Understanding water quality issues using high-frequency nitrate and phosphate data in the Wensum Demonstration Test Catchment

Aims: (i) To understand the trends in nitrate and phosphate concentrations under different meteorological and hydrological conditions; and (ii) to use high-frequency data to understand catchment processes including pollutant pathways and fluxes.

Experimental design:

The 'high-spec' monitoring kiosk at Stinton Hall Farm on the Salle Estate is situated downstream of around 700 hectares of arable fields, including 143 ha of mitigation measures fields.

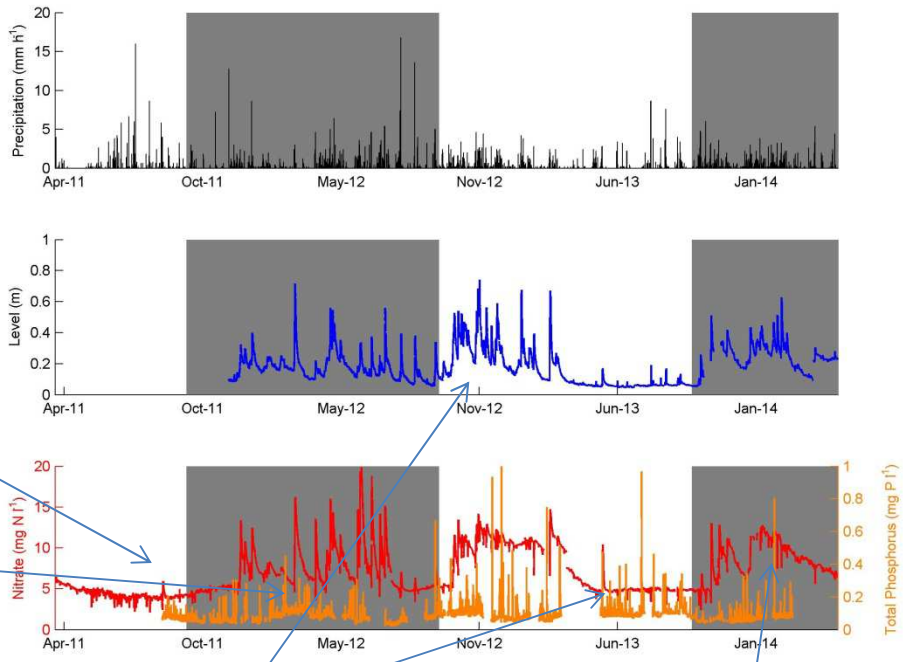
Data collection:

Nitrate and phosphate (total phosphorus and total reactive phosphorus) measurements are made using equipment in the bankside kiosk at Stinton Hall Farm on a half-hourly basis, alongside measurements of flow and other parameters including turbidity (for an estimation of sediment transfer), dissolved oxygen, ammonium, temperature and conductivity.

Three years of high-resolution data from April 2011 - 2014

- During the three years of high-frequency monitoring, the Wensum DTC has captured a large range of meteorological and subsequent hydrological conditions, which have had a profound effect on stream nitrate and phosphate concentrations.

- April 2011 – February 2012 was extremely dry, which was followed by an extremely wet summer period. This resulted in large nitrate peaks and small but frequent phosphorus peaks. Dry periods are likely to lead to accumulation of nitrate and phosphate in the soil which is then flushed when rainfall does occur.



Complete hydrological years are marked from October - September

- The hydrological year of Oct 12 – Sept 13 was a very wet winter, which resulted in fewer individual nitrate peaks but a more sustained concentration increase. The dry summer resulted in very low nitrate concentrations. The high winter flows caused regular peaks in TP which was also highly mobilised by small storms in the summer.

- So far, the hydrological year of Oct 13 – Sept 14 has been similar to the previous year with sustained nitrate concentrations and regular TP peaks throughout the winter period.

Detecting catchment processes

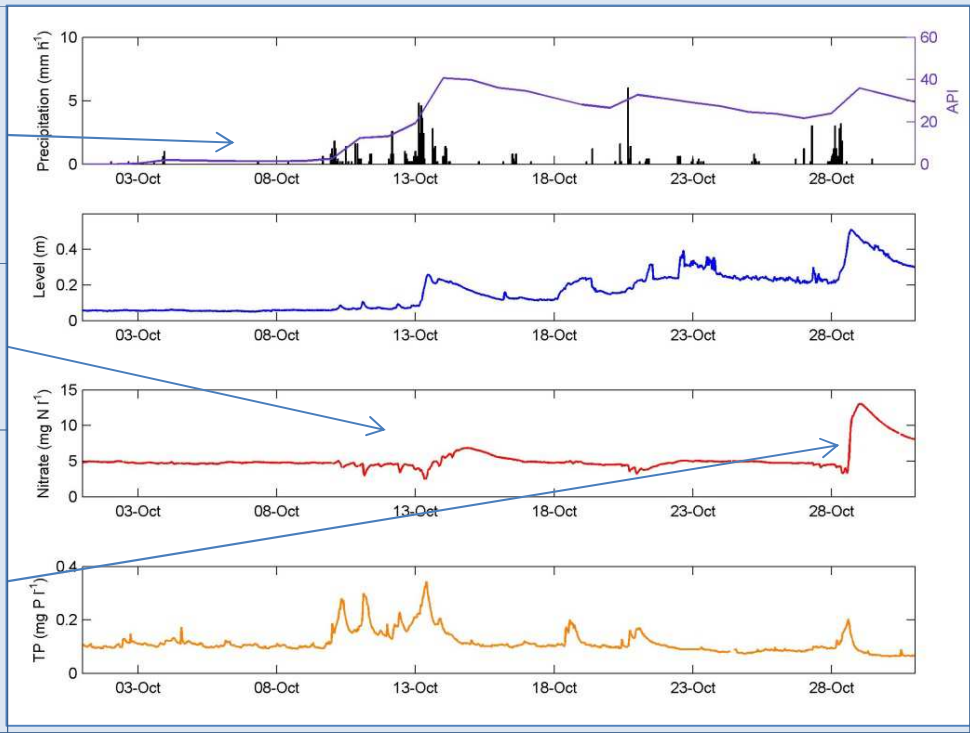
'Wetting up' of the catchment in October 2013

High-frequency data can be used to identify periods of 'wetting up' when precipitation leads to greater levels of saturation in the catchment, which in turn leads to connectivity of pollutant pathways, as observed in October 2013.

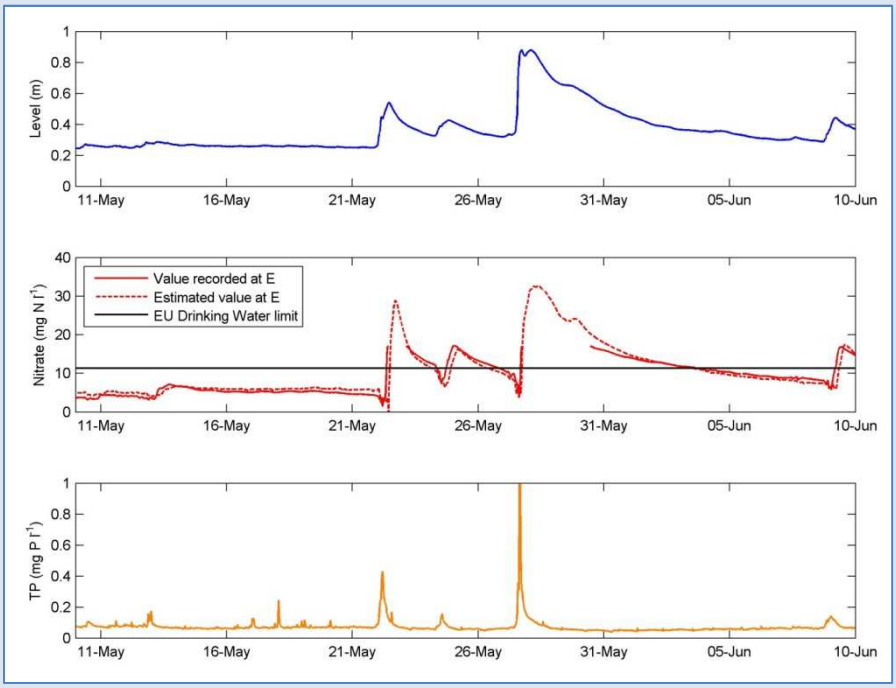
- Dry start to the month with very little rainfall.
- The Antecedent Precipitation Index (API) showed that soil conditions were dry.
- Little variation in nitrate or phosphorus concentrations.

- Small peaks in water level in response to initial rain as the catchment wets-up resulted in large TP peaks but dilutions in nitrate.

- As catchment saturation increased further, an increase in water level resulted in a large nitrate peak (or 'flush') as field drains began to run continuously.
- TP peak was smaller despite larger flow event probably due to exhaustion from previous events.



Large nitrate flushing event in May-June 2014



These large fluxes are due to a combination of: spring fertiliser applications, dry conditions, warm temperatures resulting in mineralisation of organic residues and N-fixation from spring beans, all of which lead to a build up of nitrogen in the soil. The amount and intensity of rainfall resulted in flushing of this stored nitrogen.

- Between 20-28 May 2014, 86 mm of rain fell, more than the monthly average.
- This caused a large increase in nitrate concentration, which went beyond the detection limit of 20 mg N/L of the nitrate probe in the kiosk.
- Peak nitrate concentrations have been estimated in the figure by comparing with nitrate concentrations from a second high-spec kiosk downstream.
- Although these peak concentrations are estimated, it is likely that they were around 30 mg N L^{-1} for several days, which is almost three times higher than the EU drinking water standard.
- An extremely high TP peak of 1mg P L^{-1} was also observed.
- Nutrient fluxes for this period are around 6500 kg of N and 35 kg P.
- These losses are equivalent to ~9 kg N per hectare and 0.05 kg P per hectare over the space of a few weeks.

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