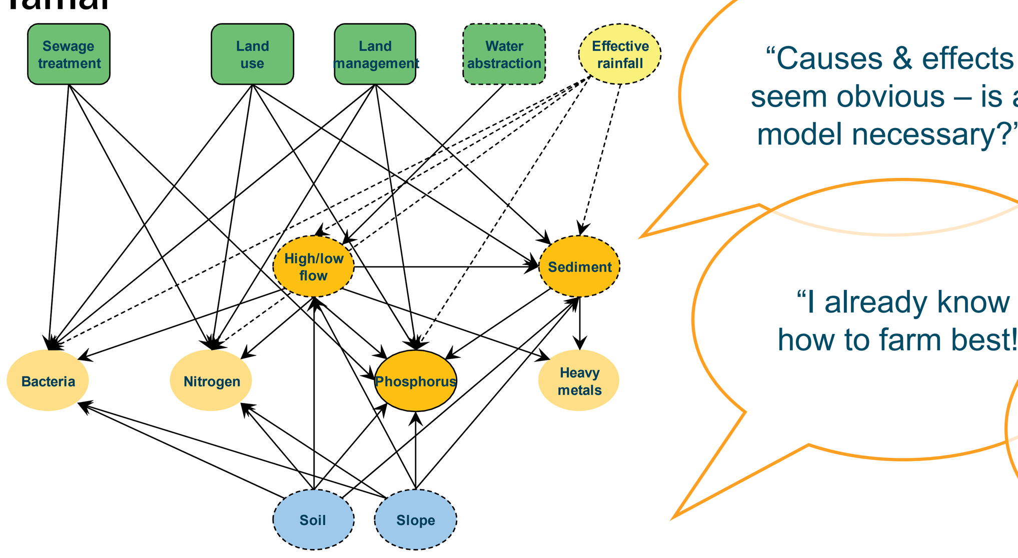
Thurne



"After living and farming in the area for so many years this has brought home to me for the first time the importance of the pumps in the Thurne."

"It does provide a good means to capture local understanding of the catchment."

Tamar



"Causes & effects seem obvious – is a model necessary?"

"I don't want a model so detailed that people can point at me as the source of pollution!"

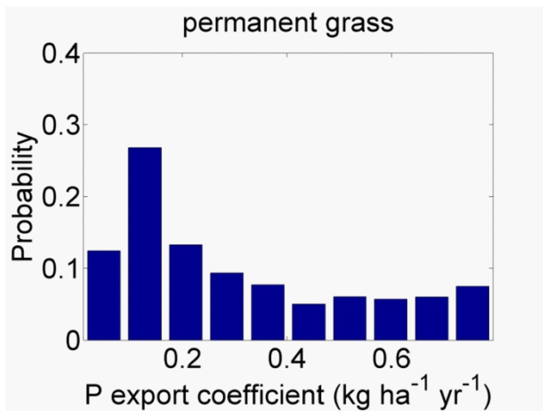
"I already know how to farm best!"

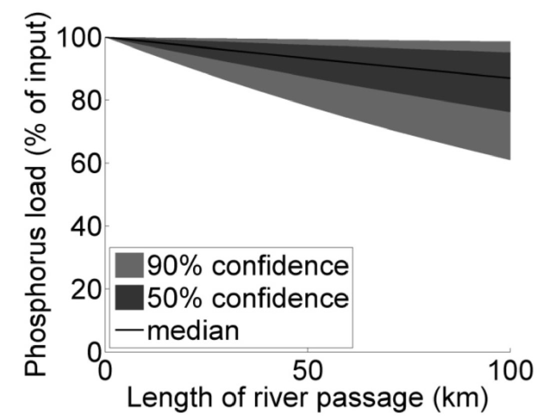
"Resources should be spent on action – not modelling!"

- In both cases it was eventually agreed that models can lend scientific credibility to catchment management and serve as a basis for scenarios and cost-benefit analysis. In the Tamar initial mistrust was overcome through a lot of post-workshop stakeholder engagement and the farmer workshop which gave opportunity to scrutinise the model.
- Stakeholders advised that the model must not neglect the effects of sewage treatment works, septic tanks, soils, land management and roads.
- This created new challenges as the understanding of some of these processes is incomplete and data are limited – the stakeholders drove the agenda at this point.

(2) Formal modelling stage

- Probabilistic treatment of Export Coefficients model (Johnes, 1996), extended by farming practices, and SPARROW model (Smith *et al.*, 1997).
- Farmers appreciated the concept of probability and explained it to others in non-scientific terms – collective learning.



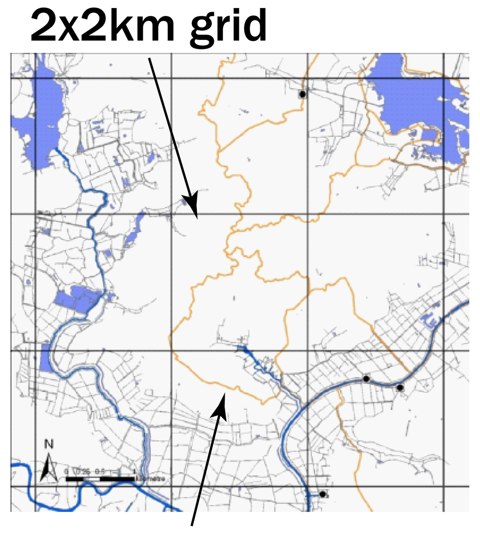


- As there are no data on the uptake and effectiveness of farming practices at the catchment scale we are in the process of eliciting this information from experts, both local and scientific.
- We also let farmers determine the list of practices included in the model according to what made sense to their farm business – this fostered their ownership of the process.

	Local expert opinion	Scientific expert opinion	
	Current uptake (%)	P export reduction (% range)	
Cultivate compacted tillage soils	30	25	35
Do not leave autumn seedbeds too fine	10	25	35
Avoid tramlines over winter	10	25	35
Loosen compacted soil layers in grassland fields	3	50	70
Build new livestock access tracks	30	10	10
Reduce field stocking rates when soils are wet	90	10	10
Integrate bag fertiliser and manure nutrient supply	90	4	4
Do not apply fertiliser, slurry & manure to high-risk areas	90	27	40
Avoid spreading fertiliser, slurry & manure at high-risk times	90	15	50
Increase the capacity of farm manure (slurry) stores	10	25	25
Minimise the volume of dirty water produced	30	5	5
Site solid manure heaps away from watercourses and field drains	90	4	4

- National datasets such as the Agricultural census were too coarse for catchment-scale modelling – local knowledge was esential.

Agcensus 2x2km grid

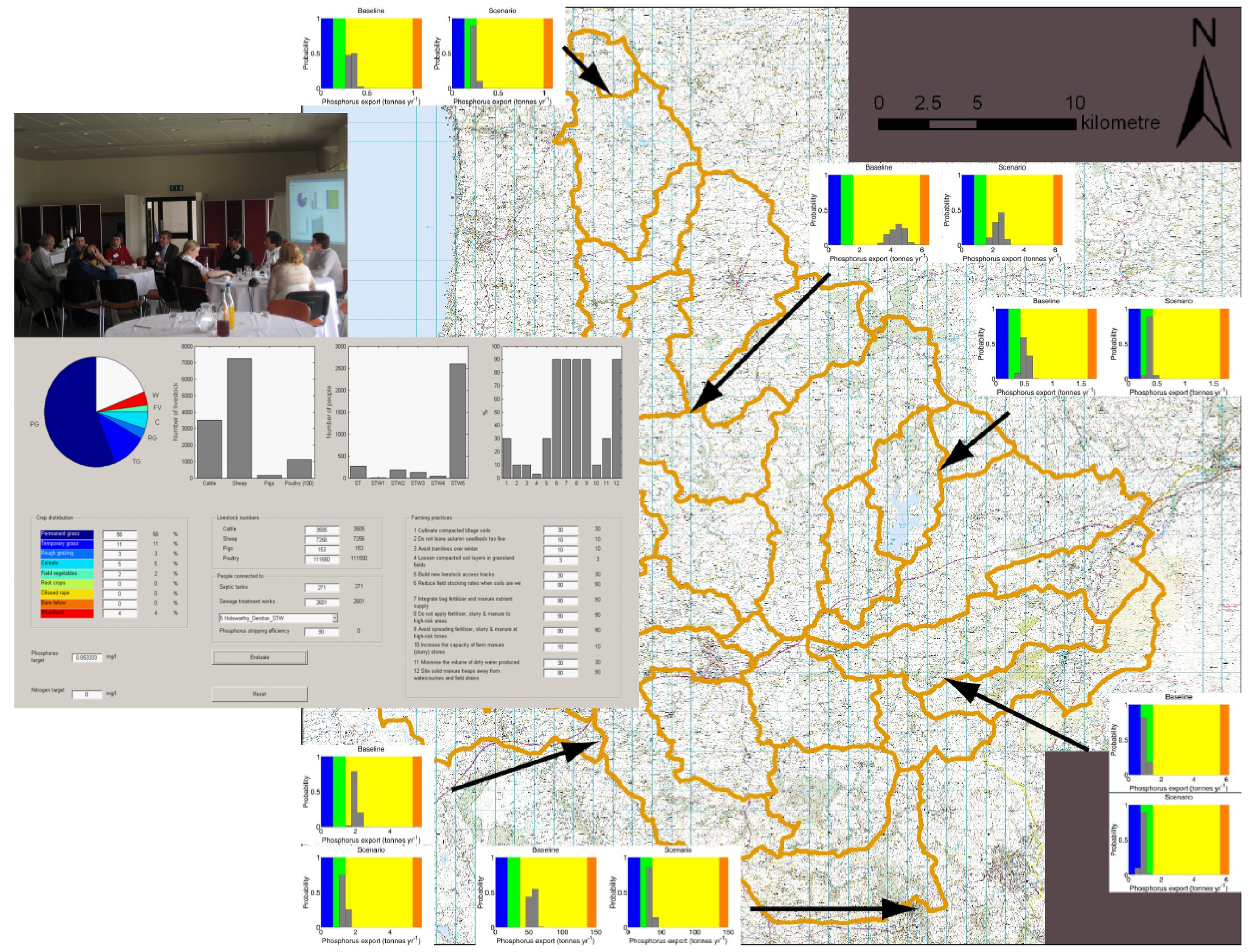


Sub-catchment area

	Agricultural census 2004	Local farmers
Permanent grass (ha)	19	19
Temporary grass (ha)	3	3
Rough grazing (ha)	3	3
Cereals (ha)	33	33
Root crops (ha)	16	16
Field vegetables (ha)	3	3
Oilseed rape (ha)	0	0
Woodland (ha)	2	2
Bare fallow (ha)	0	0
Cattle	**158**	**300**
Pigs	**110**	**0**
Sheep & goats	**97**	**10**
Poultry	**35121**	**0**

References: Johnes (1996). Evaluation and management of the impact of land use change on the nitrogen and phosphorus load delivered to surface waters: The export coefficient modelling approach. *Journal of Hydrology* 183(3-4): 323-349. • **Smith, Schwarz & Alexander (1997)**. Regional interpretation of water-quality monitoring data. *Water Resources Research* 33(12): 2781-2798.

(3) Procedural modelling stage & scenario development



Proposed management plan costs for the upper Tamar

Sewage treatment works	Capital cost (£)	Annual cost (£)
P stripping for 1 mg P l^{-1} discharge; 90% stripping for 6 STWs serving >500 people	**18,000,000**	**462,000**
Cost per head (6 STWs, incl. tourists)	814	21
Cost per head (upper Tamar, incl. tourists)	623	16
Cost per head (South West Water customers, 1.6m	11	0.30
Domestic septic tanks	**Capital cost (£)**	**Annual cost (£)**
5% of septic tanks (277) replaced by contained cesspools and emptied to STWs (P stripped)	**1,360,000**	**1,065,000**
Cost per household (3 people on average)	4,900	3,840
Replacement by packaged STW	**2,410,000**	**86,000**
Cost per household	8,700	310
Farm management practices (BMPs) (increase in adoption) (per ha/farm cost)	**Capital cost (£)**	**Annual cost (£)**
Cultivate compacted tillage soils (30% to 80%) (£20 per ha, 20% arable)		16,500
Do not leave autumn seedbed too fine (10% to 80%) (£40 per ha, 20% arable)		46,000
Avoid tramlines over winter (10% to 80%) (£22.50 per ha, 20% cereals)		22,000
Loosen compacted soil layers in grassland fields (3% to 80%) (£43 per ha, 25% grass)		535,000
Build new livestock access tracks (30% to 80%) (£5,000 per dairy farm)	710,000	
Increase the capacity of farm manure (slurry) stores (10% to 90%) (£21,260 per dairy farm)	5,545,000	
Minimise the volume of dirty water produced (30% to 100%) (£15,250 per dairy farm)	3,160,000	
Farm BMPs sub-total	**9,415,000**	**619,500**
Plan total	**28,775,000**	**2,146,500**