

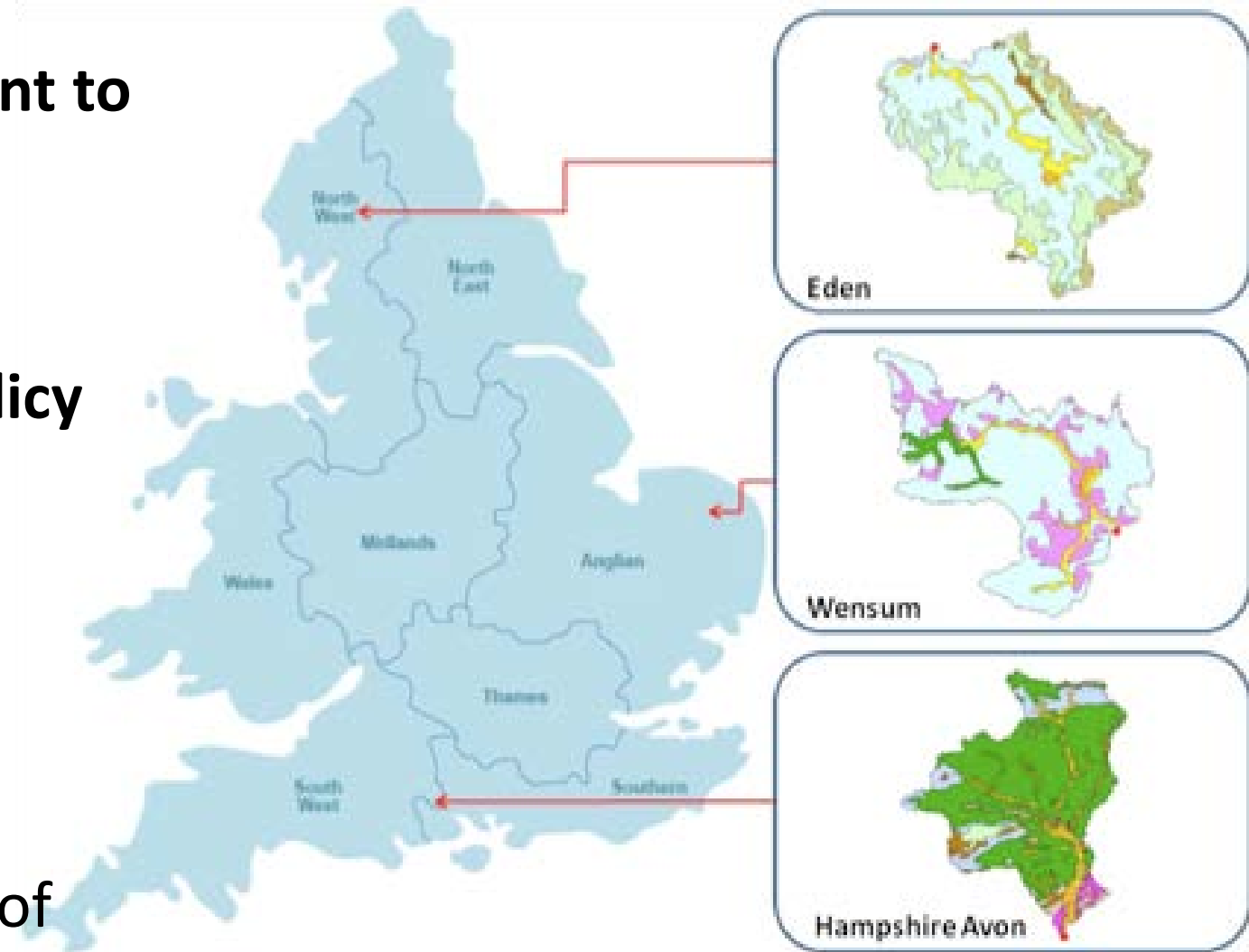
Modelling flow pathways, sediment and phosphorus fluxes in two contrasting headwater catchments using high frequency monitoring data

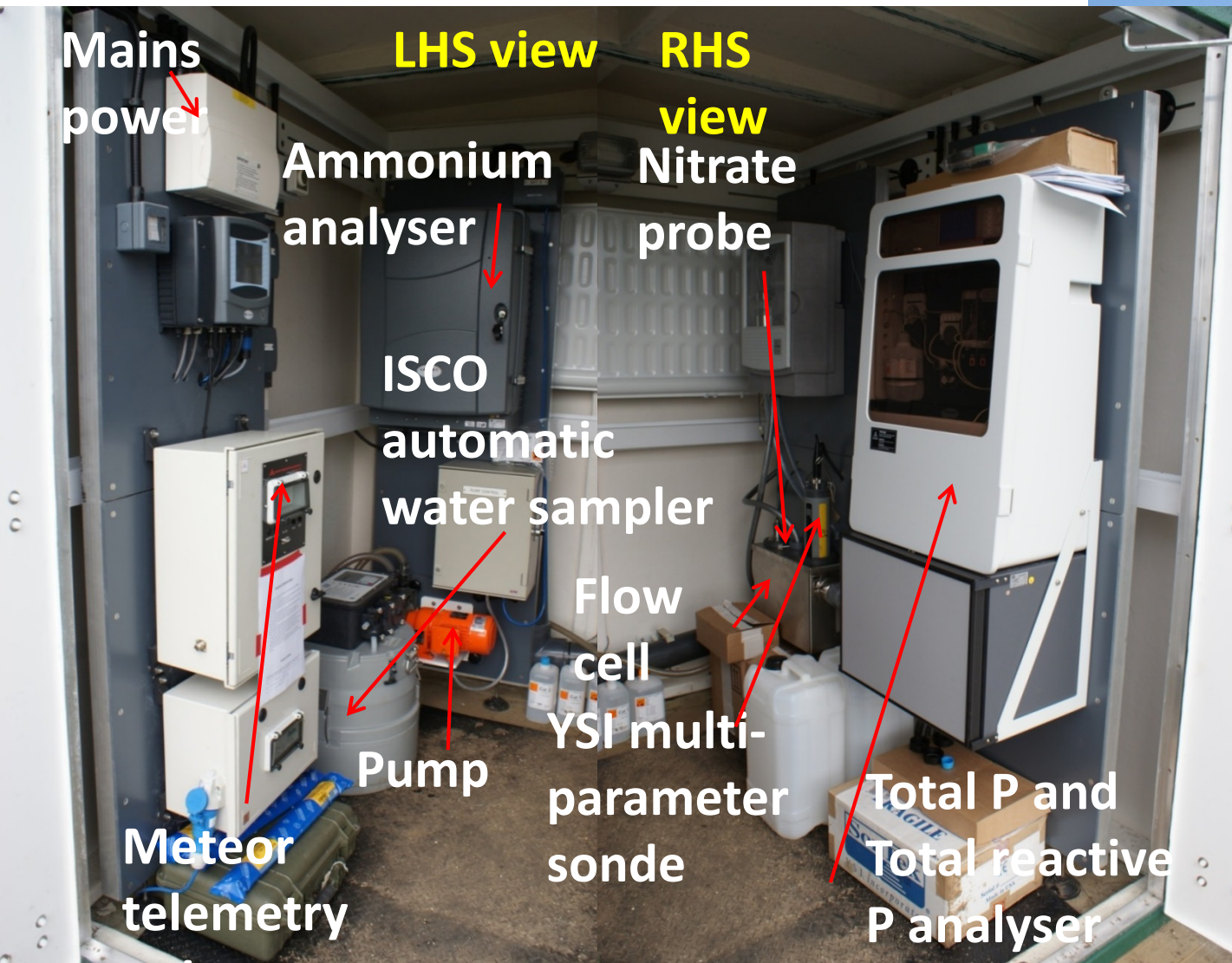
Dr Russell Adams, *Dr Paul Quinn, Dr Nick Barber*



What are “Demonstration Test Catchments”?

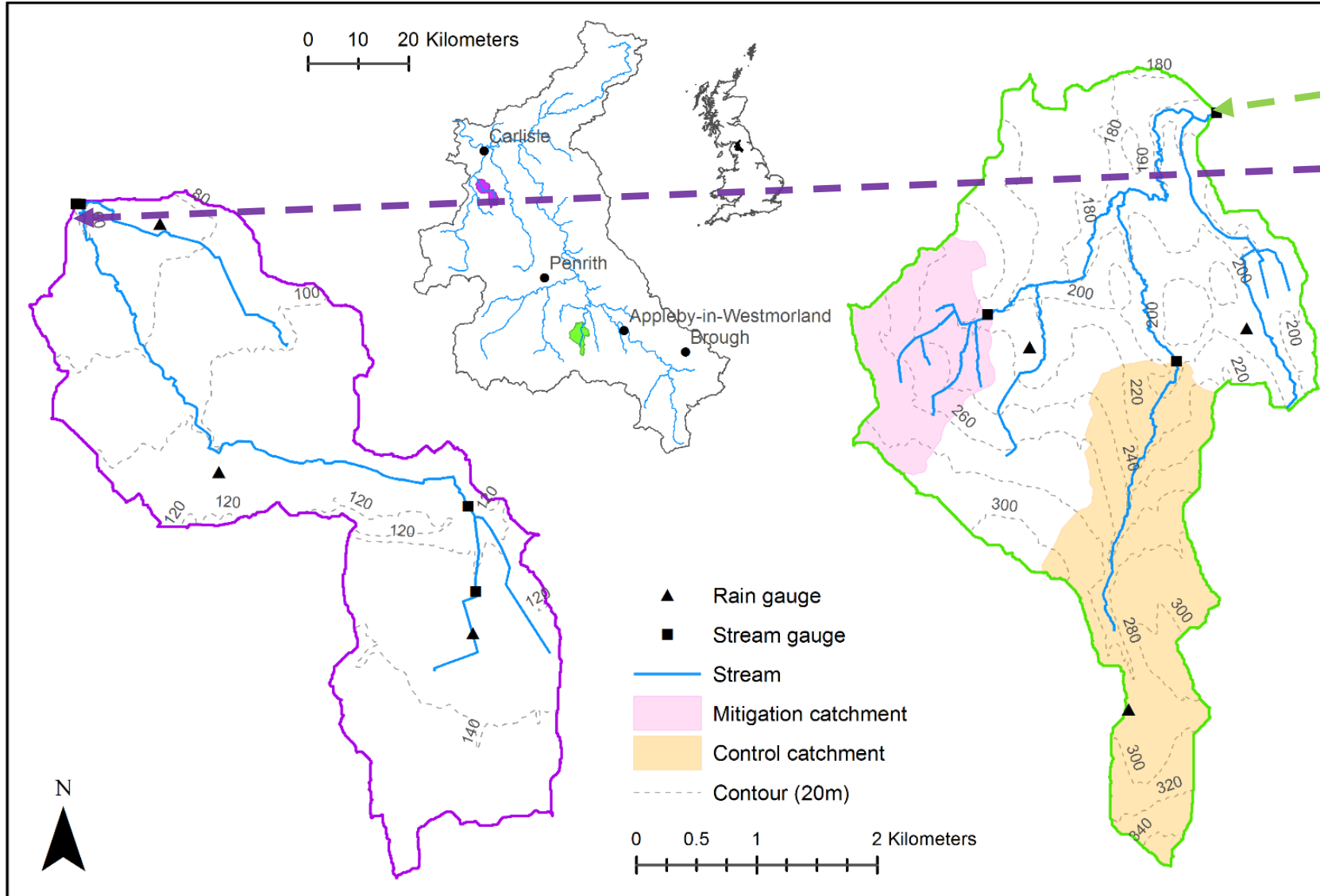
- DTC = ‘**Catchment scale experiment to evaluate policy tools**’ across 3 catchments in UK.
- ‘Evidence based evaluation of policy tools’
- ‘Observatory’
- Integration of datasets
- To serve Policy & Science
- Is it possible to reduce the impact of agricultural diffuse water pollution cost-effectively while maintaining food security?





High specification kiosks

Case Study Overview: Newby Beck & Pow Beck (Eden DTC)

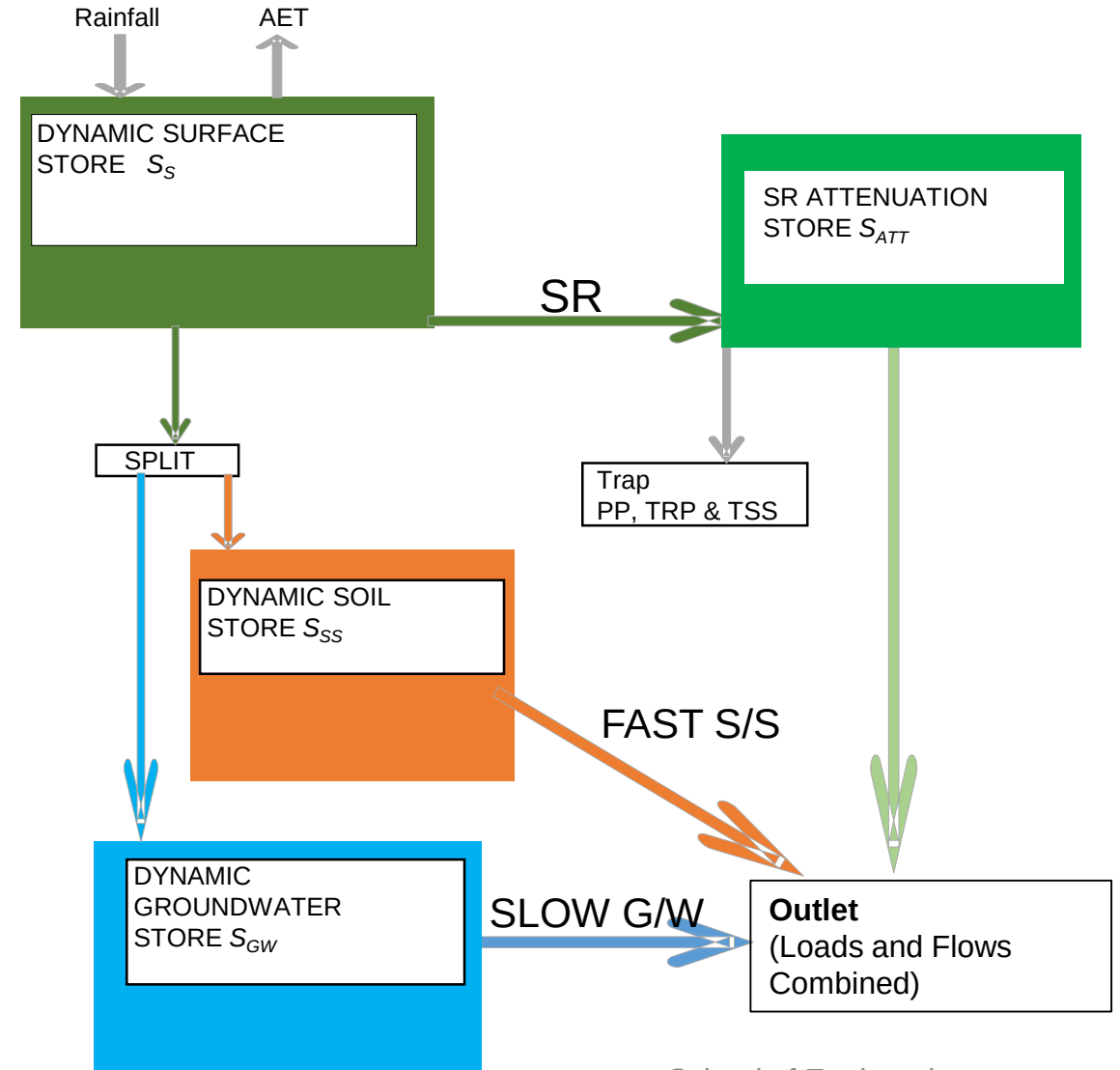


- The CRAFT runs over the entire **Newby Beck** Catchment (12.5 km²) and entire **Pow Beck** Catchment (10.4 km²)
- Similar land-use and climate.
- Different soils and geology
- Farming more intensive in PBC (pigs, poultry etc)

Catchment Runoff Attenuation Flux Tool (CRAFT)

Overview

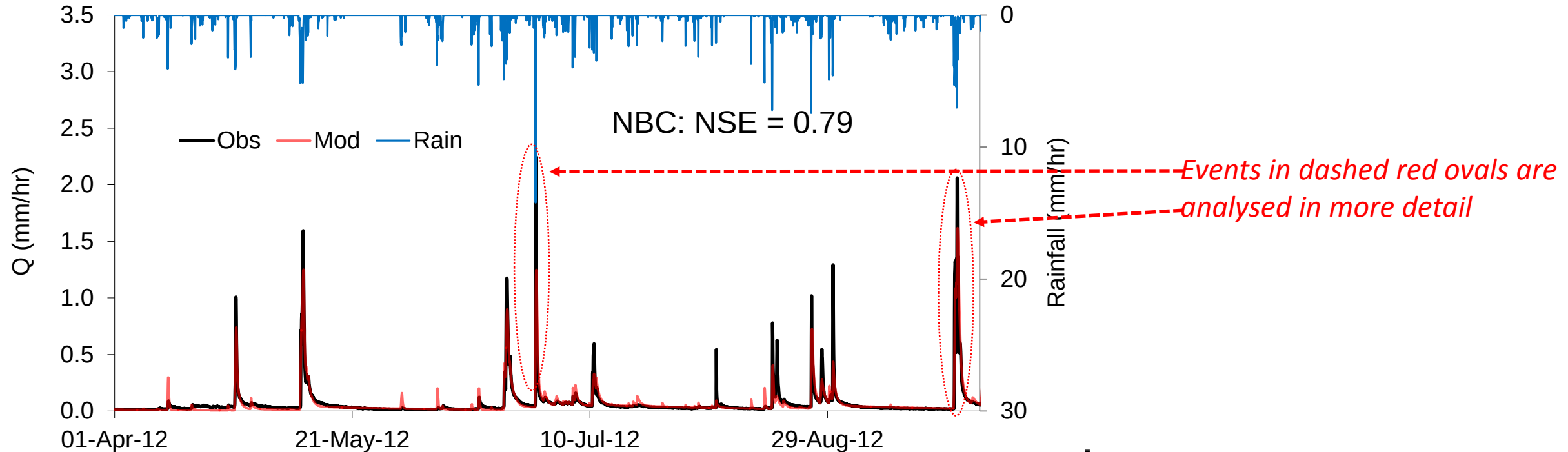
- Flow and nutrient pathways informed by data
- Lumped model with constant Cs in Fast S/S and Slow G/W Pathways, C vs. Q in SR (linear)
- Attenuation can be added to SR pathway, will be used later on.... CRAFT can also remove sediments and particulate nutrients by trapping.



Modelling Overview

- We make use of high resolution data to inform model structure and processes
- Many approaches to calibration: Deterministic (“Expert”) vs. full uncertainty analysis (e.g. GLUE)
- Multi-objective criteria. What to use (Flow, Loads, Concentrations , or a combination of these)?
- Validation important too and often overlooked with nutrient models
- What’s Important in a model? High flows and loads during events obviously?
- Model must inform policy makers in terms of mitigation options down the line

Modelling Results: 1. NBC – “Expert”



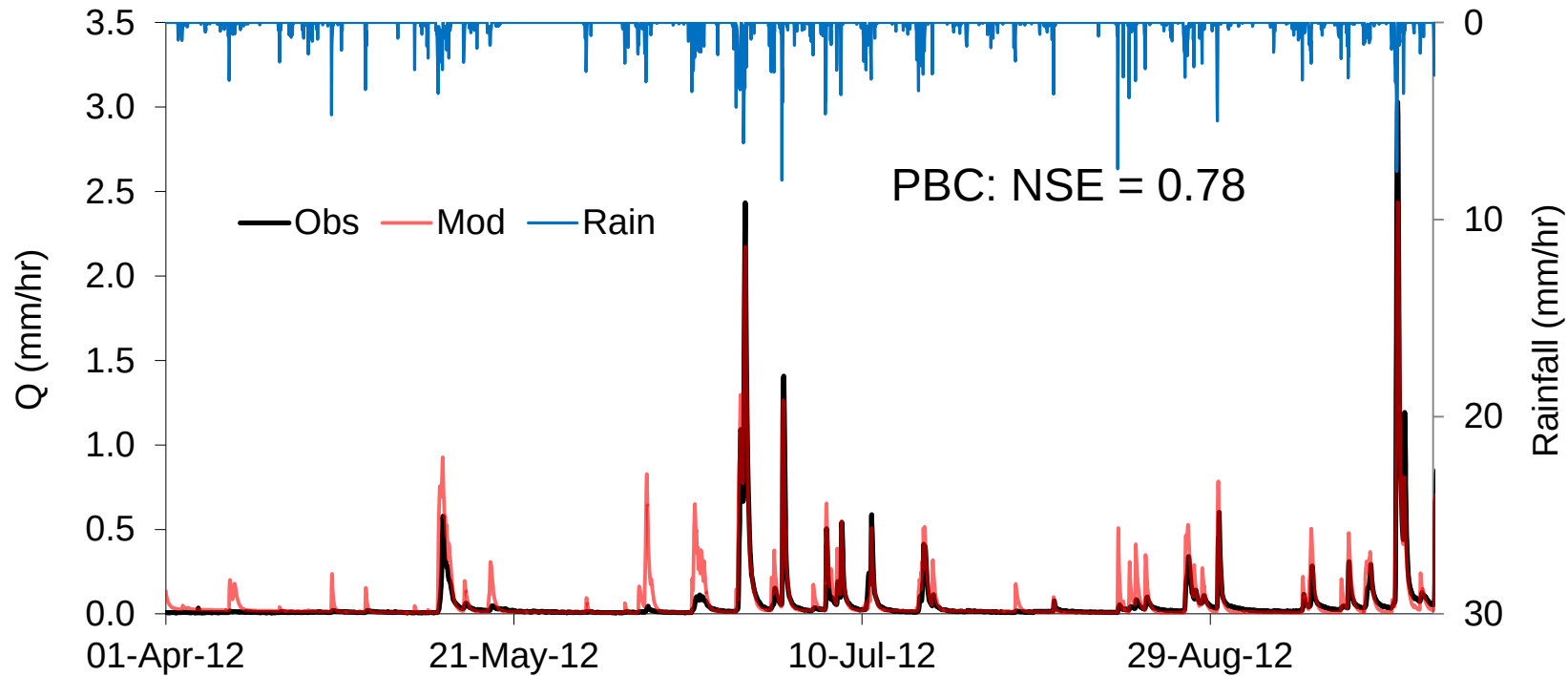
NBC Observed & Modelled Q plus rainfall (blue)

Period 1, calibration

Validation (Period 2) NSE = 0.76

See Adams et al. (STOTEN, 2016) for more details

Modelling Results: 2. PBC -"Expert"



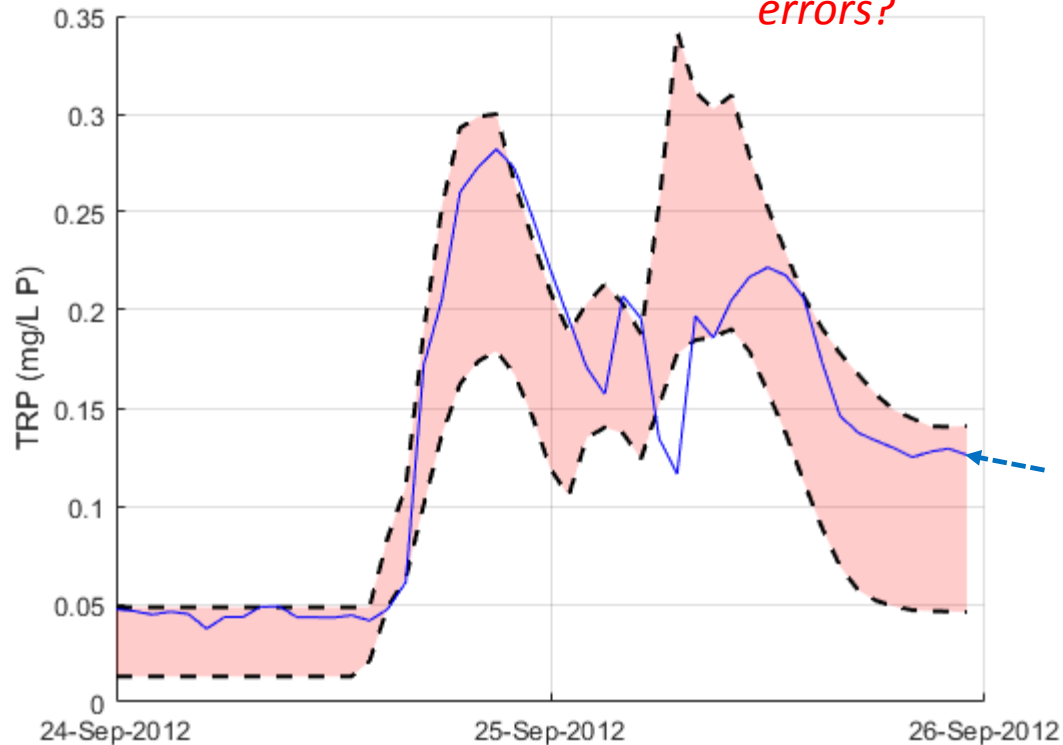
PBC: has reasonably similar hydrological response over these periods to NBC. The CRAFT was recalibrated with a good fit to Q although some over estimation in calibration period.

PBC Observed & Modelled Q plus rainfall (blue)
Period 1, calibration

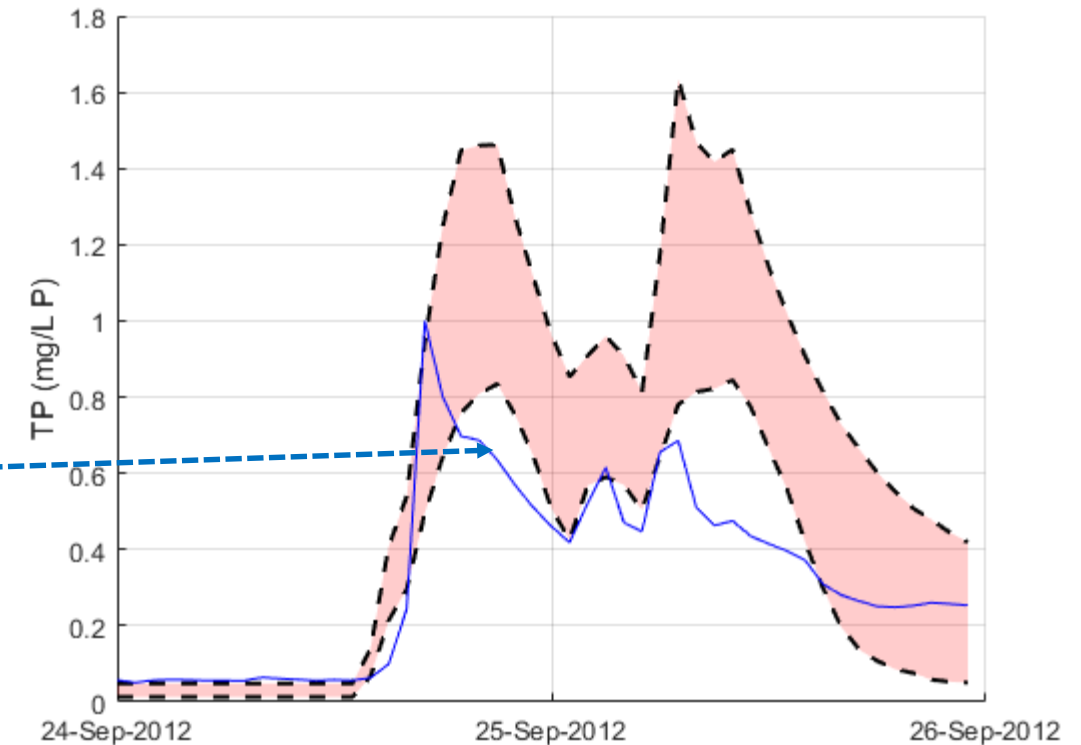
Validation (Period 2) NSE = 0.75

Modelling Results 3: Phosphorus: Single Event at NBC (Multi Objective)

Introduces uncertainty which is popular! Shaded area bounded by 5th and 95th modelled concentration. Blue line shows observed concentrations. Needs uncertainty bounds too due to measurement/equipment errors?



Observed



Modelling Results 3: Example of Multi-Objective calibration (for TP)

1. NSE (TP Concentration) ≥ 0

2. Load Error (TP) $< \pm 20\%$

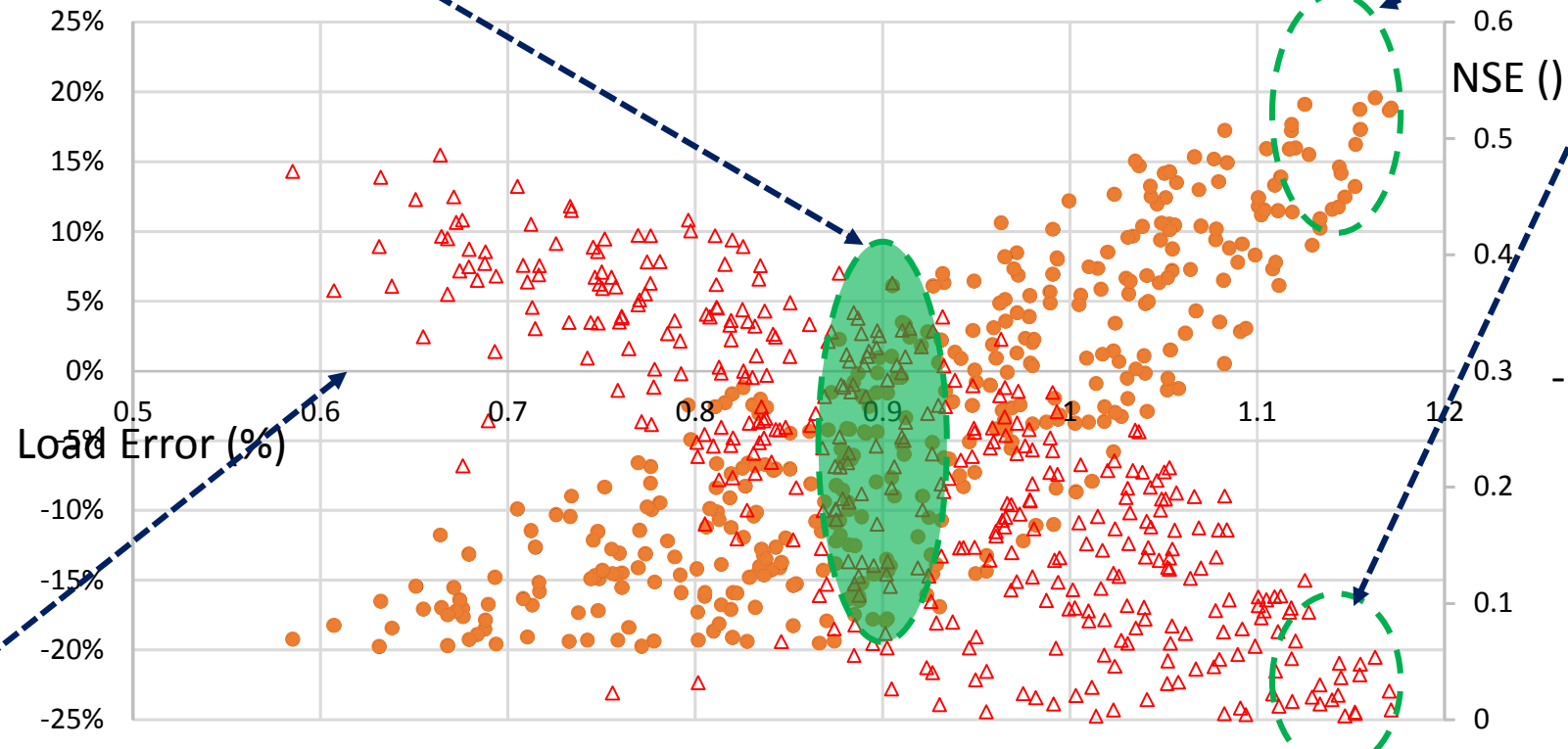
20000 Model Runs

“Expert” value 0.9 informed by multiple simulations

NBC

High Parameter values overpredicts TP Load and NSE Tends to zero

● LE(TP) ▲ NSE



$K_{SR}(PP)$ Parameter

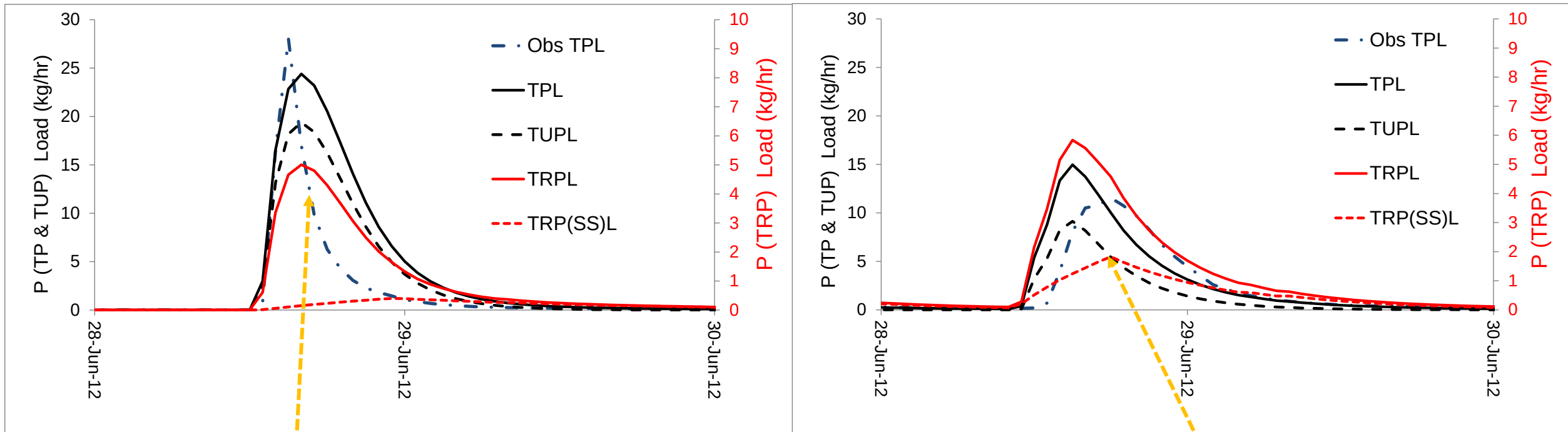
(gives concentration of PP in Surface Runoff Pathway $CSR(PP) = q_{SR} \times K_{SR}(PP)$)

Modelling Results 4:Phosphorus: Loads

*P Loads are important. When planning Mitigation Measures to reduce them, Surface Runoff pathway is easiest to target
CRAFT supplies loads by flow pathway. Plots show Fast S/S load and total load from model (TP & TRP) and Observed TP Load*

NBC

PBC

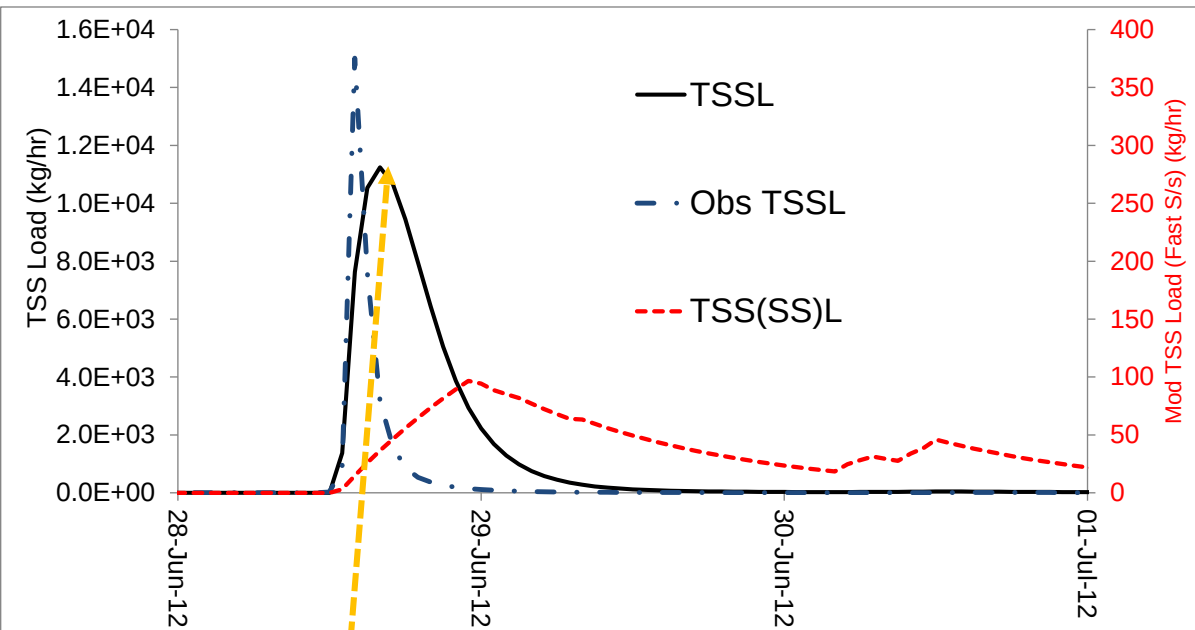


- NBC: Observations indicate flashy TP dynamics with sharp peak in load, rapid decrease follows.
 - PBC: Event dynamics appear to be different to NBC, more lag observed in TP load
 - Most of the TP in the NBC is in the form of TUP (i.e. particulate)
- The TRP load in the fast S/S pathway is about 5 times greater in the PBC than in the NBC during this event.

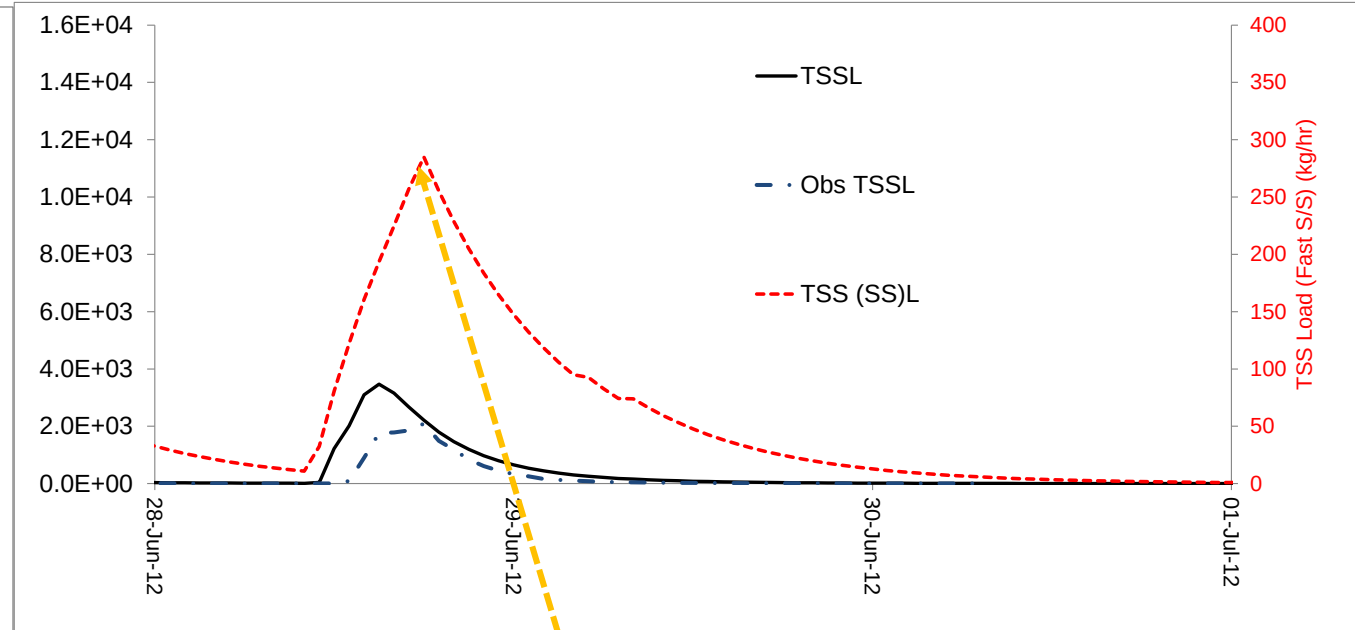
Modelling Results 5: Suspended Sediment (SS)

*SS Loads are important. When planning Mitigation Measures to reduce them, Surface Runoff pathway easiest to target
CRAFT supplies loads by flow pathway, here we show Fast S/S load and total load*

NBC

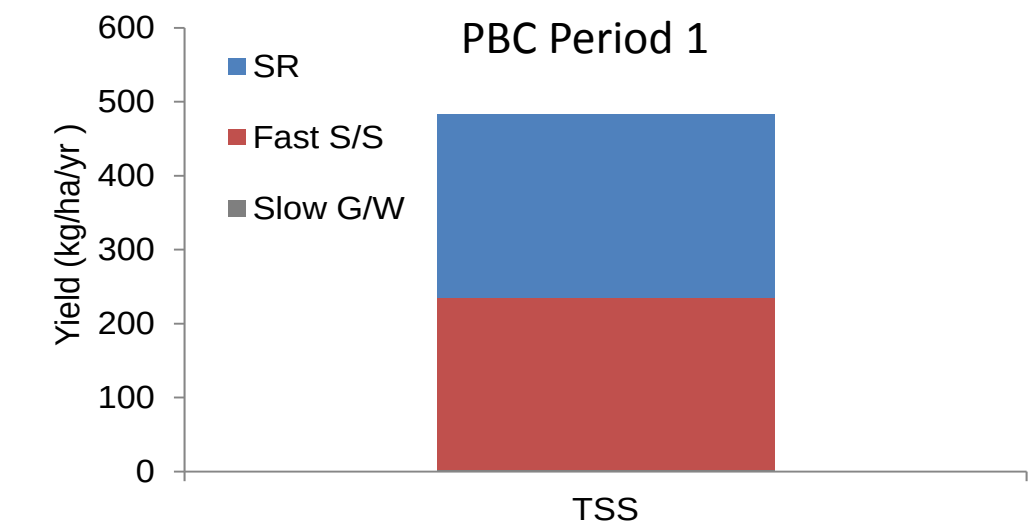
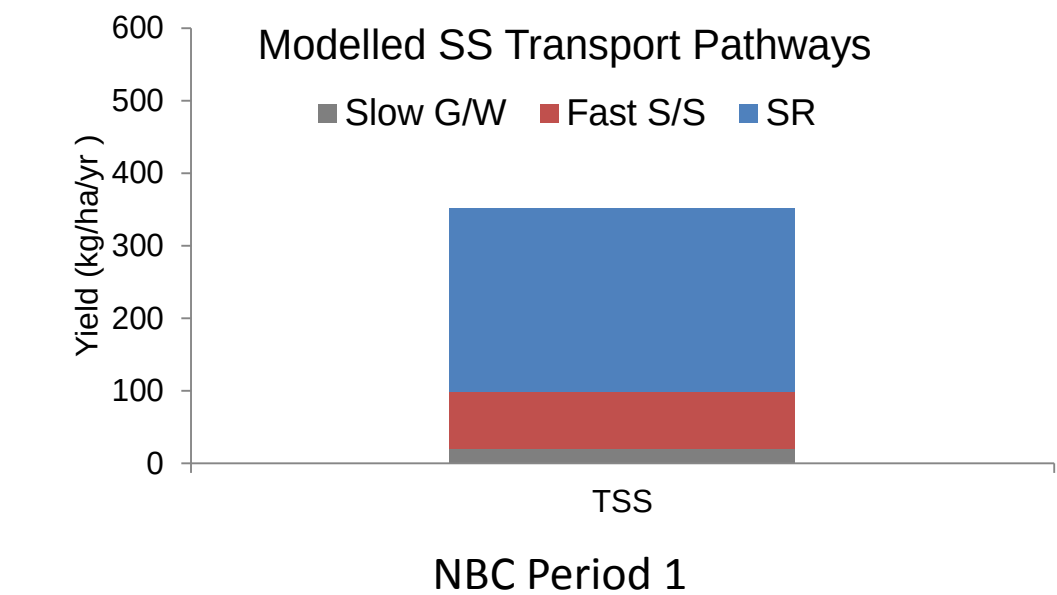
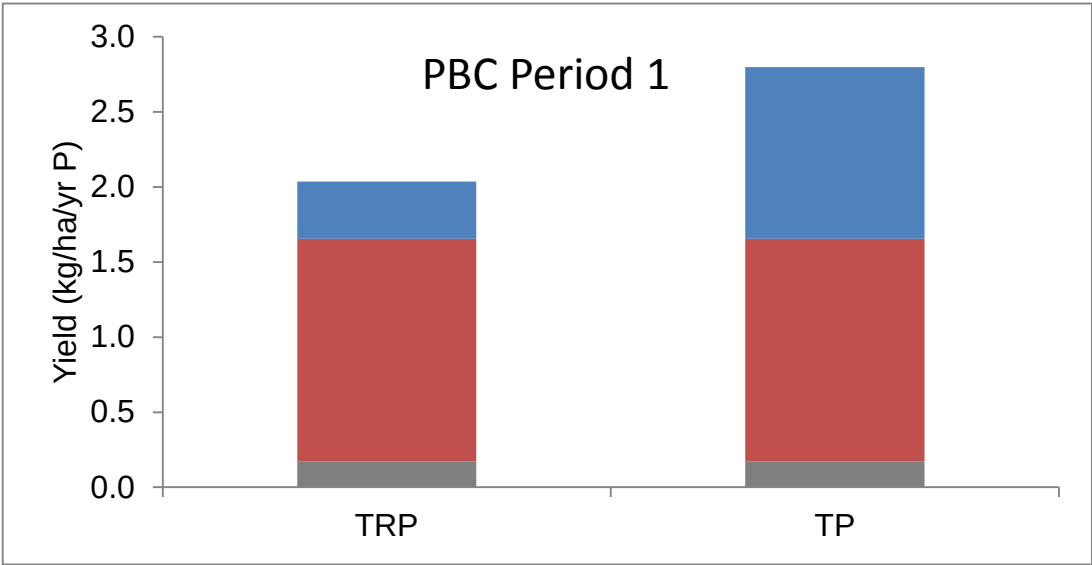
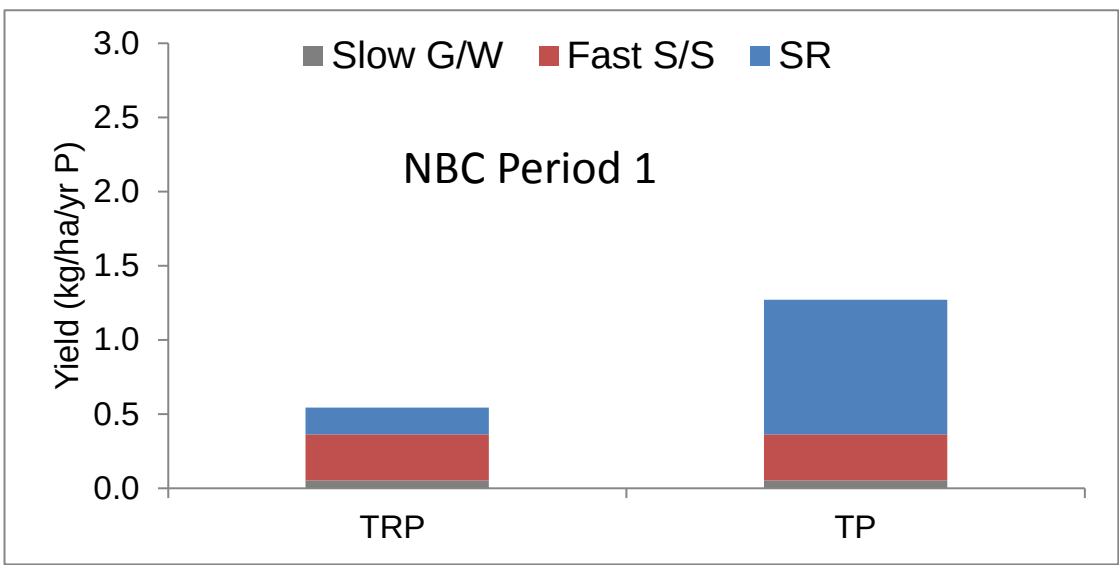


PBC



- NBC: Left pane, SS and TP event dynamics are similar. Model response more damped.
- PBC: Right pane, small event in terms of SS export from Pow. Fast S/S component higher than in NBC for this event but SR component lower

Modelling Results 6:Smart Export Coefficients



Conclusions

- The two catchments are hydrologically similar (runoff)
- Flow pathways and P export differ (PBC > NBC in terms of TRP)
- Fast subsurface pathway in PBC equally important too (For PP and SS)
- Variability in “Smart” export coefficients quite high
- Mitigation options in PBC may be focussed on drain flow and soils to target SRP as well as particulates?
- High-resolution data enables detailed forensics of event P dynamics
- Our capability to model hourly concentrations unmatched by other models to date.

Thank you!

