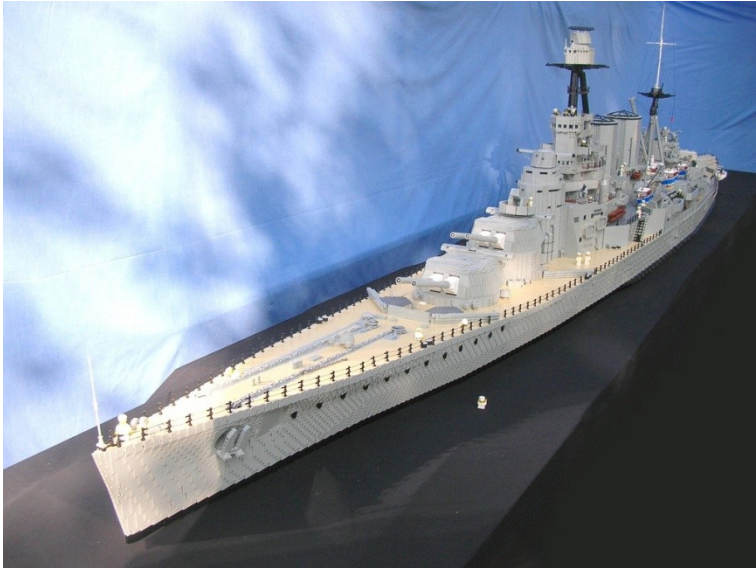


# Linking Land-Use and Water Quality - Modelling Results and Discussion

Lisa Norton, Stephen Maberly, Linda May and  
Alex Elliott

with help from John Rockliffe, Leslie Webb, farmers and householders  
in the catchment



A model is a simulation of reality  
*which:*

- looks like the real thing
- provides an opportunity to look at something in its totality (which might be difficult to do in real life)
- provides information on how different parts of an object relate to one another

*A model does not necessarily*

- function like the real thing it represents
- contain all the detailed internal workings of the thing it represents

Scientists use models to:

- Represent reality
- Understand how things work
- Test how things might work under different (including future) conditions (because it's easier than doing it in reality)

**What do we want the  
Lowswater catchment  
model to do?**



*Tell us how what is done in the  
catchment is related to the  
algal blooms in the lake*



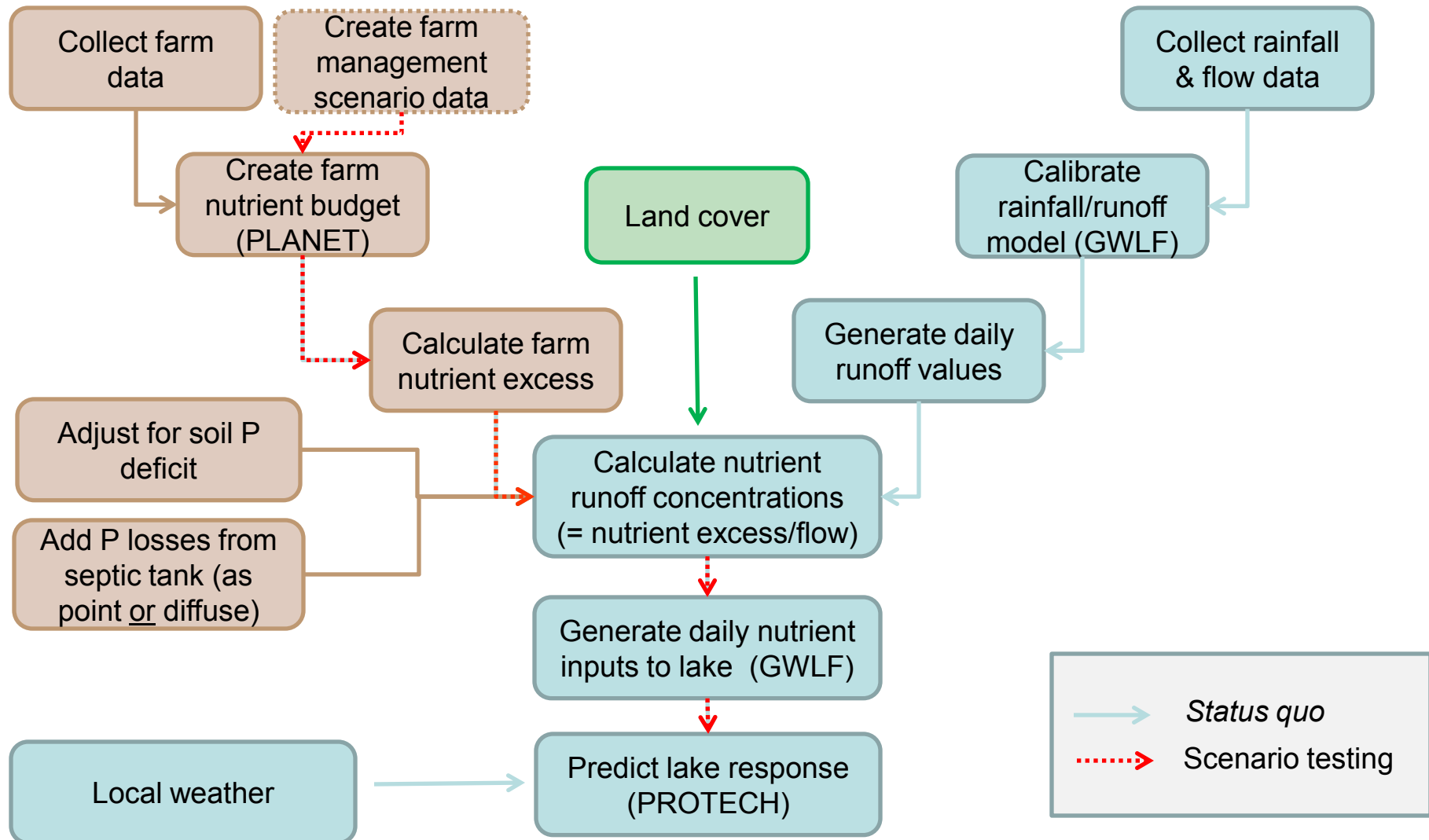
**What are the building blocks for a  
Lowswater model?**

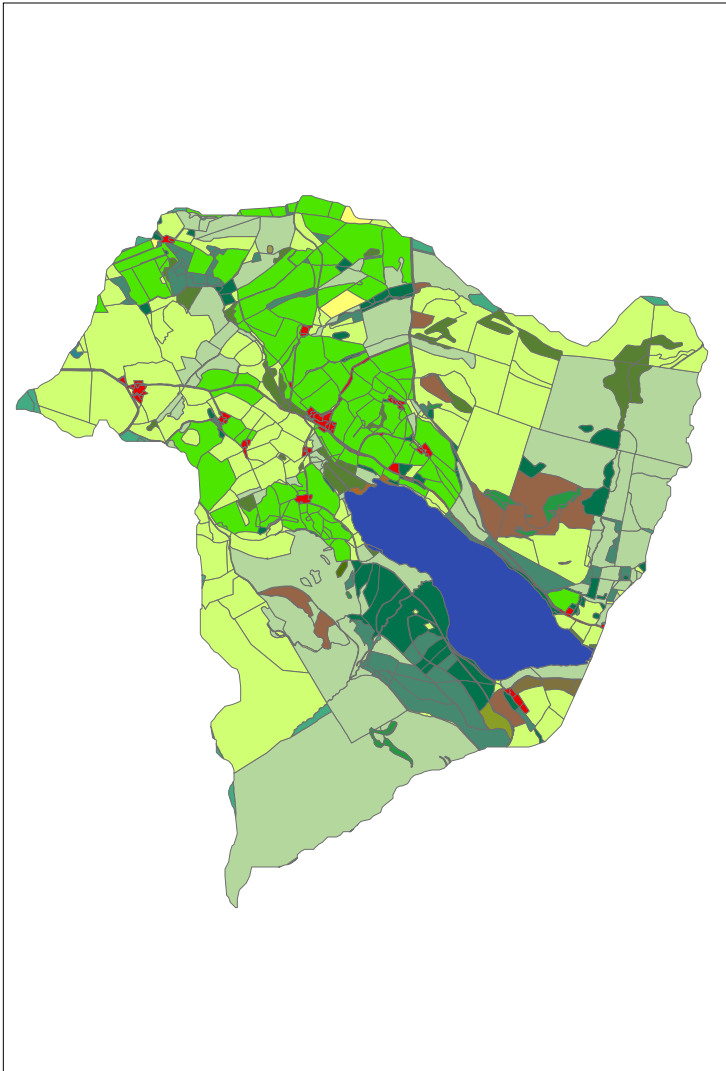
- Land cover information
- Land management information and soil P levels for farmed land
- Numbers of people
- Septic tank condition, use and management
- Rainfall
- Lake discharge
- Wind speed
- Air temperature/humidity
- Cloud cover
- Lake data for validation

## Data/information that is likely to be important but which we don't have/ haven't been able to incorporate

- Slurry tank/midden stead condition
- Yard water /waste arrangements
- Connectivity between waste storage and water bodies (*under normal conditions*)
- Connectivity between waste storage and water bodies (*under extreme weather conditions*)
- Locations of animal feeders in relation to water bodies
- Animal access to water bodies in lake feeder streams





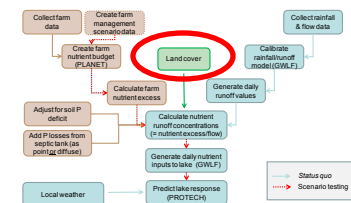


Each land cover type has an associated average **nutrient export** value

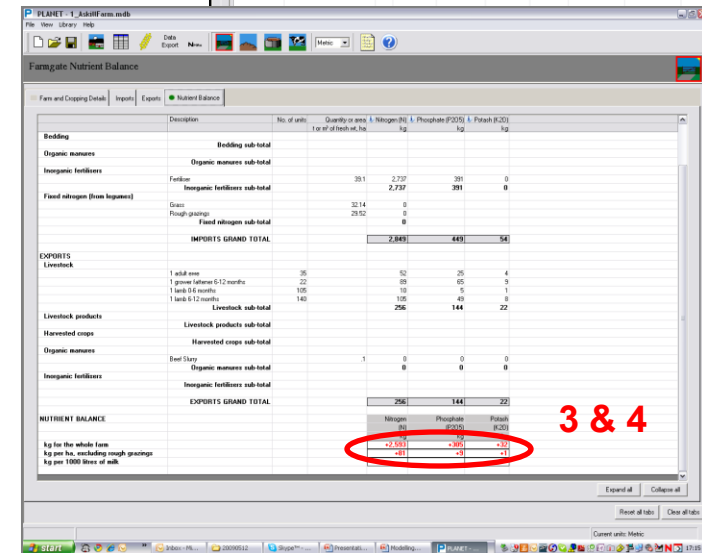
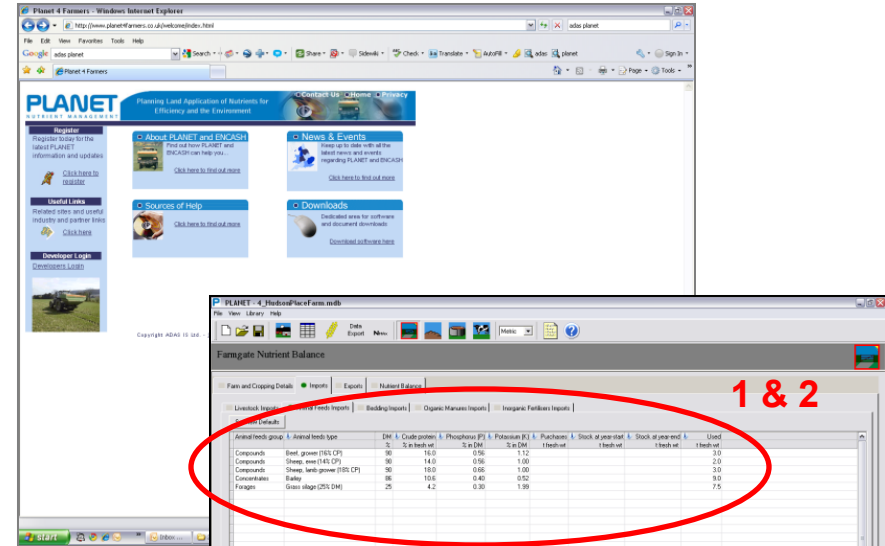
Land cover type	Area (km <sup>2</sup> )	P (mg P m <sup>-3</sup> )	Nitrate (mg N m <sup>-3</sup> )
A High production grass	2.79	32	3,540
B Broadleaved woodland	0.65	10	190
C Coniferous woodland	0.35	10	190
D Natural grass	1.39	5	2,100
E Urban	0.12	56	0
F Arable	0.03	17	2,900
G Moors and heathland	2.29	7	190

Nutrient Exports on managed farmland depend heavily on inputs and stocking levels

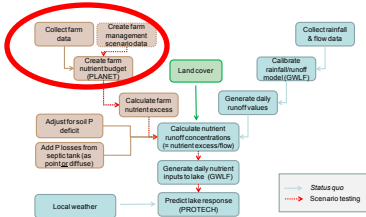
Hence specialist farmer nutrient budgeting software was used to calculate **nutrient exports** from the farmland using John Rockliffe's information on farming practice and soil nutrient status



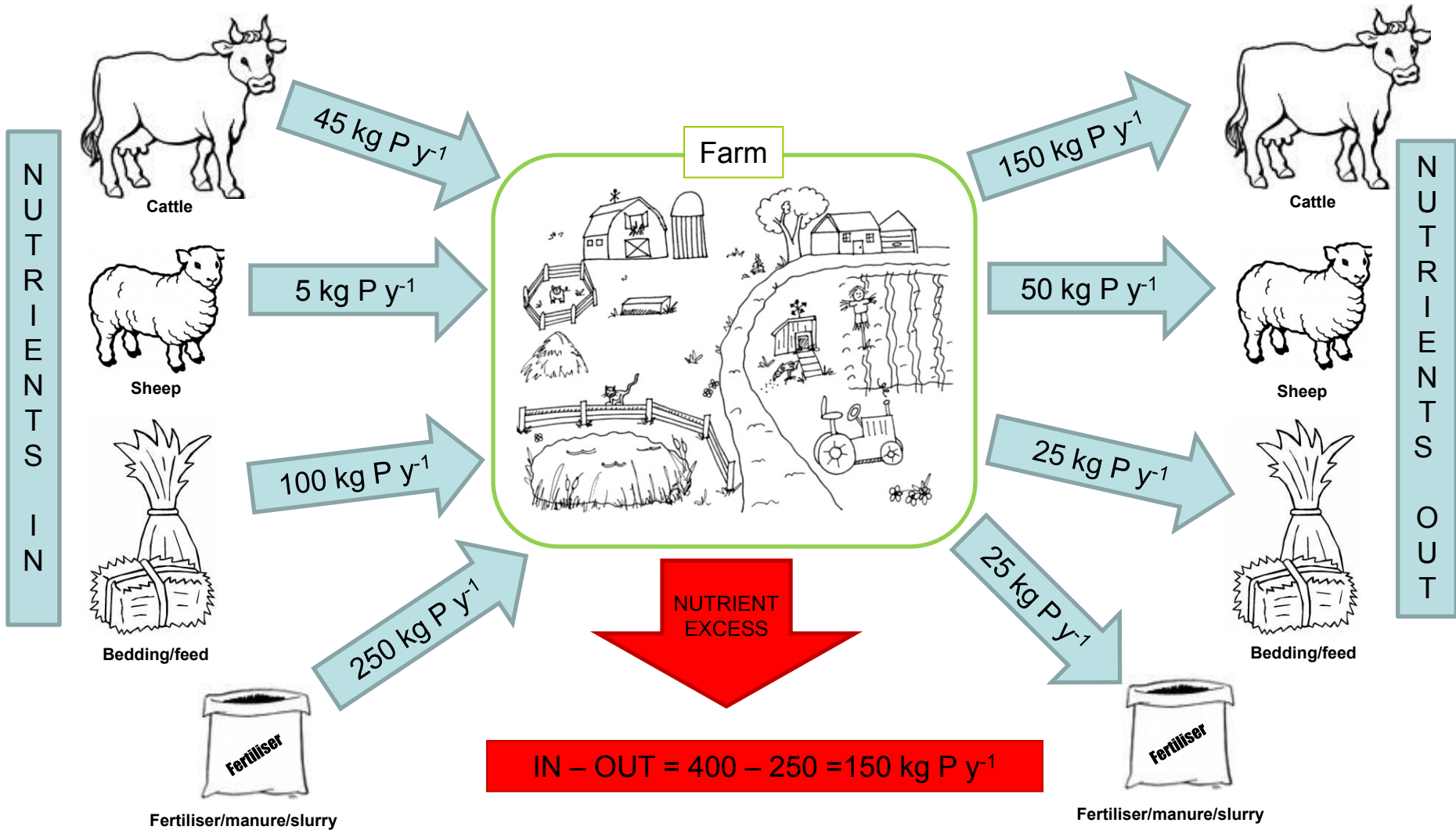
1. Collect data from farmers
2. Enter data into PLANET (Planning Land Application of Nutrients for Efficiency and the Environment)
3. Calculate phosphorus and nitrogen balance for each farm, based on 'imports' and 'exports' of :
  1. Fertiliser
  2. Livestock
  3. Feedstuffs
  4. Bedding
  5. etc.



1. Predict nutrient excess on each farm



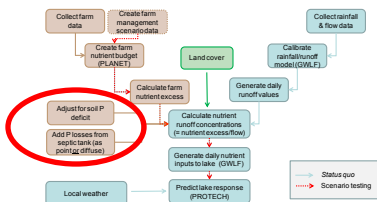
# Example: predicting the P excess on each farm



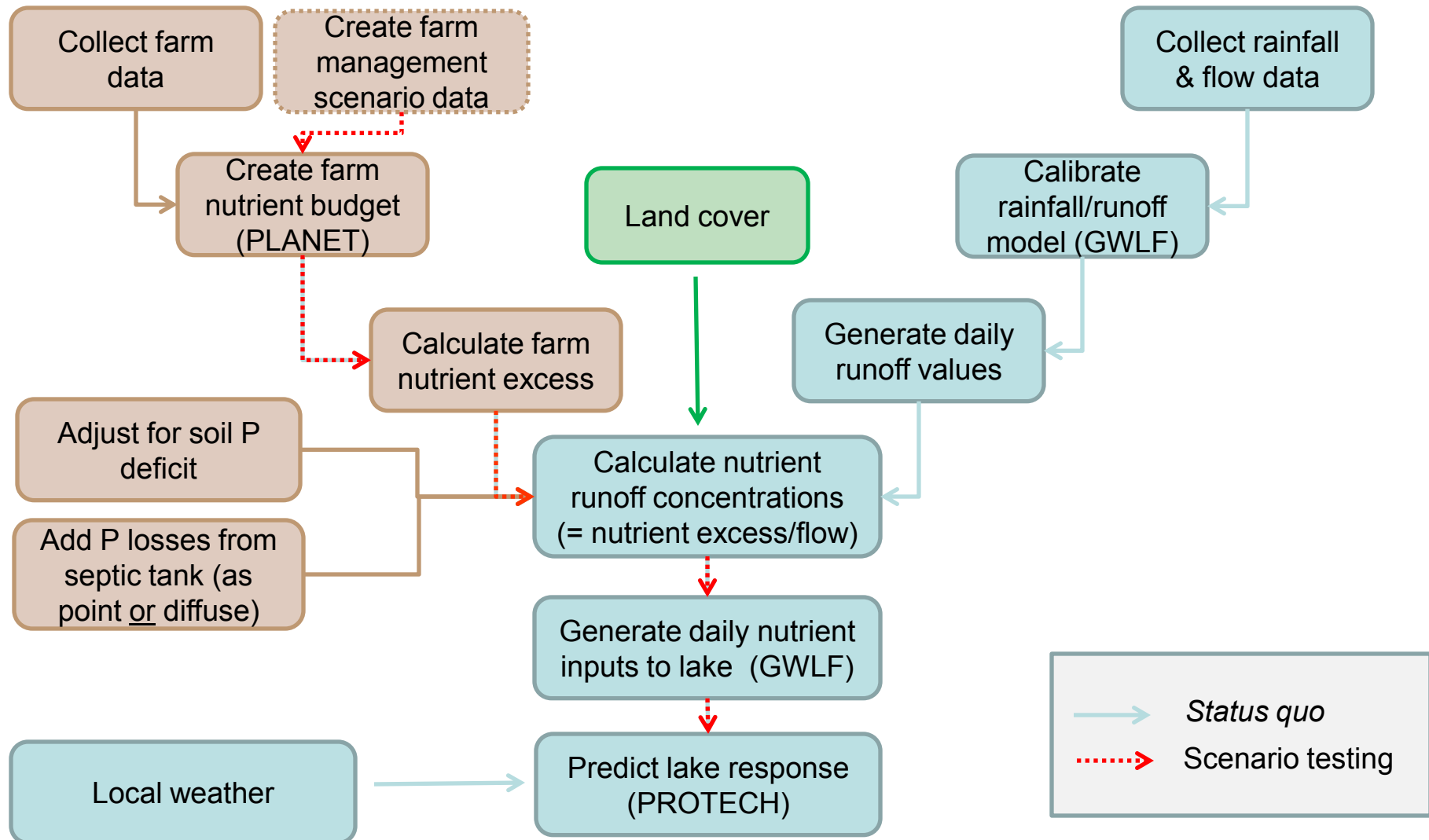


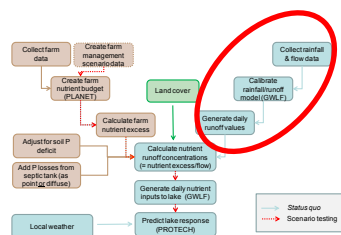
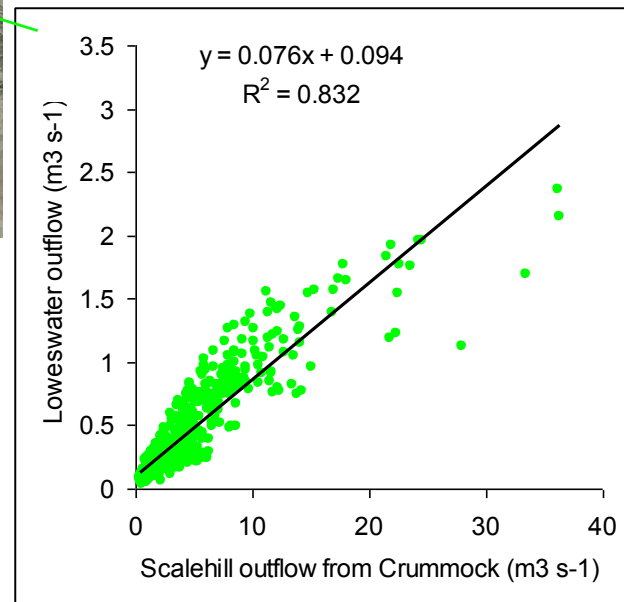
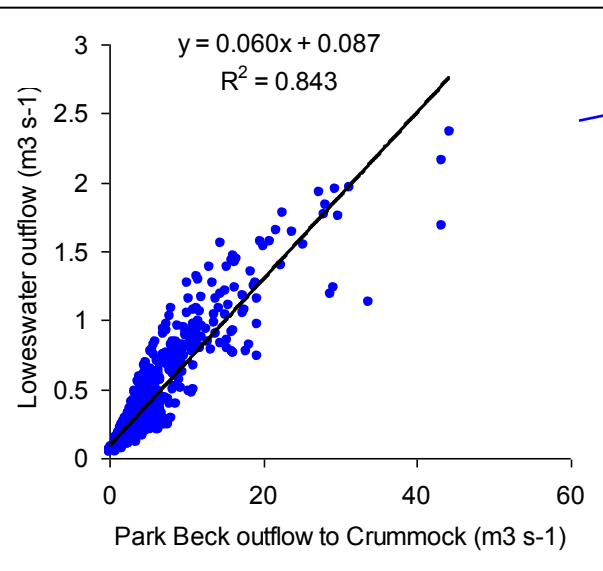
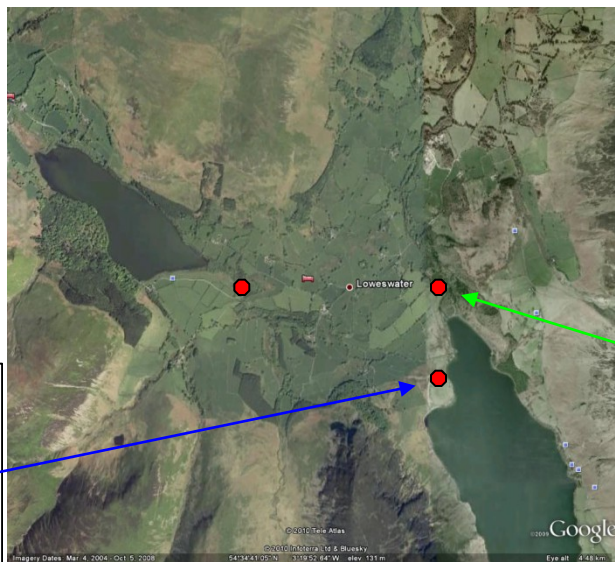
## Update P surplus values to take account of soil uptake and septic tank discharges:

1. P surplus for each farm *minus* soil P deficit  
 (calculated in PLANET) (as calculated from John Rockliffe's soil sampling)  
 (calculated by farm – on the assumption that P deficit = capacity for P uptake by soil)
  
- 2a. Either- add P from septic tanks on farms into the above sum (data from Leslie Webb)  
 (P from septic tanks is taken up the soil in the same way as farm nutrient surplus – *a diffuse source*)
  
- 2b. Or add P from septic tanks in as a direct input to streams (*a point source*)
  
3. Summed to produce an annual P-load for all the farms

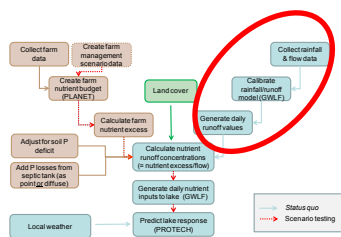
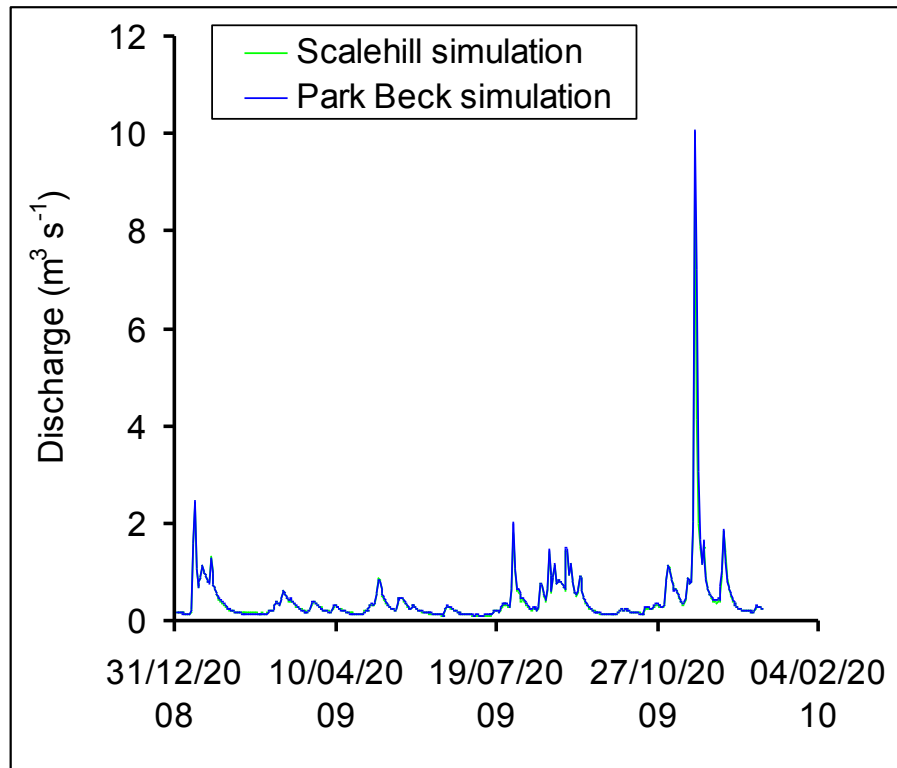
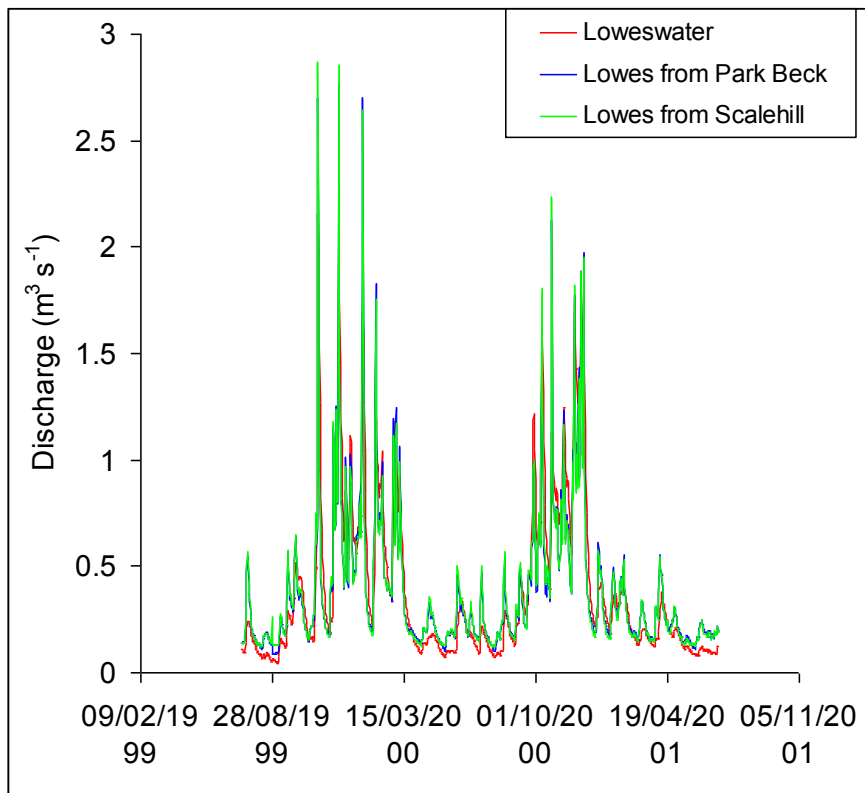


Farm no.	Surplus P	Soil P deficit	P from septic tanks	Net P surplus
1	134	375	3.1	0
2	356	161	2.0	197





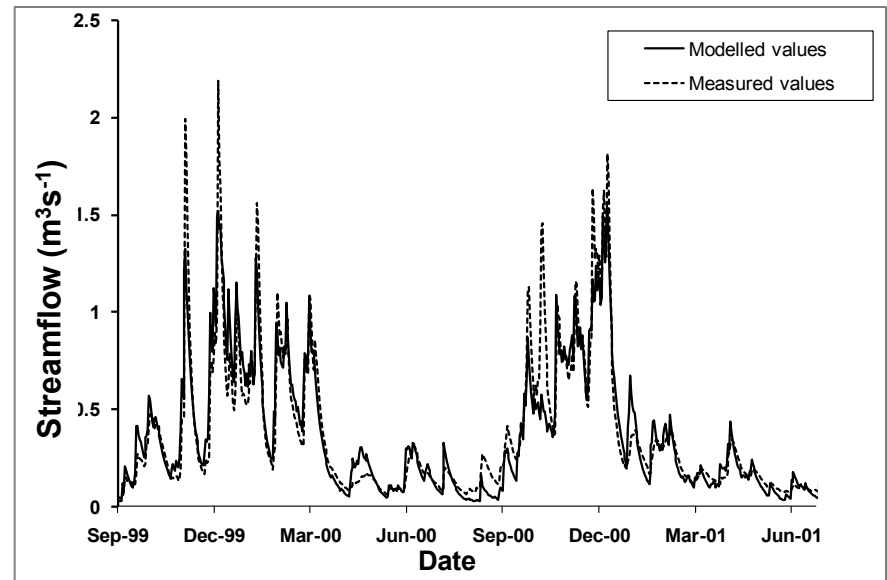
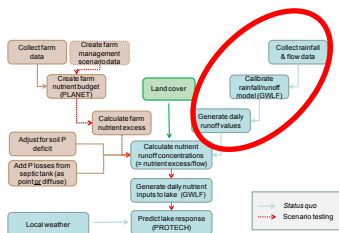
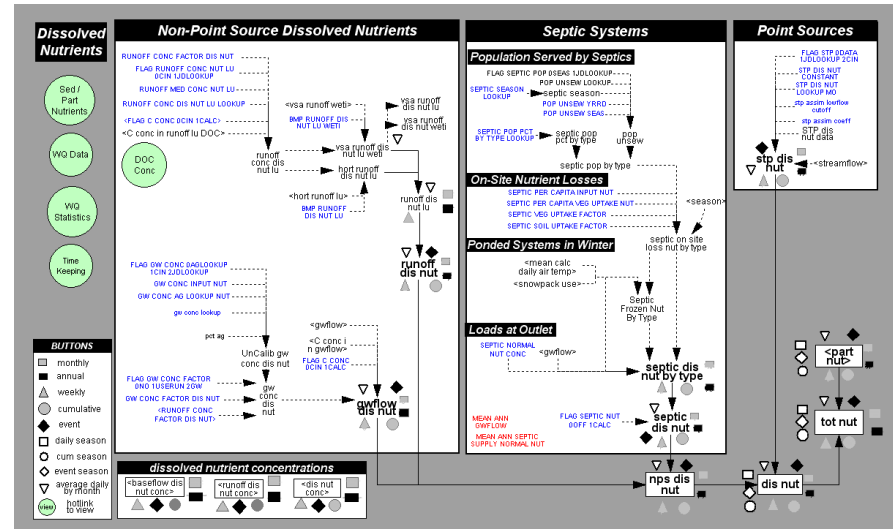
- Last data available for Loweswater in 2001
- 2009 data reconstructed from adjacent gauging stations



# Predict streamflow from rainfall

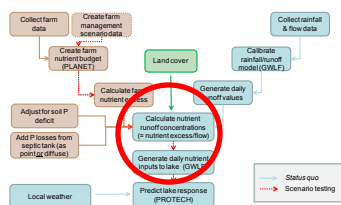
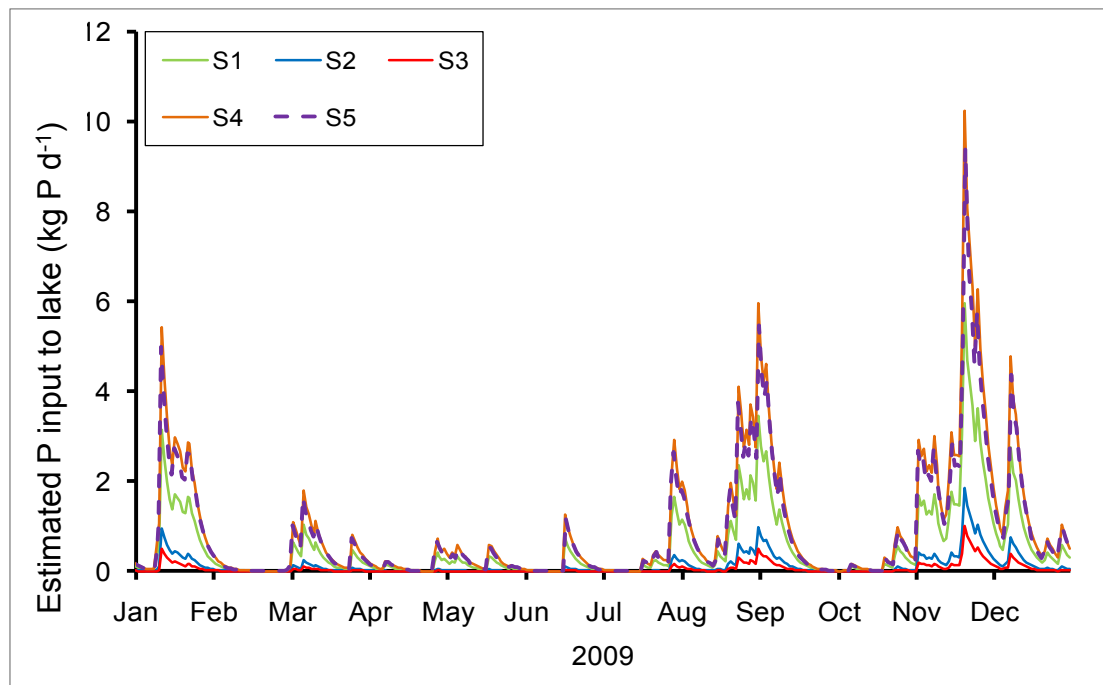


1. Generate modelled streamflow from rainfall (local rain gauge plus Ken) and air temperature (buoy)
2. Values compared to simulated discharge for Loweswater

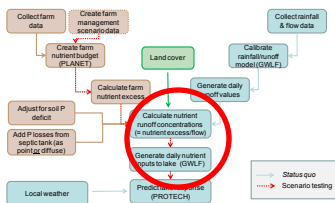
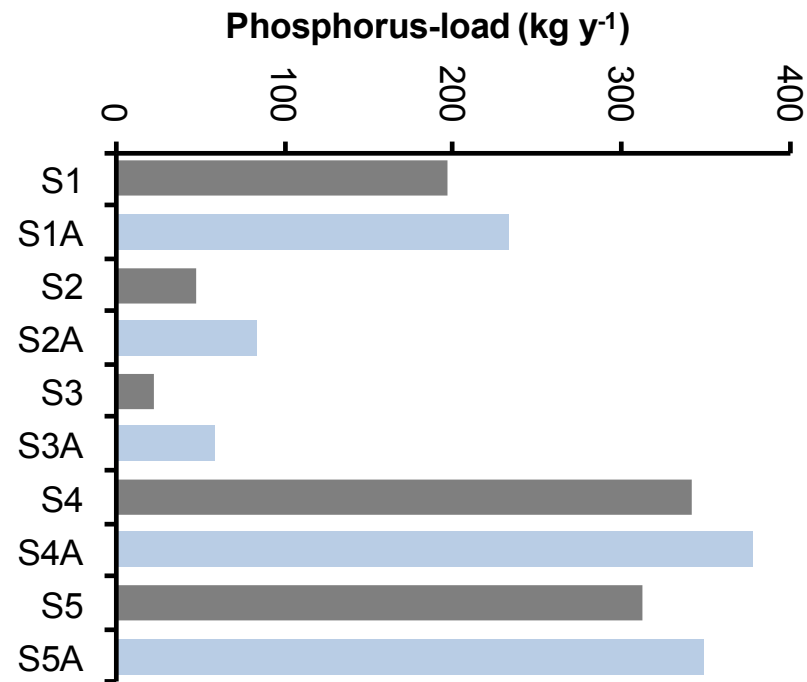


1. Annual P-inputs from the farms added to annual P-input from the other land in the catchment (export coefficient) to produce a total annual load of P ( $\text{kg y}^{-1}$ )
2. Different scenarios of possible land management were investigated (each with/without direct septic tank input) and annual P-load calculated
3. GWLF hydrological model (daily discharge) combined with these P-loads to produce daily loads of P (also using a similar approach nitrogen and silica)

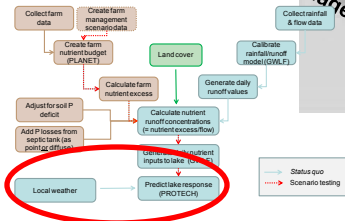
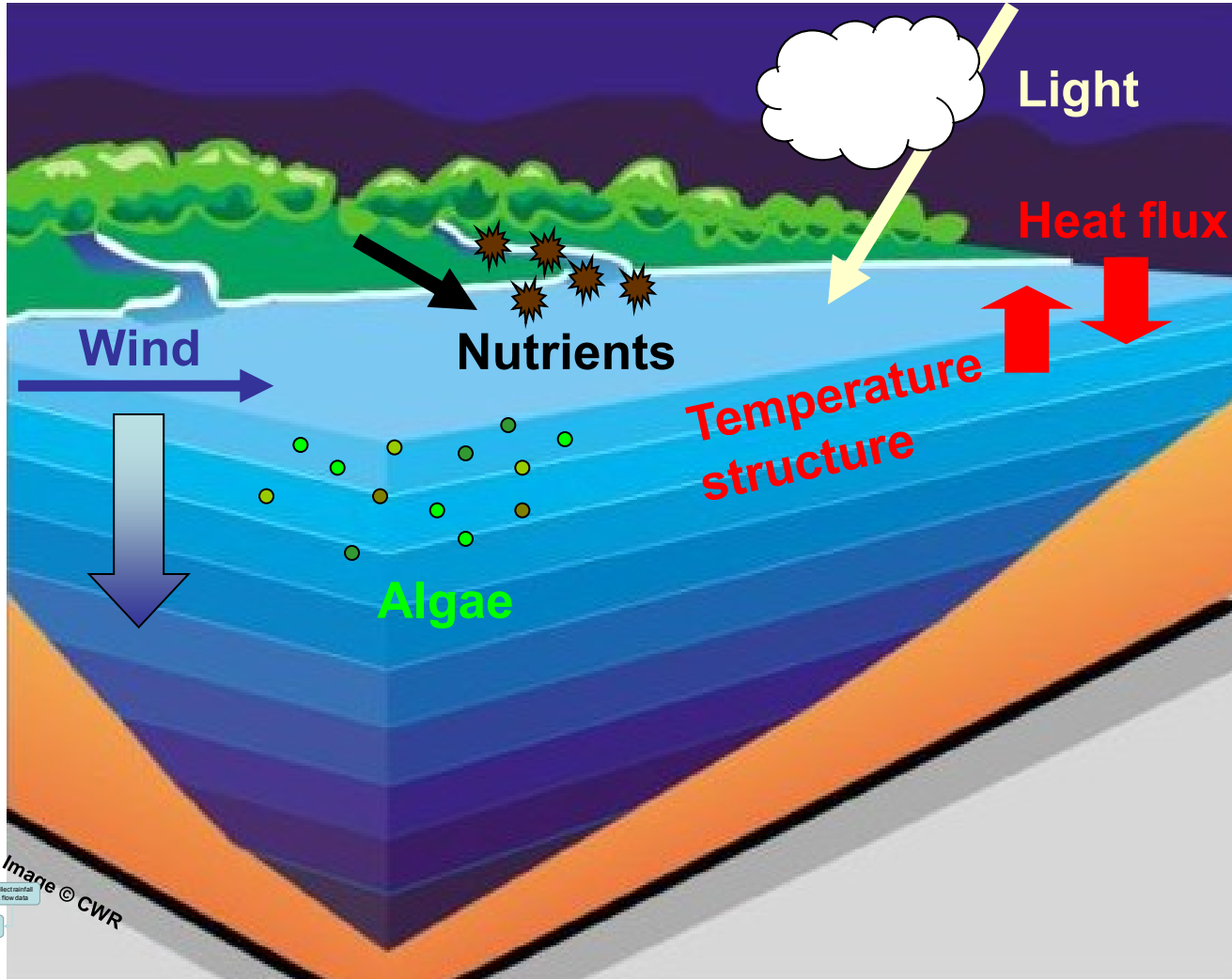
Scenario	Description
S1	Status quo
S2	All farmland to deciduous forest
S3	All improved grassland to natural grassland
S4	Remove cattle; double sheep
S5	Double cattle; halve sheep



Scenario	Description
S1	Current land cover & stocking densities (A = Septic tanks as point sources)
S2	All farmland changed to deciduous forest (A = Septic tanks as point sources)
S3	All improved grassland changed to natural grassland (A = Septic tanks as point sources)
S4	No cattle; double sheep (A = Septic tanks as point sources)
S5	Double cattle; half sheep (A = Septic tanks as point sources)



# What controls phytoplankton growth?

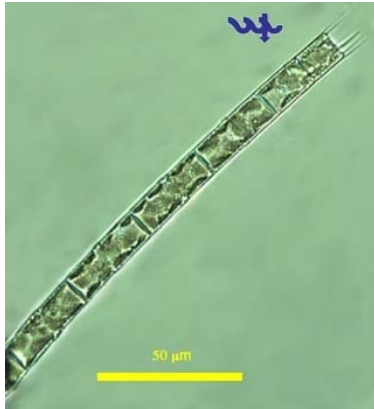


Imane © CWR

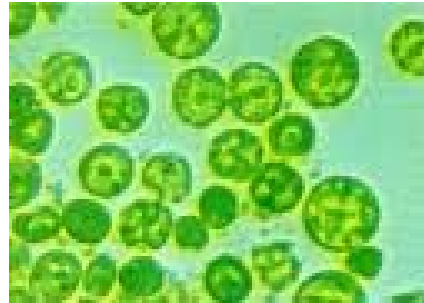




Asterionella



Aulacoseira



Chlorella



Plagioselmis



Dinobryon



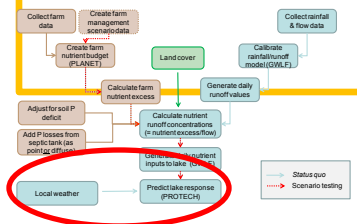
Anabaena



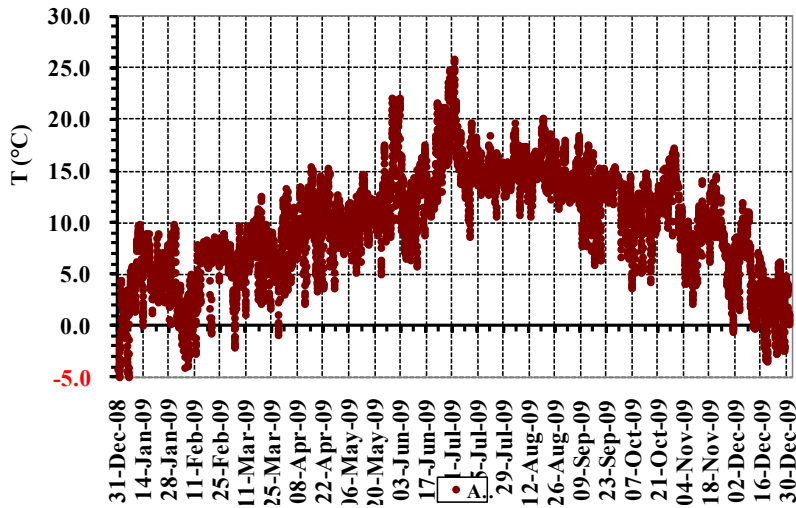
Planktothrix



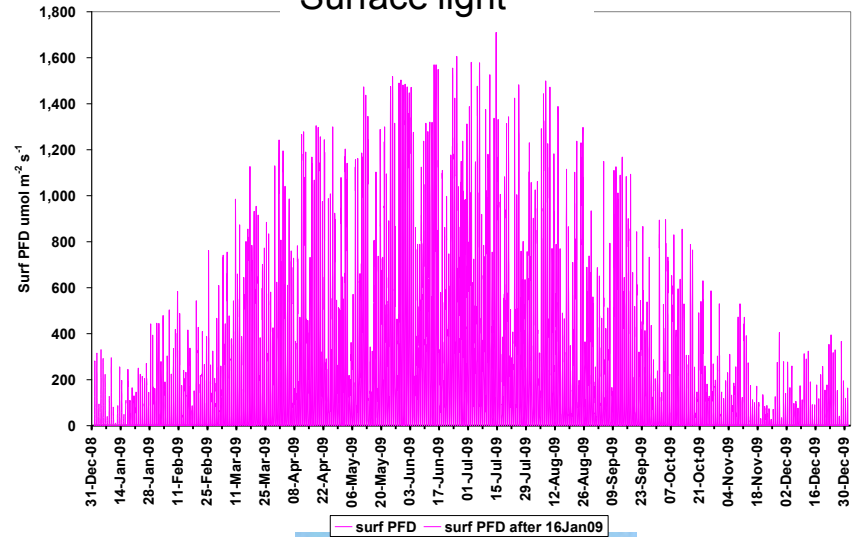
Aphanizomenon



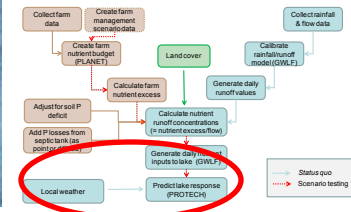
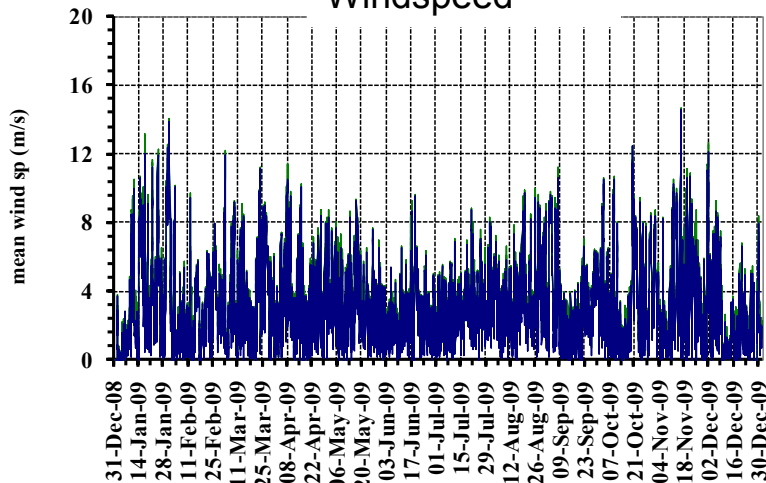
## Air temperature



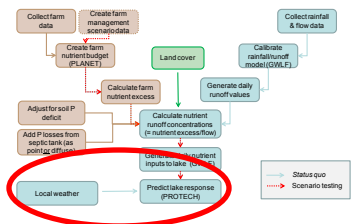
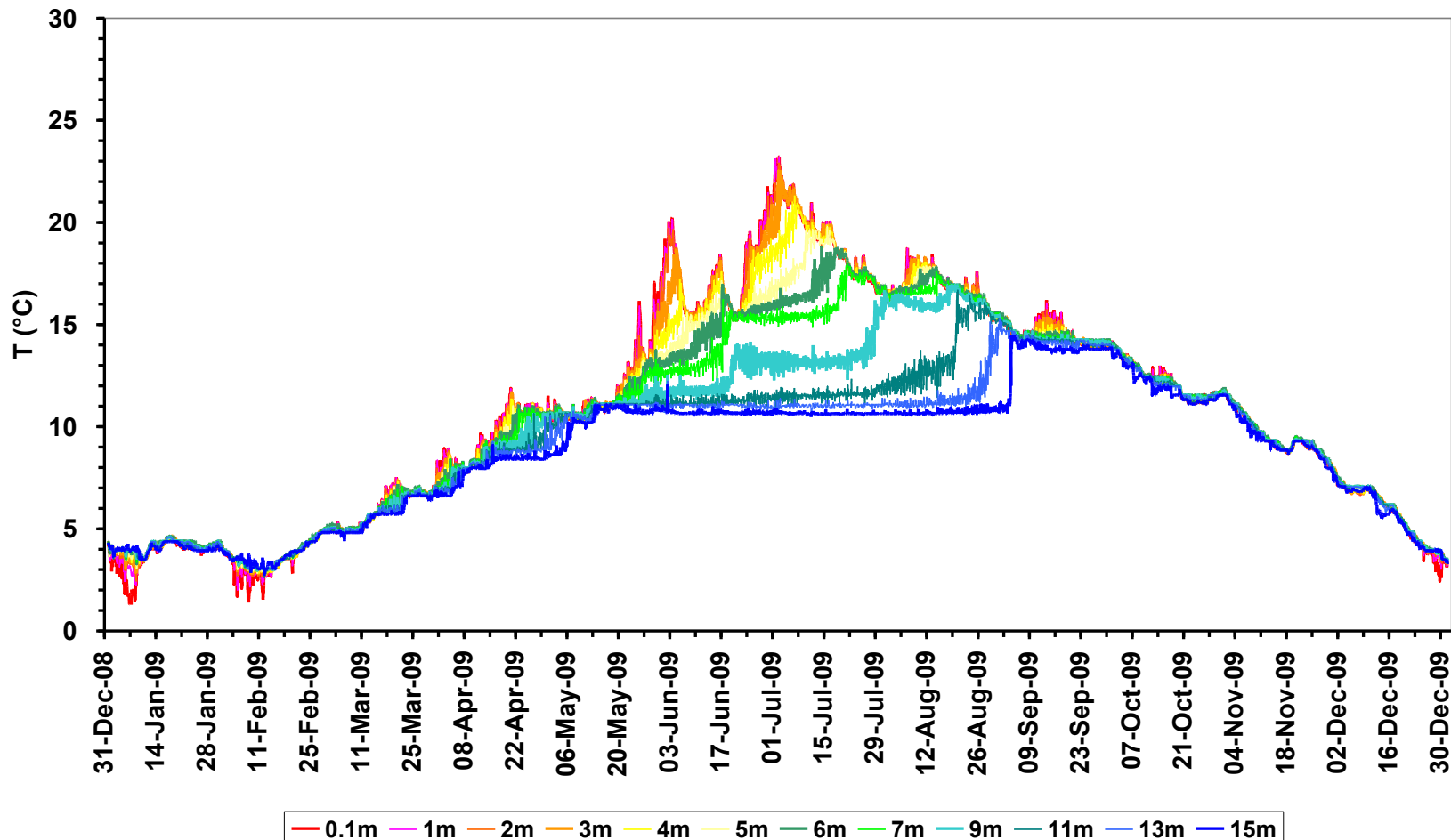
## Surface light

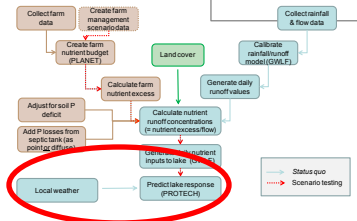
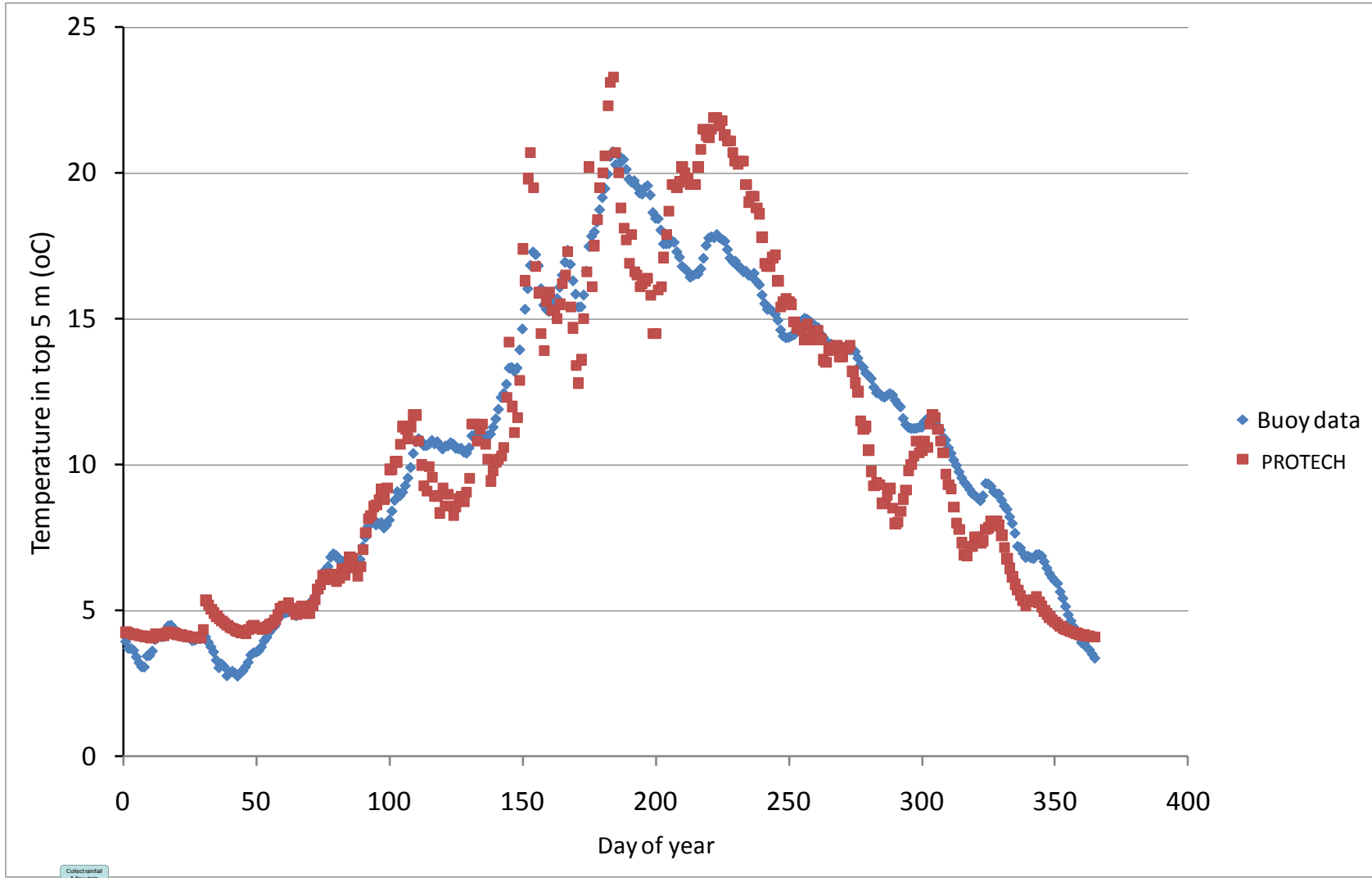


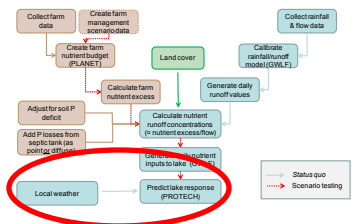
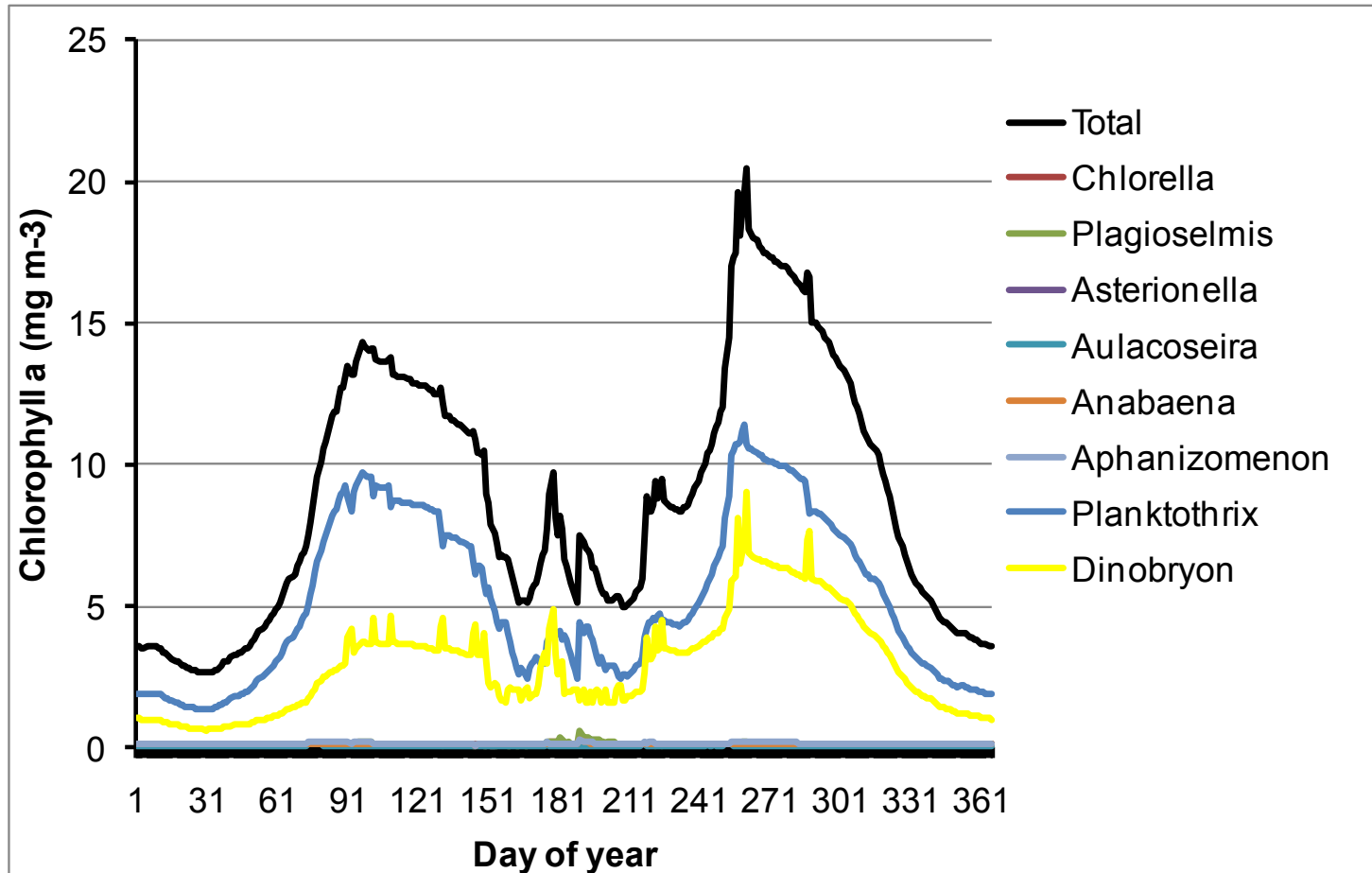
## Windspeed



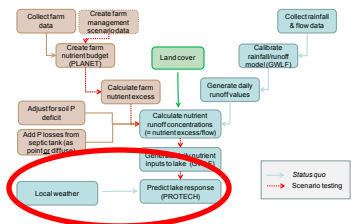
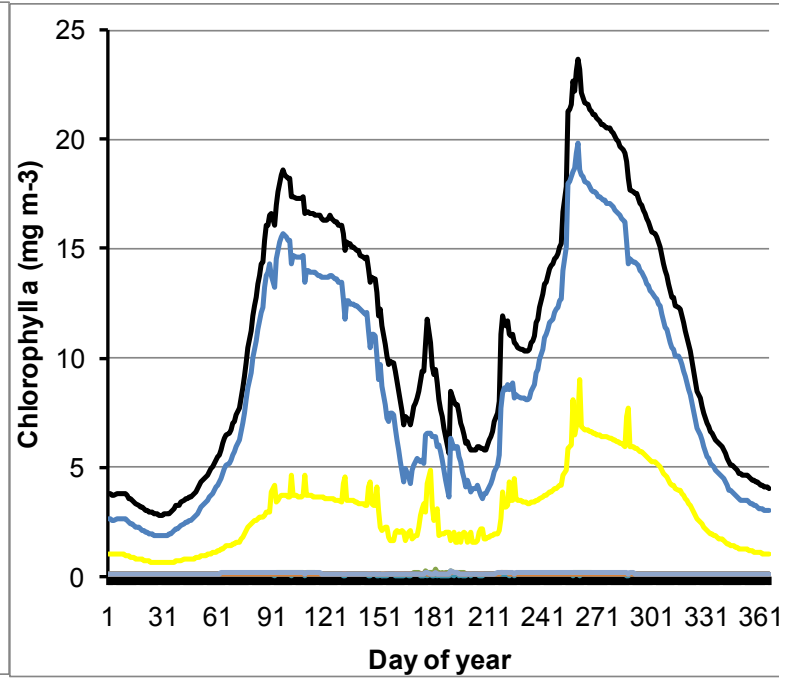
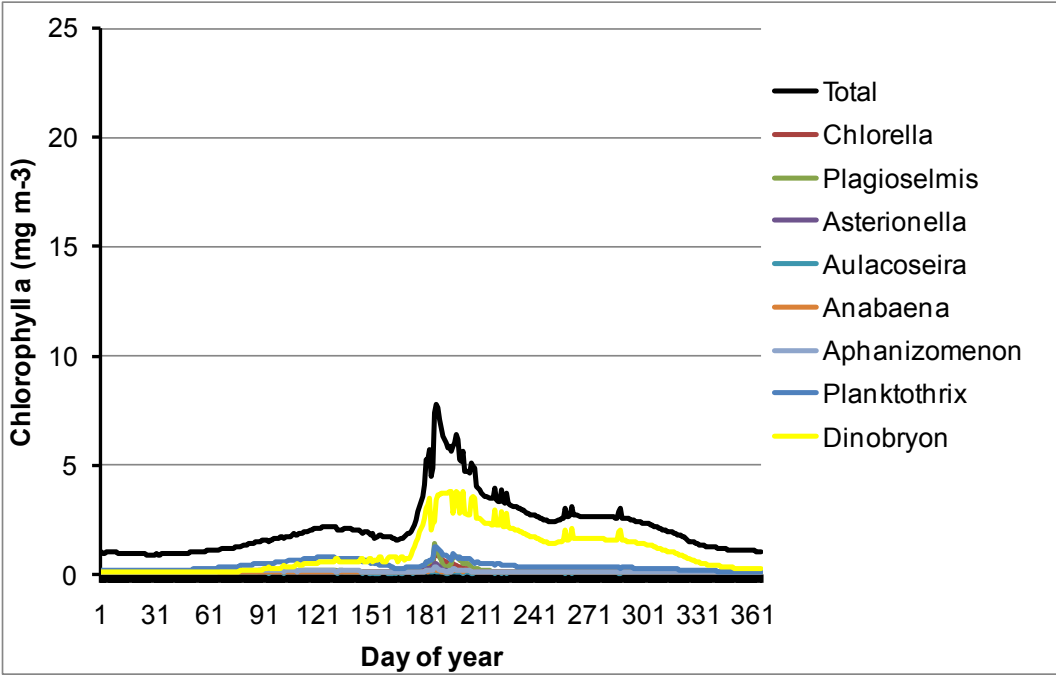
Loweswater, 2009

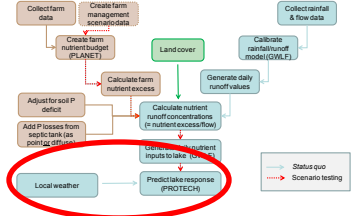
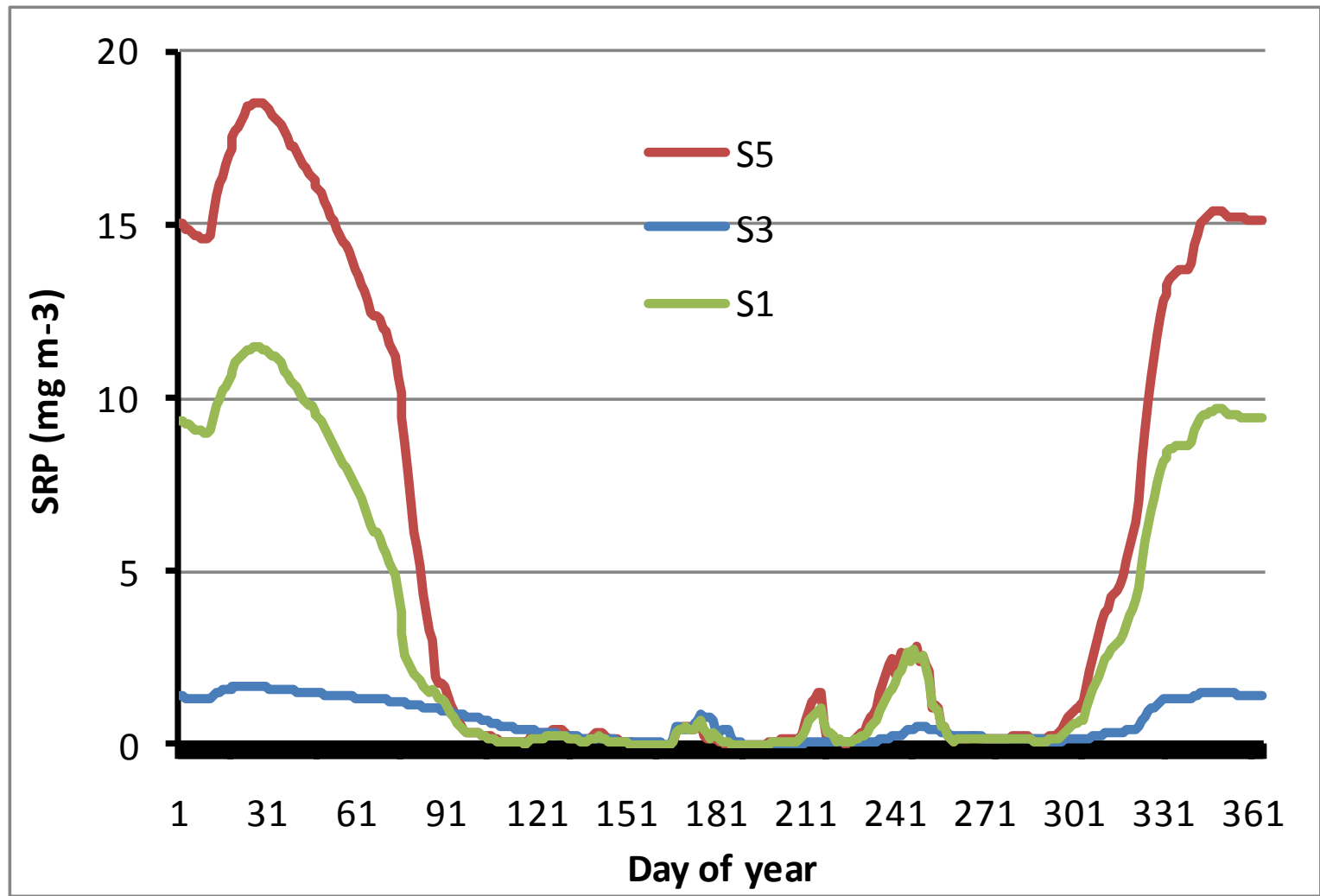


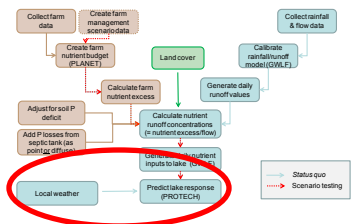
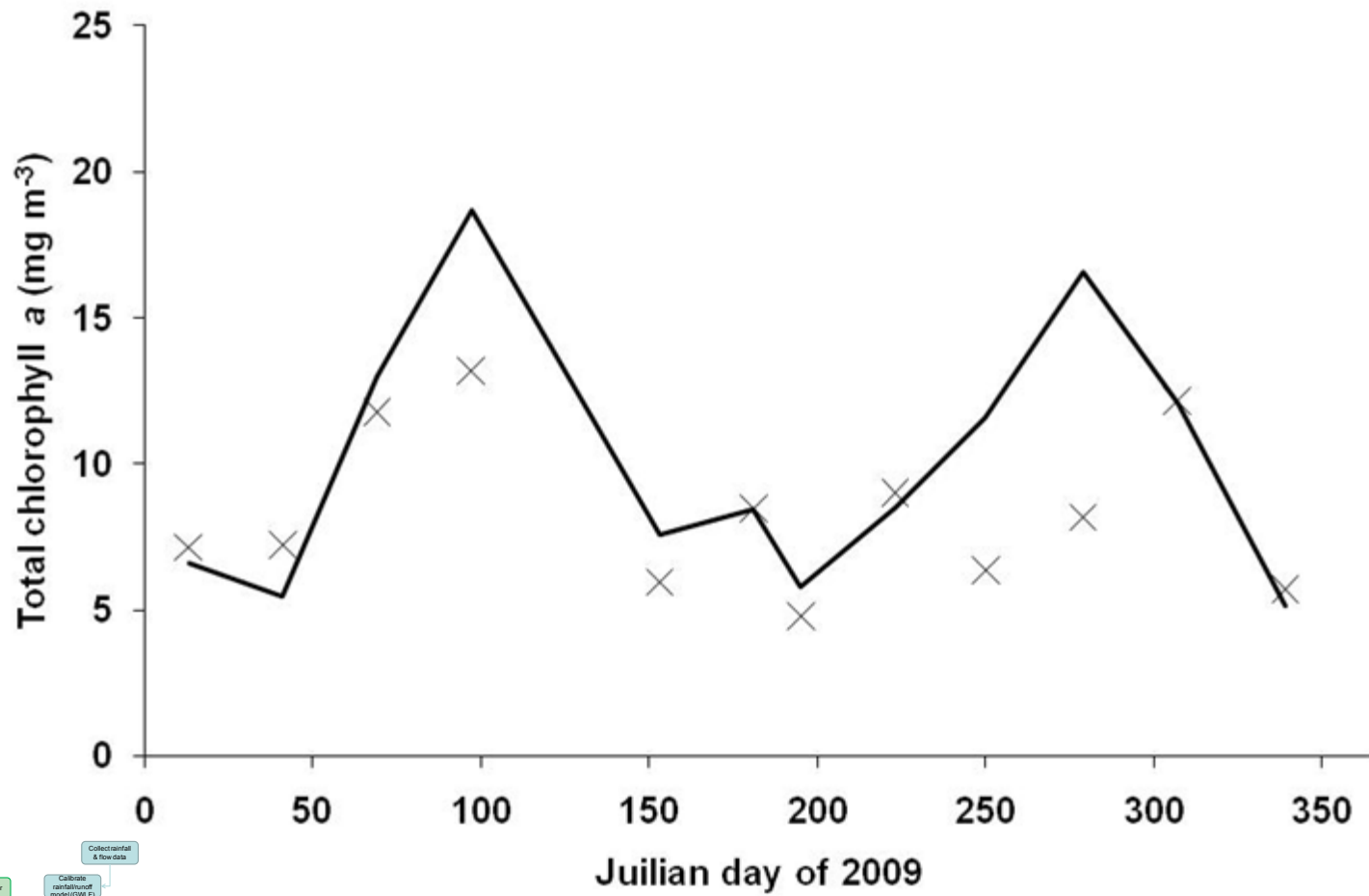




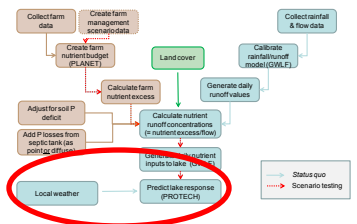
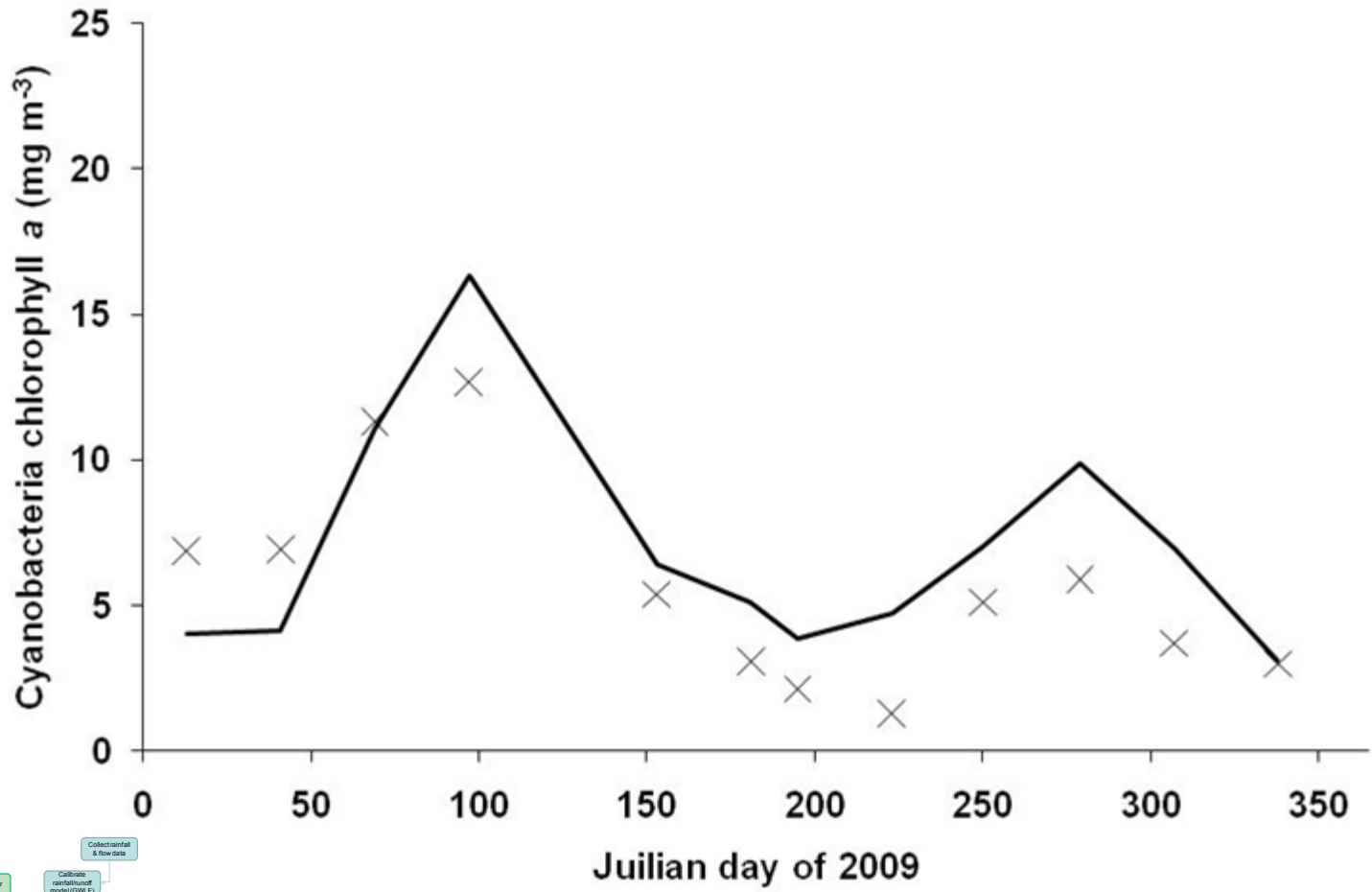
# PROTECH output for S3 (low P load) & S5 (high P load) scenarios

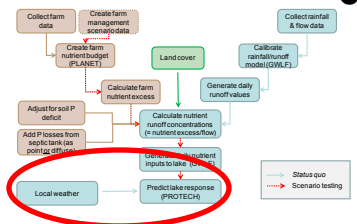
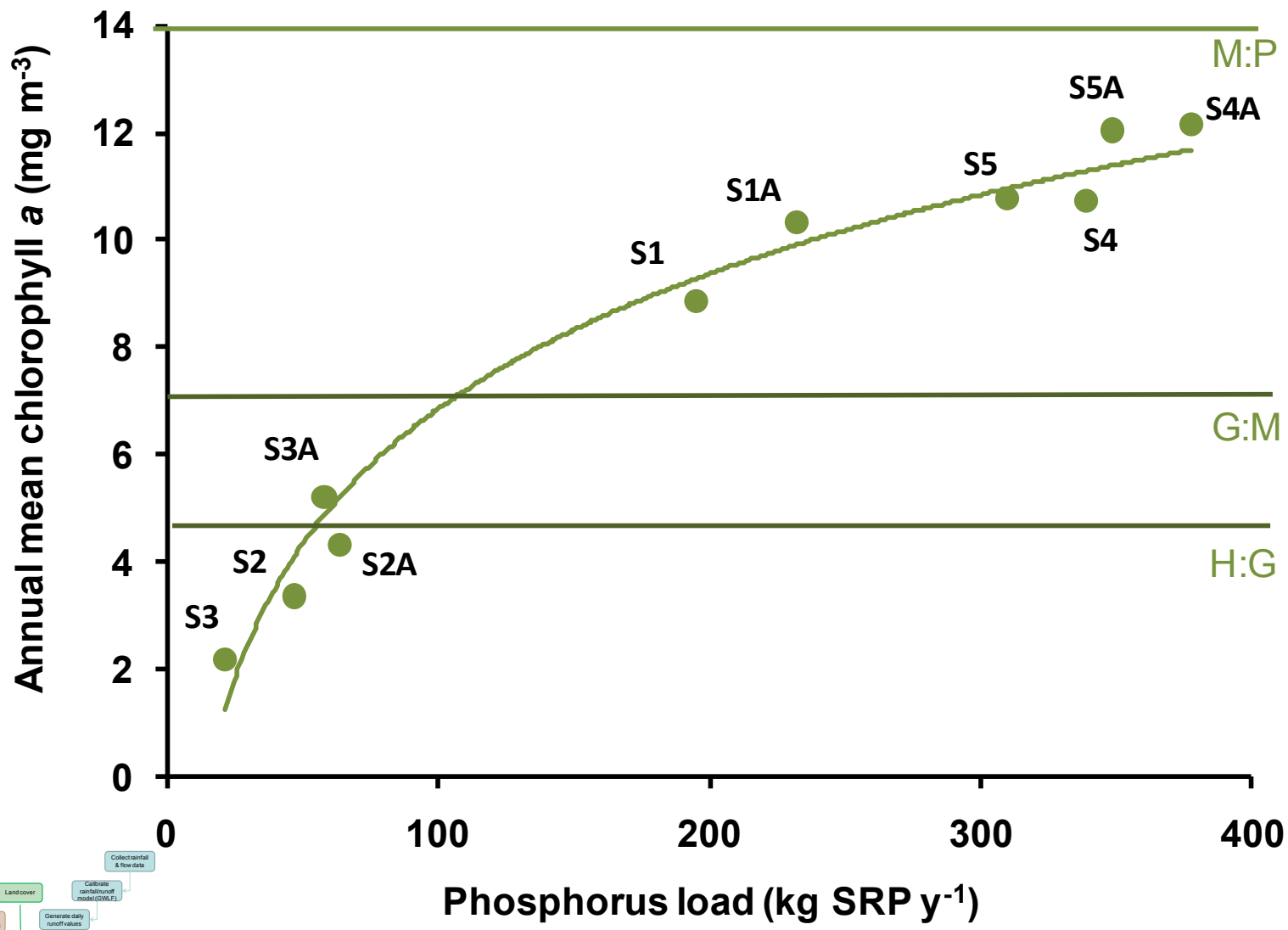


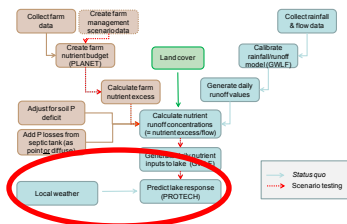
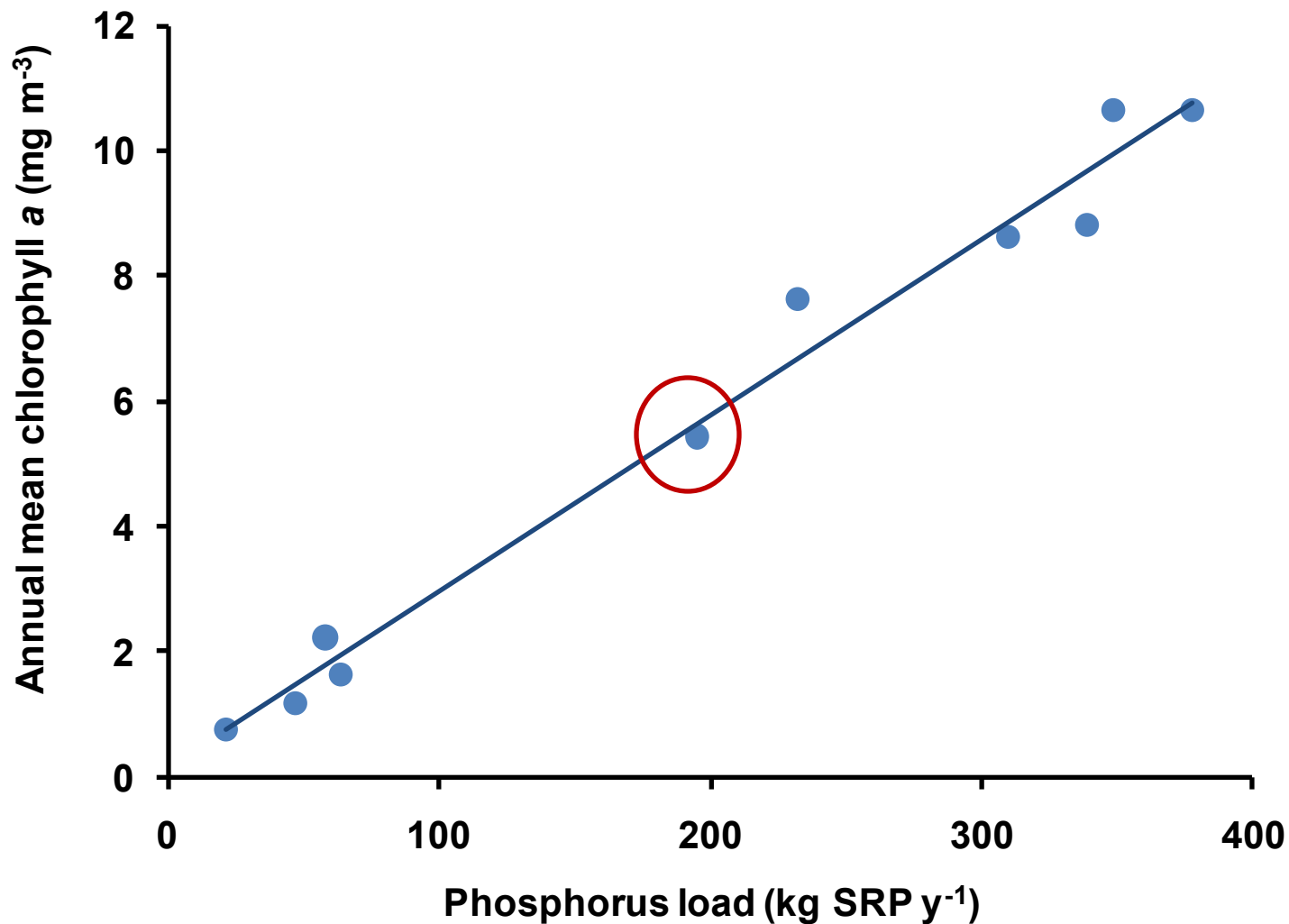


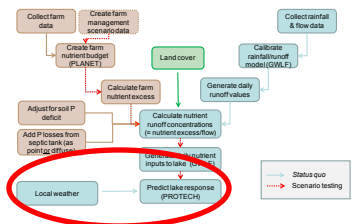
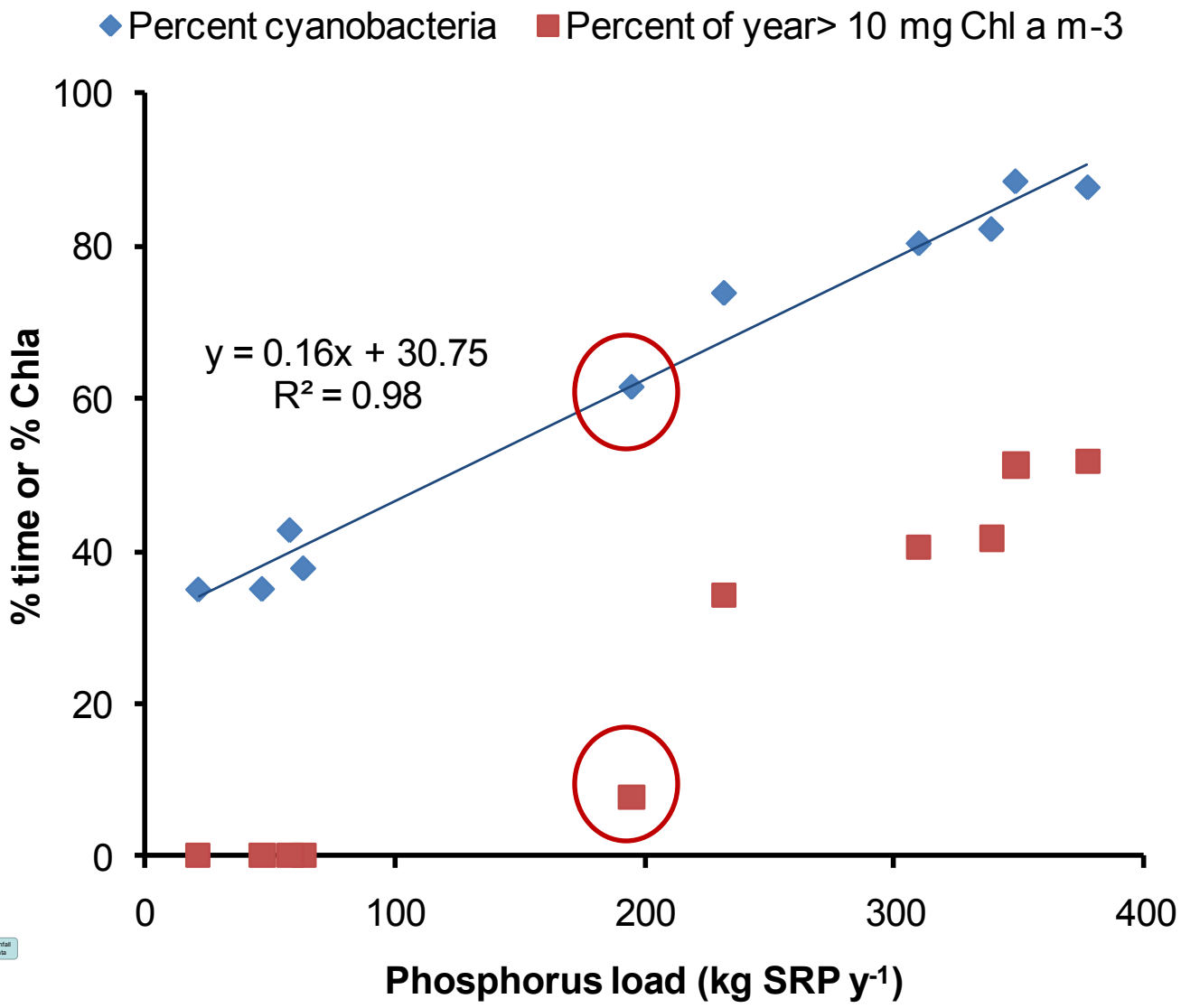




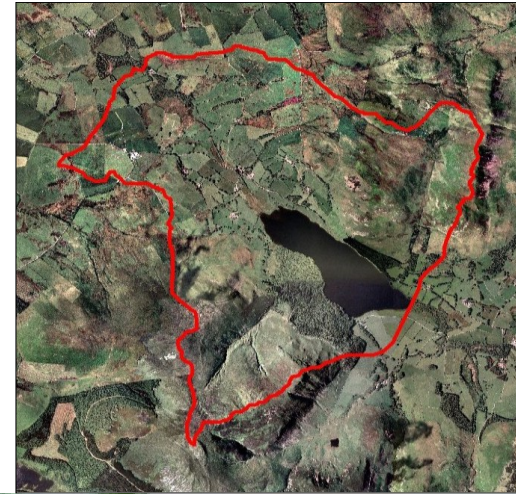








- All models are simplifications of reality but, despite the simplifying assumptions and inevitable non-perfect data, the three models, PLANET, GWLF and PROTECH were successfully linked to produce a reasonable simulation of the effect of the land on the lake
- Currently, observations and models suggest that the lake is at moderate ecological status for WFD with a total annual load of about  $200 \text{ kg P y}^{-1}$ .
- The models suggests that if the load was halved, the lake could be brought to good ecological status (time.....). The model could be used as a tool to inform future land-management decisions.
- Septic tanks have a relatively small effect on P and phytoplankton today, but- they can be improved without major changes to way of life and would become increasingly important if P-losses from the land were reduced.



- Discuss these and other scenarios
- Are there any actions that LCP could instigate following on from the modelling?
- Sources of funding for further improvements (septic tanks, slurry/ waste management)
- Known unknowns
- Can it help with the 'tension' between economy and ecology?
-

