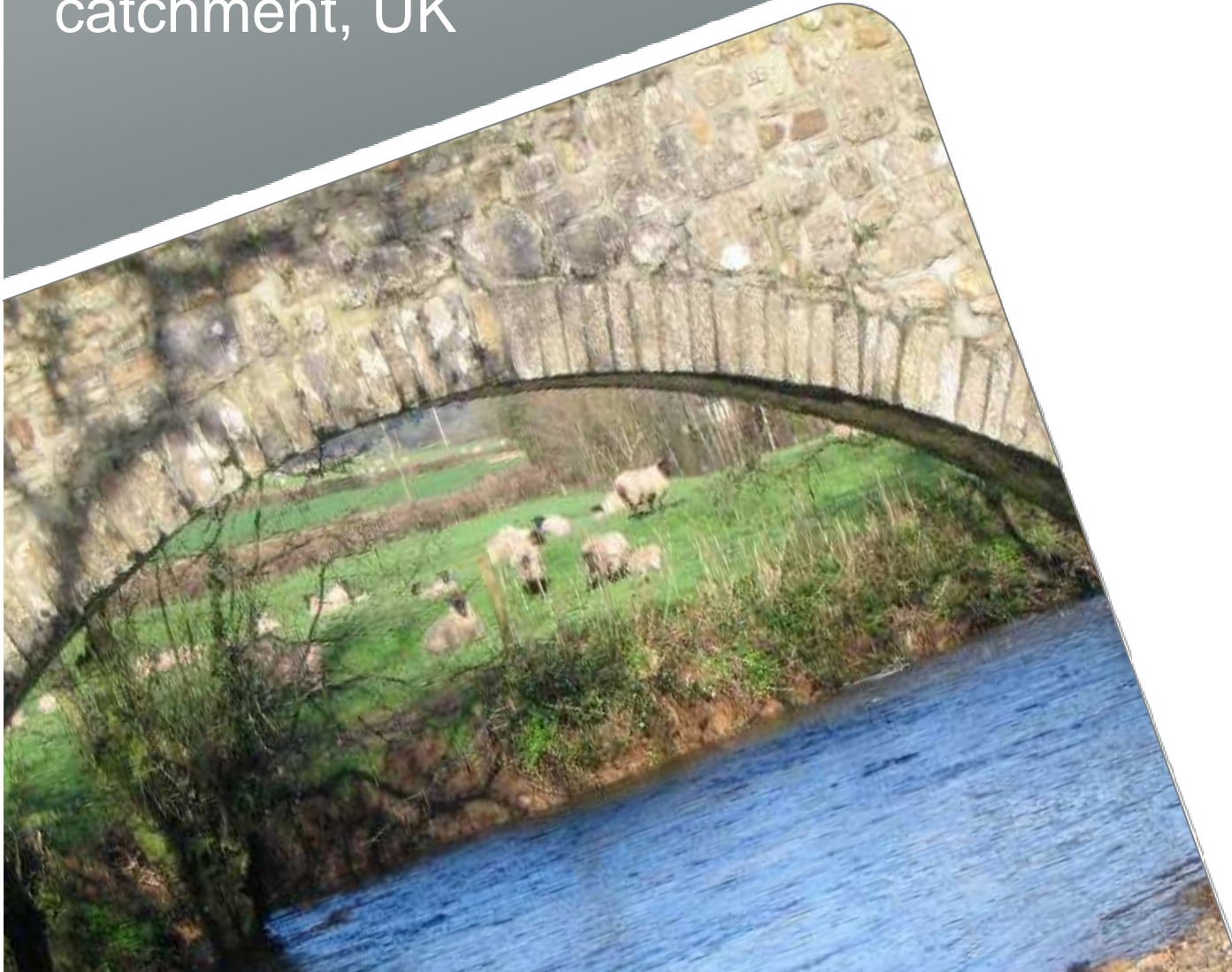


Using SWAT to assess  
nutrient reduction  
measures in the Axe  
catchment, UK

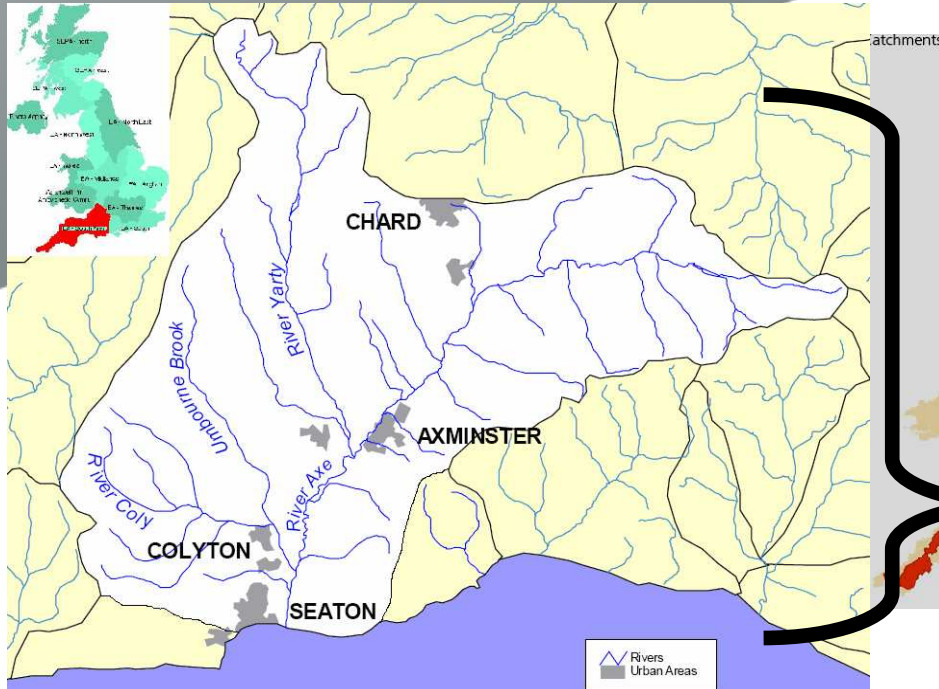
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UNIVERSITY



**Matjaž Glavan  
and  
Sue White**

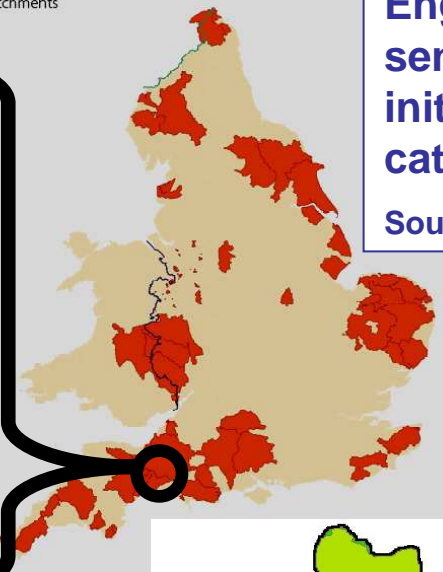
[www.cranfield.ac.uk](http://www.cranfield.ac.uk)

# The Axe catchment



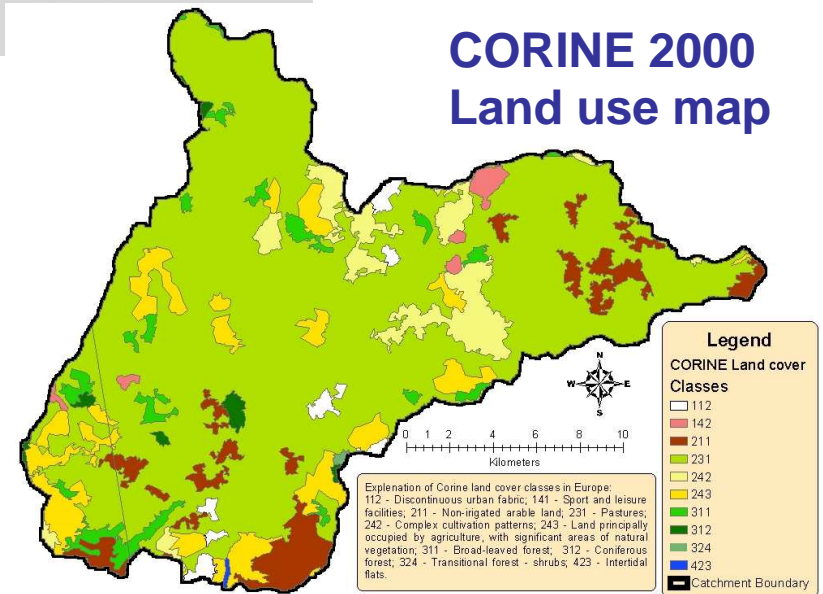
English catchment  
sensitive farming delivery  
initiative priority  
catchments

Source: DEFRA, 2006



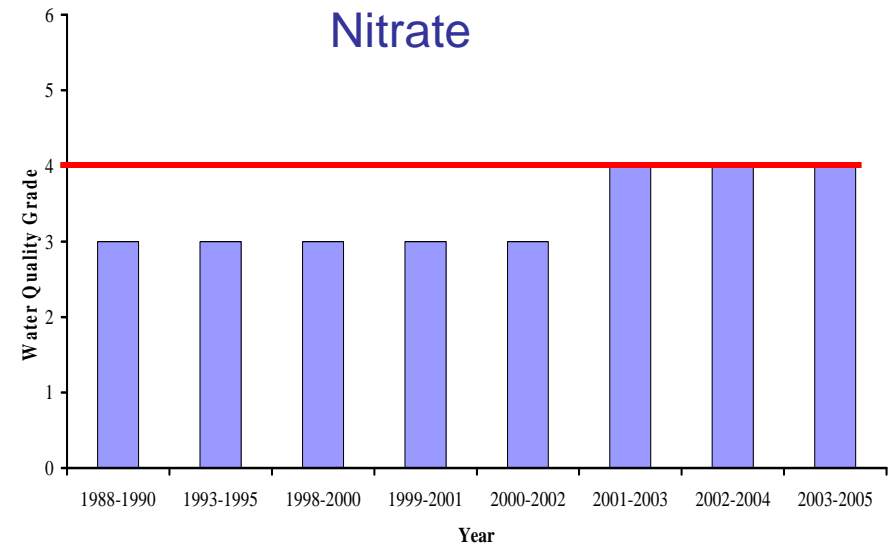
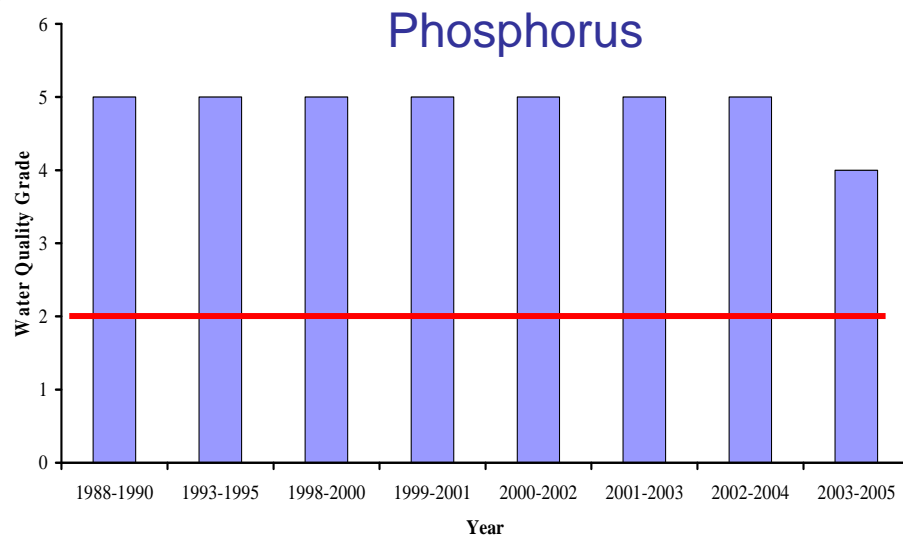
- Area: 400 km<sup>2</sup>
- Altitude: 0 – 316 m above sea level
- Average Rainfall: 1063 mm/year
- Land use:
  - 73% grassland,
  - 21% arable,
  - 4% forest,
  - 2% urban, water, etc.

CORINE 2000  
Land use map



# The problem

## Water quality grade at the River Axe tidal limit (Axe Bridge).



**Target quality: below 0.06 mg/l or grade 2 – Low (Environment Agency, 2005)**

**Target quality: below 30 mg/l or grade 4 - High (Environment Agency, 2005)**

**Water quality grade range:**

**1 – Very low, 2 – Low, 3 – Moderately low, 4 – Moderate, 5 – High, 6 – Very high.**

# Data available for AVSWAT 2005

- available maps/spatial data

digital elevation model – topography (DEM 50×50), land use map (CORINE 2000), soil type map-soil properties (NATMAP)

- temporal data

weather data - daily precipitation, temperatures, relative humidity, solar radiation, wind speed; water abstractions and discharges; cropping regime – tillage and crop rotation schemes, fertilizer and manure application, stocking numbers and densities

- calibration/validation data

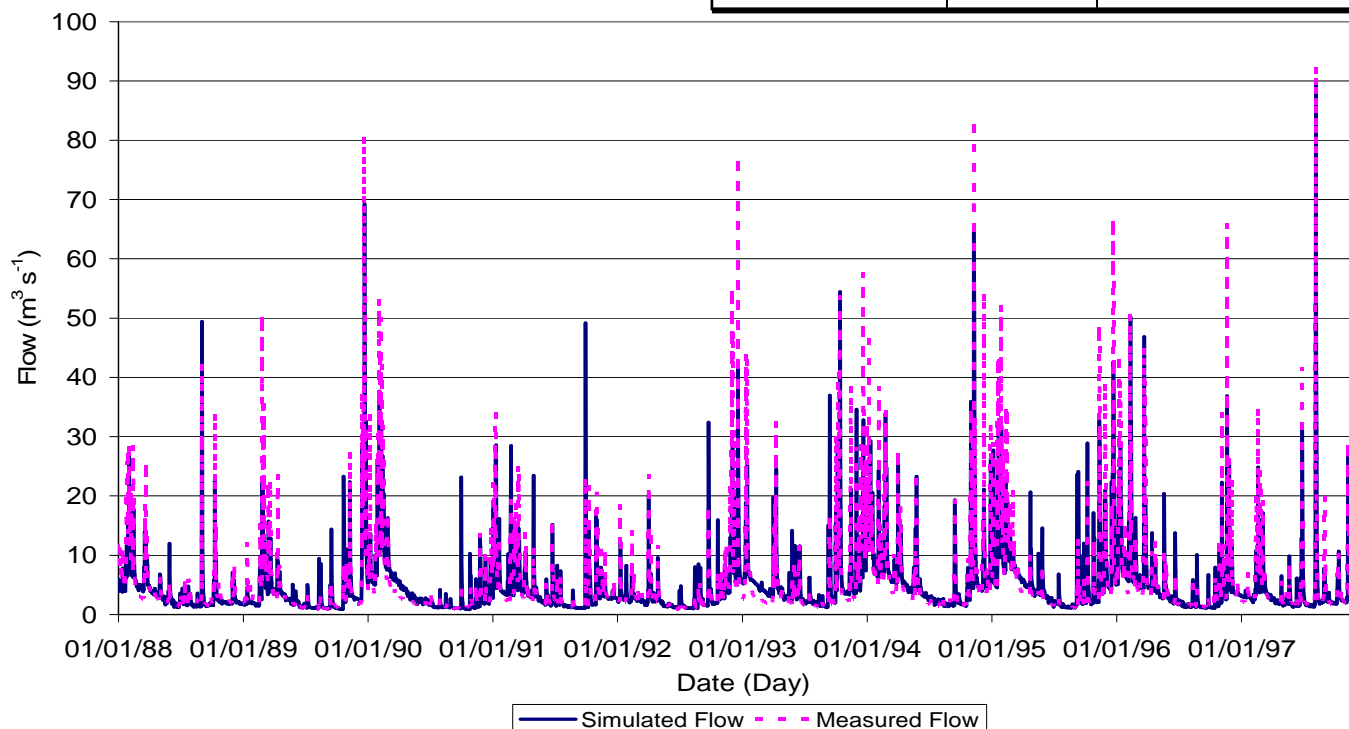
river flow; water quality - nitrate, ortho-phosphorus



# Calibration – River flow

Daily time step stream flow model performance statistics for the Whitford gauging station (1988 – 1997).

Statistical test	Units	Optimal values	Base flow	Total flow
$R^2$	-	1	0.79	0.62
$E_{NS}$	-	1	0.75	0.62
RMSE	-	0 (lower value - a better model performance)	1.34	4.68
PBIAS	%	0 (+ values = underestimate; - values overestimate)	-20.31	6.58



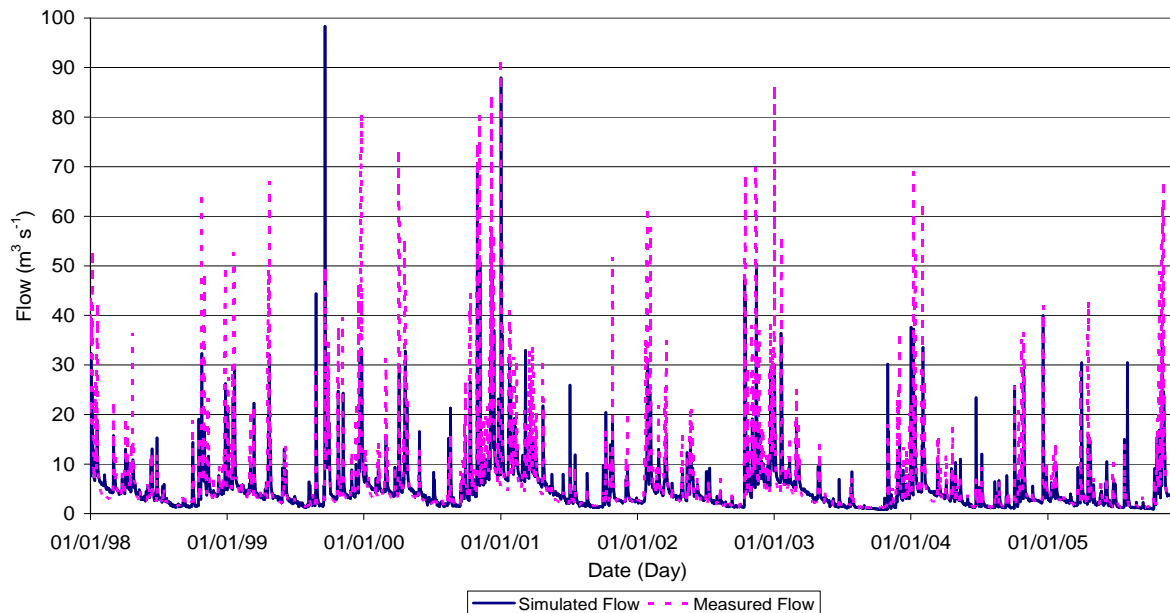
Comparison between simulated and measured flow values ( $m^3/s$ ) at Whitford (1988-1997).

# Validation – River flow

Daily time step stream flow model performance statistics for the Whitford gauging station (1998 – 2005).

Statistical test	Units	Optimal values	Base flow	Total flow
$R^2$	-	1	0.75	0.53
$E_{NS}$	-	1	0.74	0.47
RMSE	-	0 (lower value - a better model performance)	1.36	7.24
PBIAS	%	0 (+ values = underestimate; - values overestimate)	3.88	15.11

If the variance for flow stayed in the same range the  $E_{NS}$  would be 0.53 (satisfactory performance statistic for  $E_{NS}$ ).

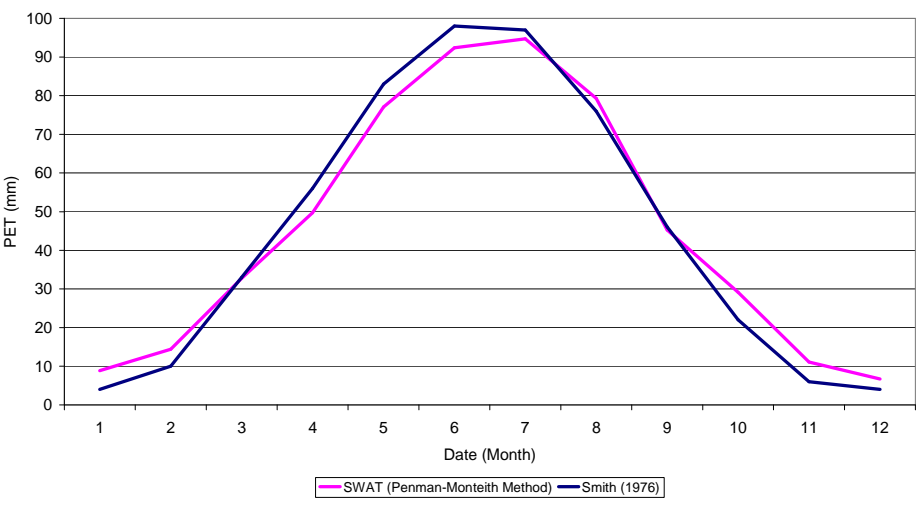
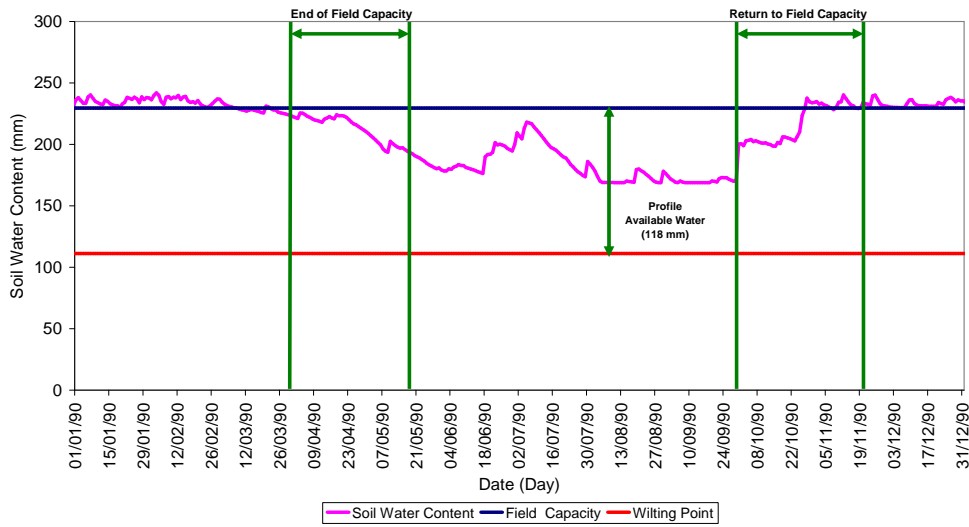


Comparison between simulated and measured daily flow values ( $m^3 s^{-1}$ ) for the Whitford gauging station (1998 – 2005).

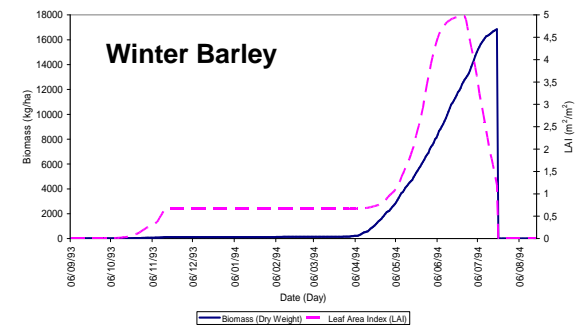
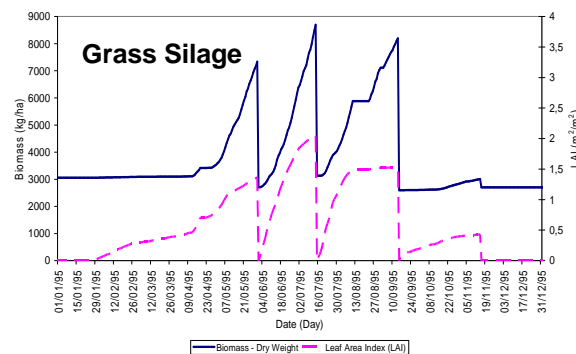
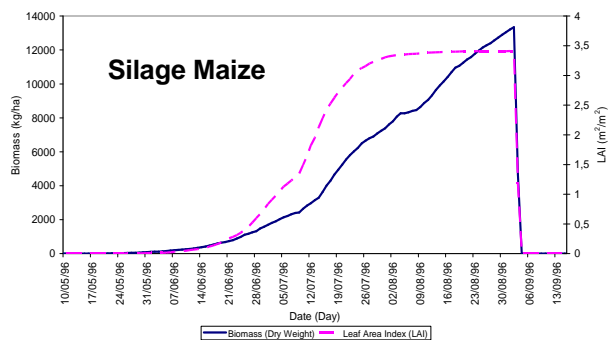
# Calibration – model performance

**SOIL WATER CONTENT**  
for the HRU 57 (Whimble 3, 3-cut silage grass)  
during calibration year 1990.

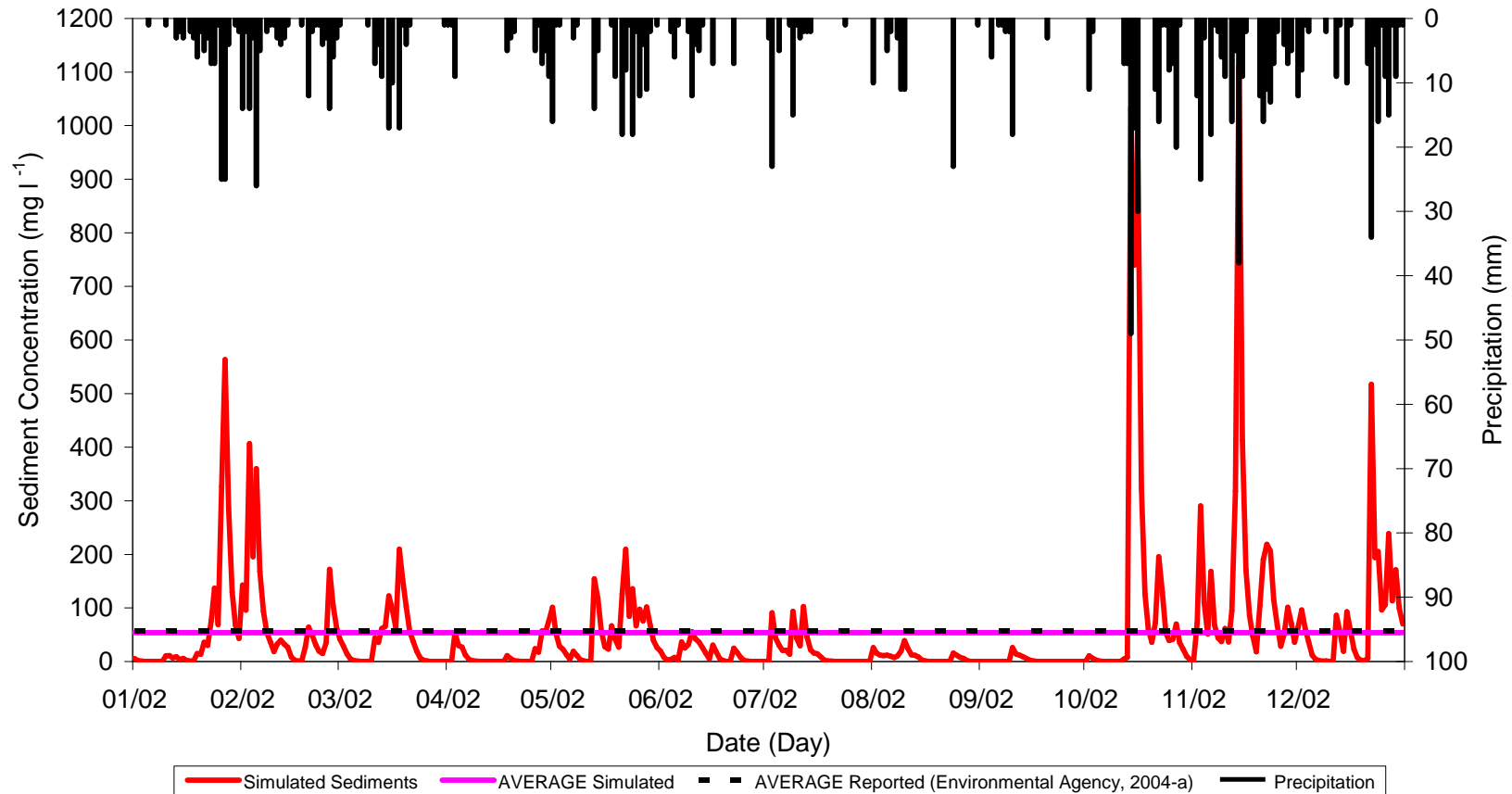
**EVAPOTRANSPIRATION**  
Simulated (1988-97) (Penman-Monteith method) at Whitford and reported (1941-70) (Smith, 1976) average monthly evapotranspiration for the study area.



## Crop Growth



# Calibration - sediment

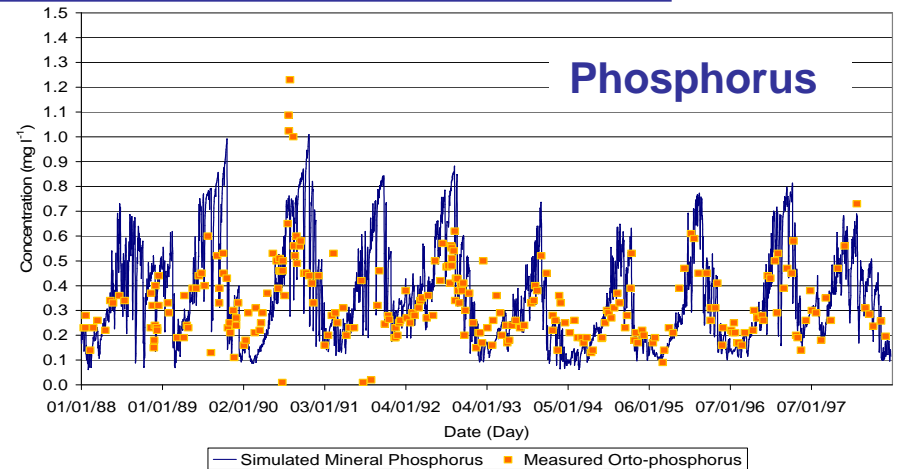
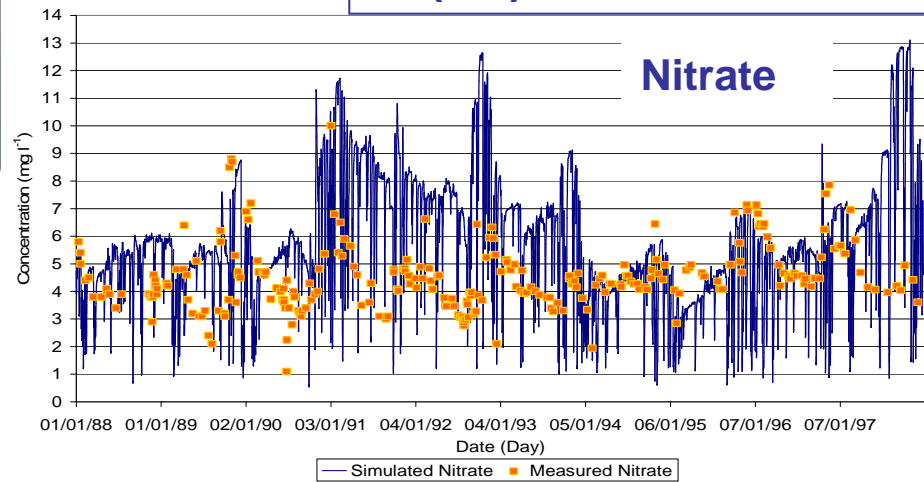


**Comparison between SWAT simulated sediments (mg/l) at Whitford for the year 2002 (average value 54.3 mg/l) and reported average sediment concentration (57.7 mg/l) from Environment Agency reports.**

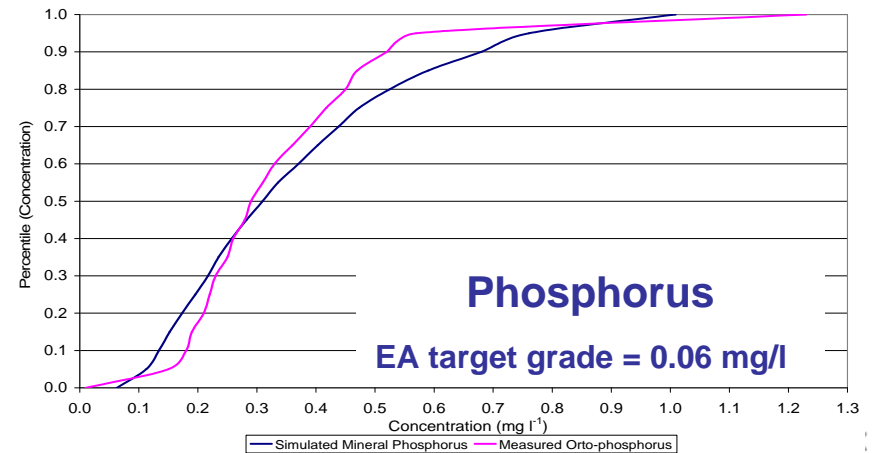
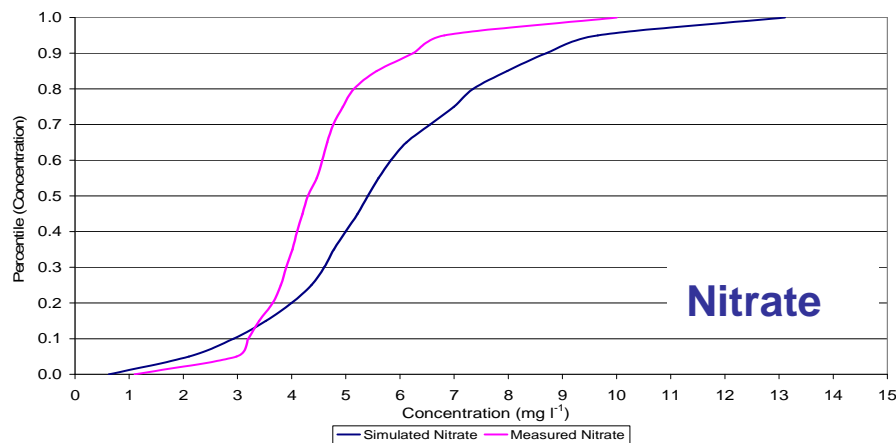


# Calibration - nutrients

Comparison between daily simulated (SWAT) and measured (EA) nutrient concentrations at Whitford (1988 – 1997).

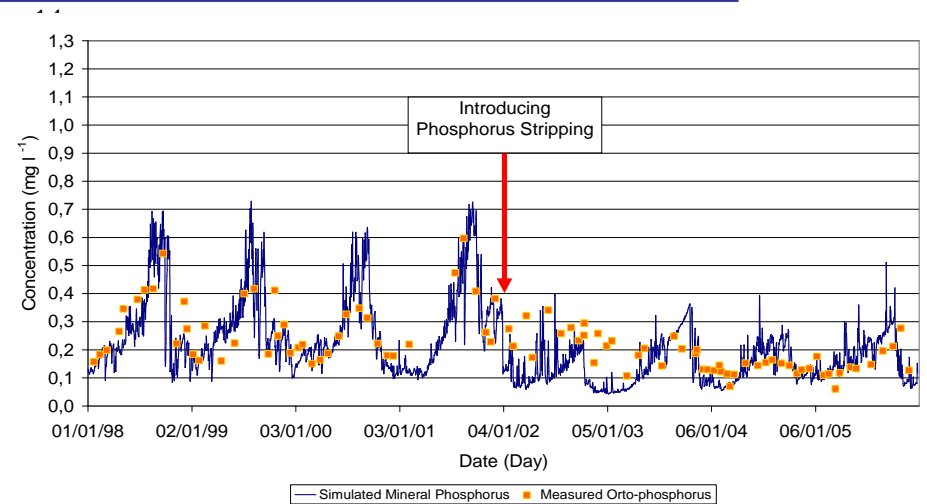
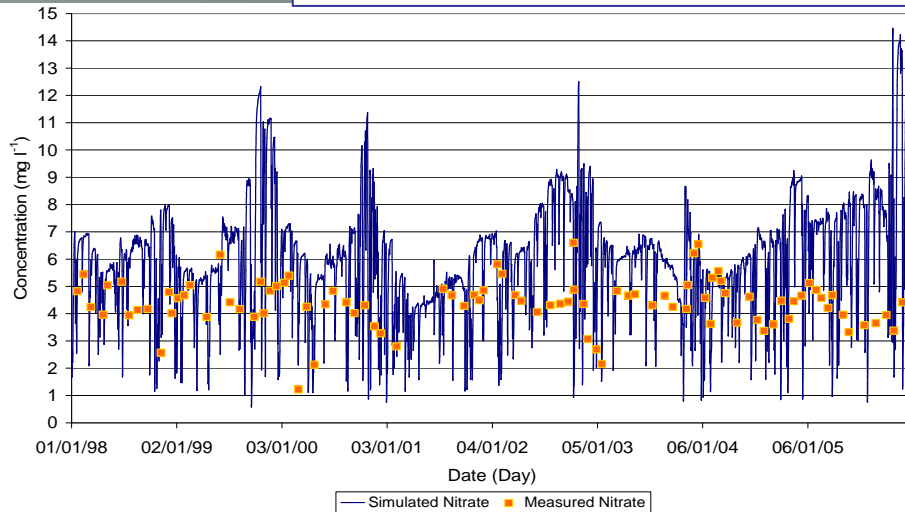


Comparison between cumulative distribution of simulated (SWAT) and measured (EA) nutrient concentrations at Whitford (1988 – 1997).

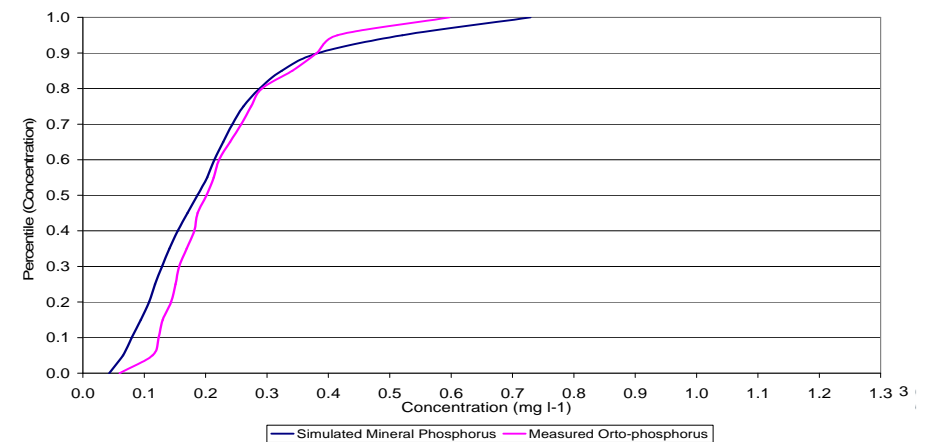
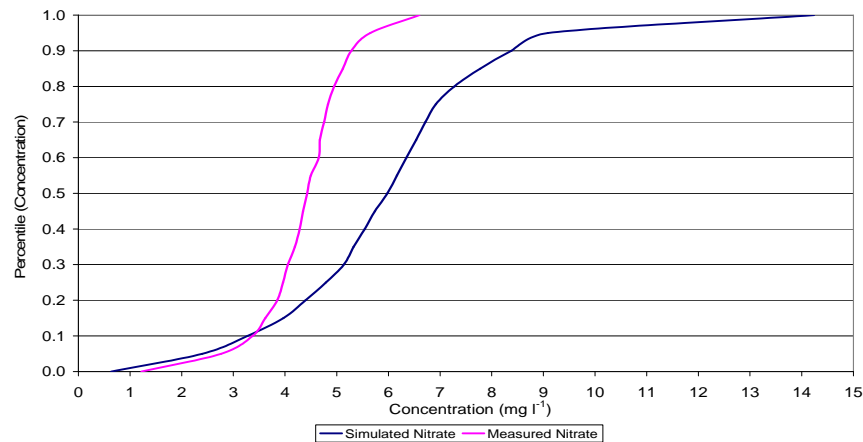


# Validation - nutrients

**Comparison between daily simulated (SWAT) and measured (EA) concentrations for the gauging station at Whitford (1998 – 2005).**



**Comparison between cumulative distribution of simulated (SWAT) and measured (EA) nutrient concentrations at Whitford (1998– 2005).**



## **Scenario 1 – Field Buffer Strips (FBS)**

- aim: to minimize influence of diffuse pollution resulting from agricultural activities, (soil compaction and over fertilisation),
- without drastic changes in crop or pasture management,
- implementation of filter strips.

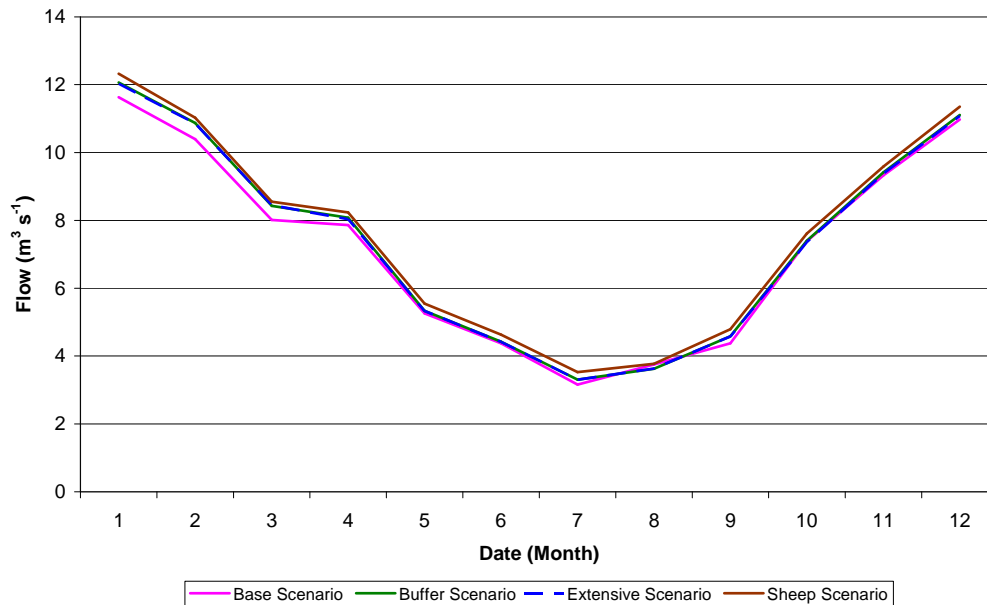
## **Scenario 2 - Extensive Land Use Management (ELUM)**

- based on interview at Coombe Farm (organic based dairy farm),
- aim: not to simulate organic but rather more extensive land use management,
- farmers change intensive cropping with maize for red clover or other legumes to reduce nitrogen application rates.

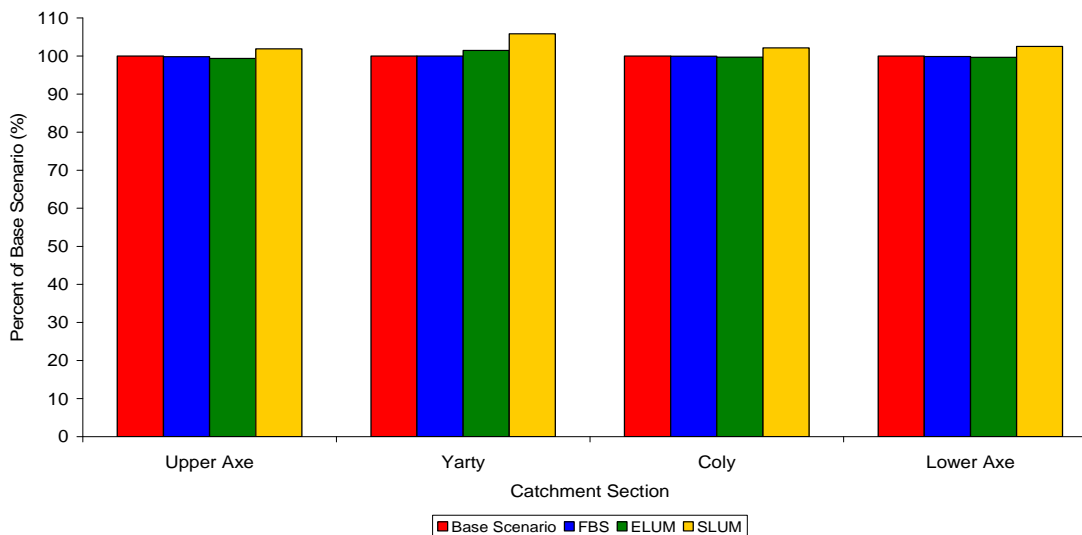
## **Scenario 3 - Sheep Land Use Management (SLUM)**

- aim: to investigate how far land use would need to change to deliver water quality improvements,
- agriculture would still exist at an appropriate level to maintain current landscape,
- dairy cow based farming excluded from the study area.

# Results – river flow

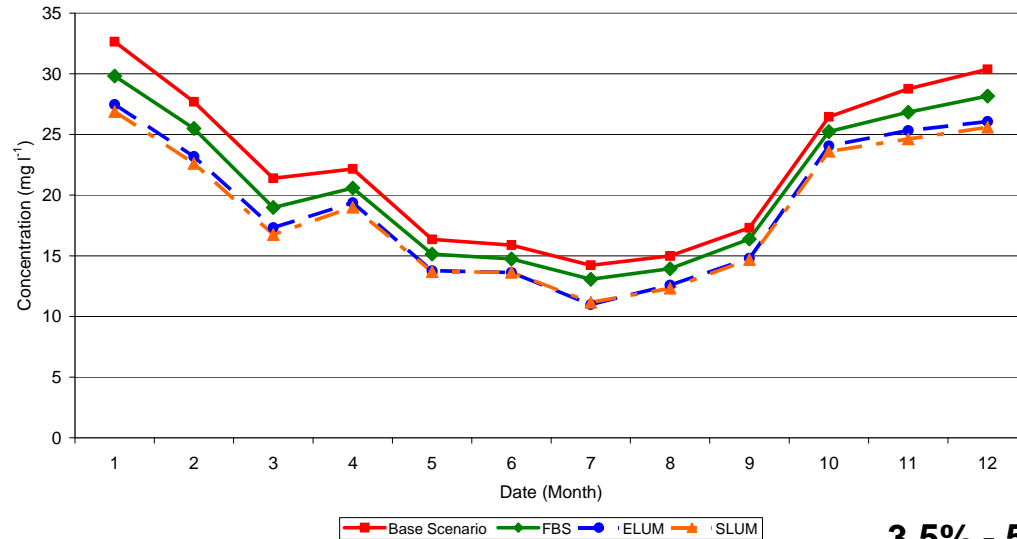


- Comparison of average daily flows on monthly basis between base and future scenarios for the simulation period of 18 years at main catchment outlet.

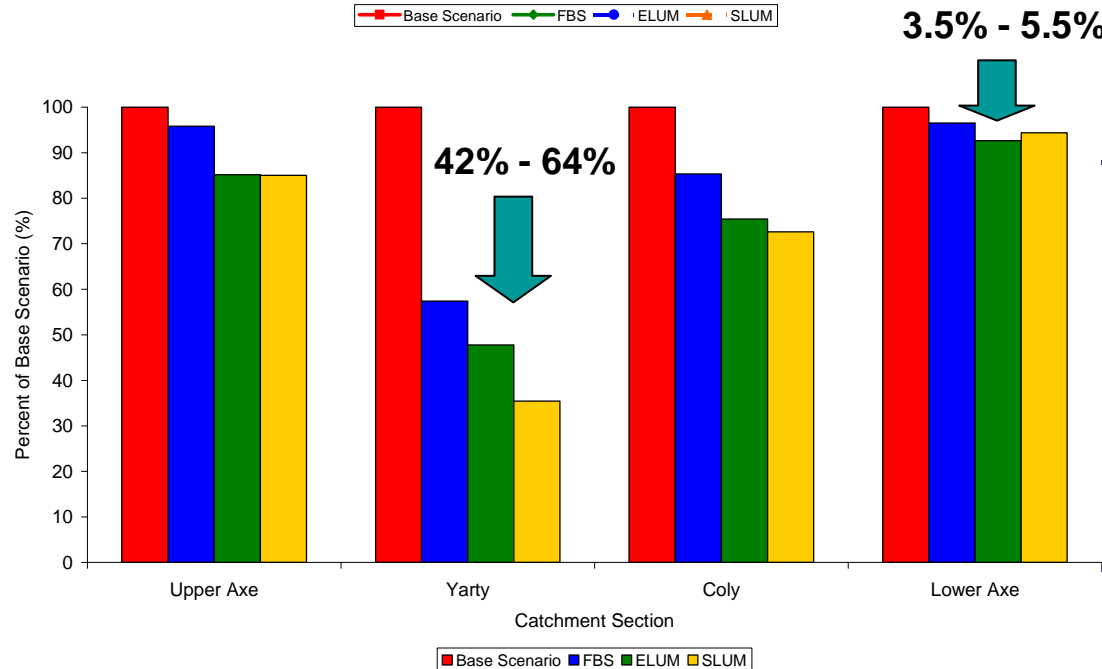


- Future scenarios daily average river flows at the outlet of the four catchment sections as percent of base scenario for the simulation period of 18 years.
- (Base scenario is 100%)

# Results - sediment

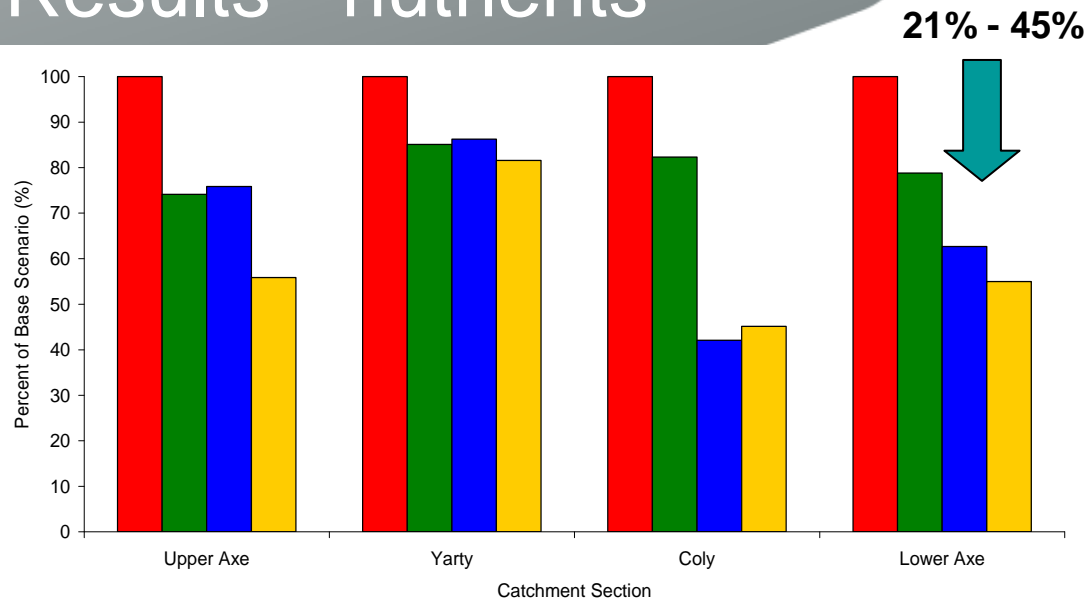


- Comparison of average daily sediment concentration on monthly basis between base and future scenarios for the simulation period of 18 years at main catchment outlet.

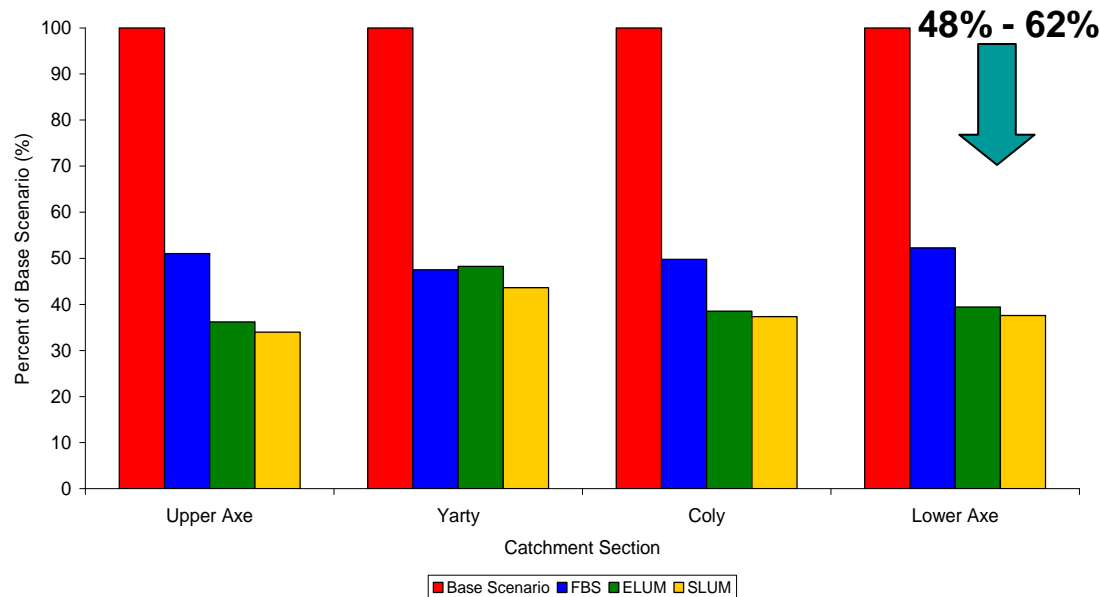


- Future scenario load of sediment at the outlet of the four catchment sections as percent of base scenario for the simulation period of 18 years. (Base scenario is 100%)

# Results - nutrients



- Future scenarios load of total nitrogen at the outlet of the four catchment sections as percent of base scenario for the simulation period of 18 years.
- (Base scenario is 100%)



- Future scenarios load of total phosphorus at the outlet of the four catchment sections as percent of base scenario for the simulation period of 18 years.
- (Base scenario is 100%)



# Conclusions

- Calibration and validation was in the range for satisfactory model performance.
- SWAT is able to represent the proposed mitigation methods for all three management scenarios.
- Reduction in sediment yield was higher in parts of the catchment with high velocity.
- Measures were found to be effective in reducing pollutants loads at the main outlet.
  - field buffer strips of 4m to all arable and grassland land use,
  - exclusion of high risk crops (maize),
  - lower stock density on pastures.
- Environment Agency targets ( $0.06 \text{ mg PO}_4^{3-} \text{ l}^{-1}$ ) would still not be achieved for the catchment as whole.

Thank You for Your  
Attention.

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