

Catchment Conference 2019

Causes of phosphorus elevations during low-flows across three contrasting watercourses

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AGRICULTURAL CATCHMENTS PROGRAMME

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An Roinn Talmhaíochta, Bia agus Mara

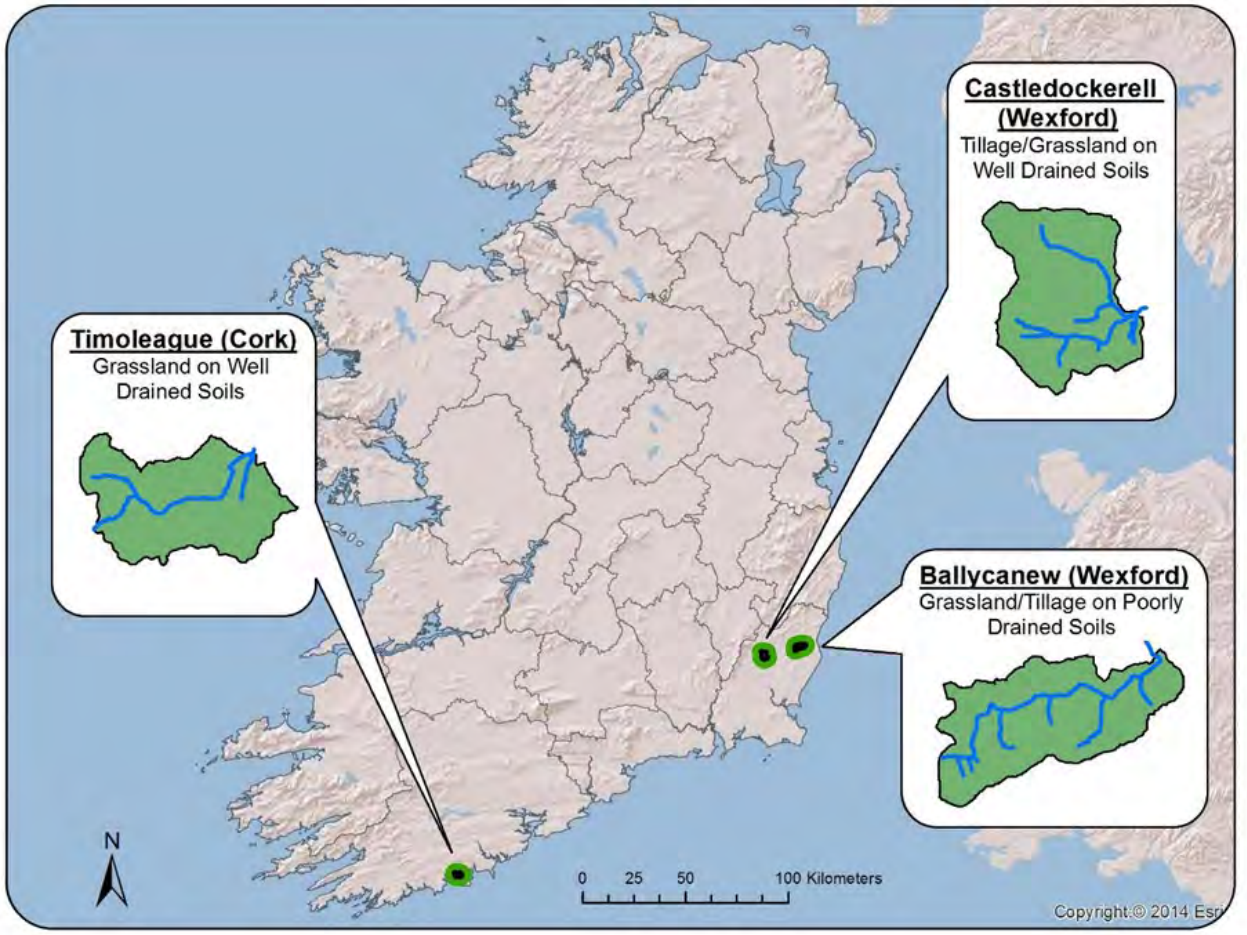
CatchmentCARE
Community Actions for Resilient Ecosystems

Chemical Thresholds for Surface Water

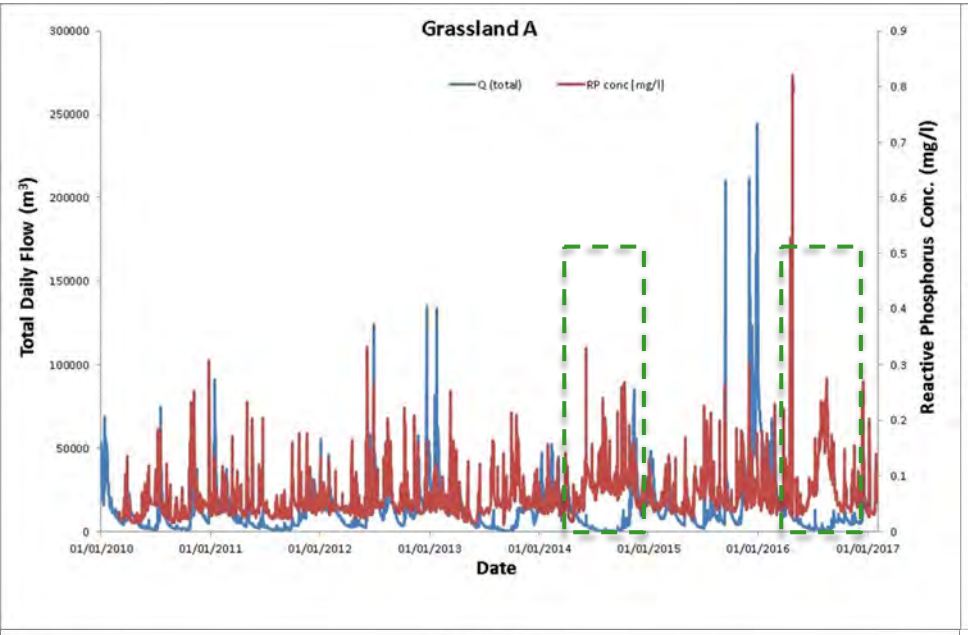
In mg/l annual mean

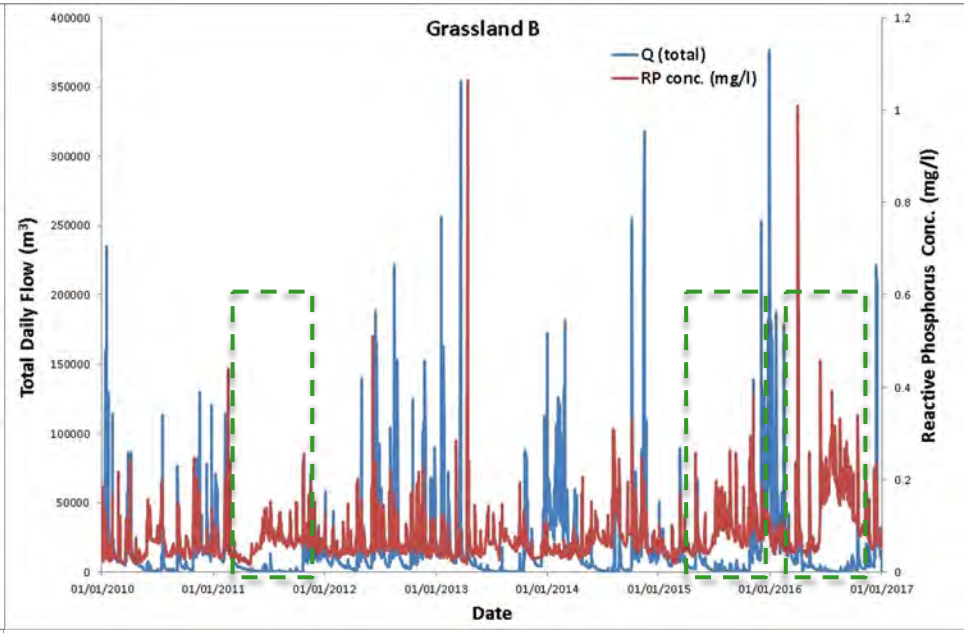
Total Reactive Phosphorus
>0.035
0.025-0.035
<0.025

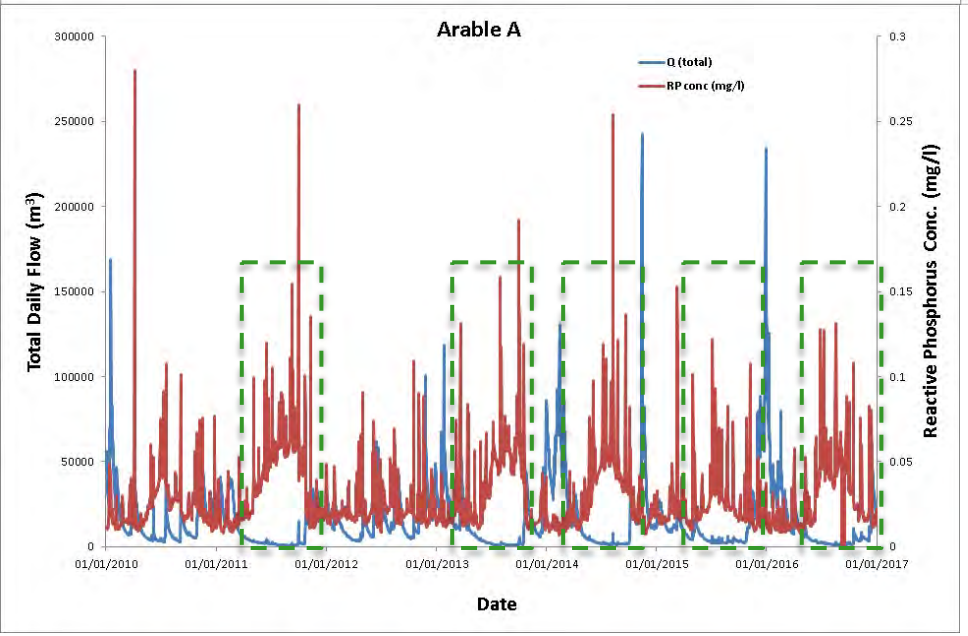
- Timoleague
- Ballycanew
- Corduff
- Dunleer
- Castledockerell



 Vero et al., 2019. Water. 11. doi:10.3390/w11071497







Average Low-Flow RP Conc.

Grassland A – 0.063 mg/l
Grassland B – 0.084 mg/l
Arable A – 0.045 mg/l

- Av. 110 days low-flow per year
- Ecologically sensitive periods

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What is elevating P at low-flows?

Framework of Hypotheses			
	1	2	3
Hypotheses	Source-Pressures	Pathways - Meteorology	Biochemical - Mobilisation
	Increased pressure on facilities (yards, septic tanks) Persistent point sources	Leaching of soil P accelerated by antecedent rainfall, bringing existing P nearer to the receptor Lack of dilution during low-flow	Release of P from a) sediment column and/or b) riparian zone
Questions	What areas/sources are contributing? Why is it occurring at low flows – dilution?	Is there a time lag – how long?	What is the mechanism of release?


Synoptic Survey

- Comprehensive overview of surface-water
- Simultaneous sampling of multiple points
- Identification of ‘active’ stretches during low-flow

Monthly Snapshots	Synoptic Survey
c. 15 points per catchment	c. 50 points per catchment
Set sampling points	5-6 points per km
Overview of catchment across years	Focus on low flow conditions <70th%
Monthly	Spring, Summer & Autumn

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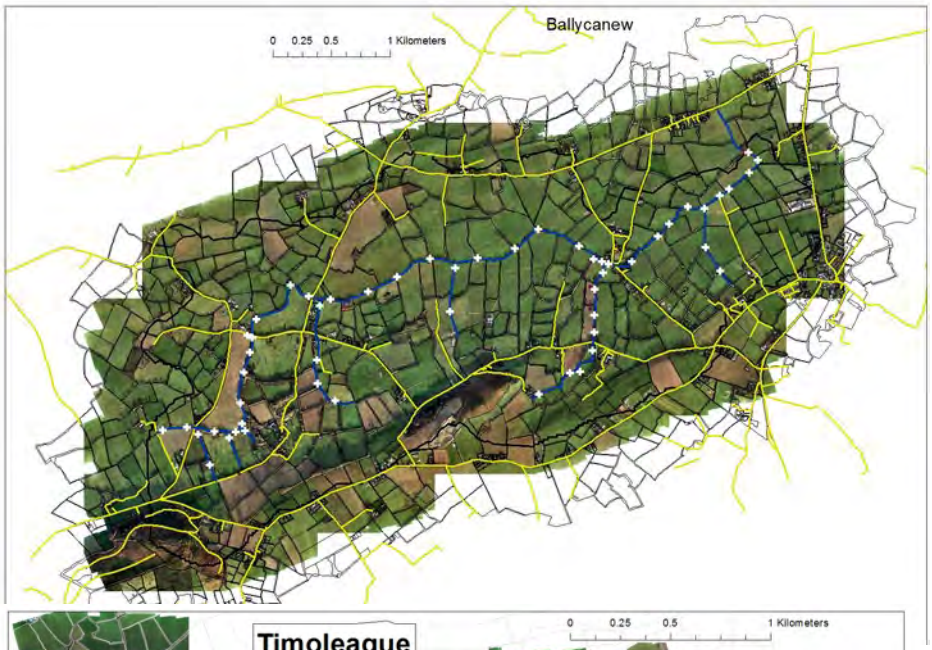
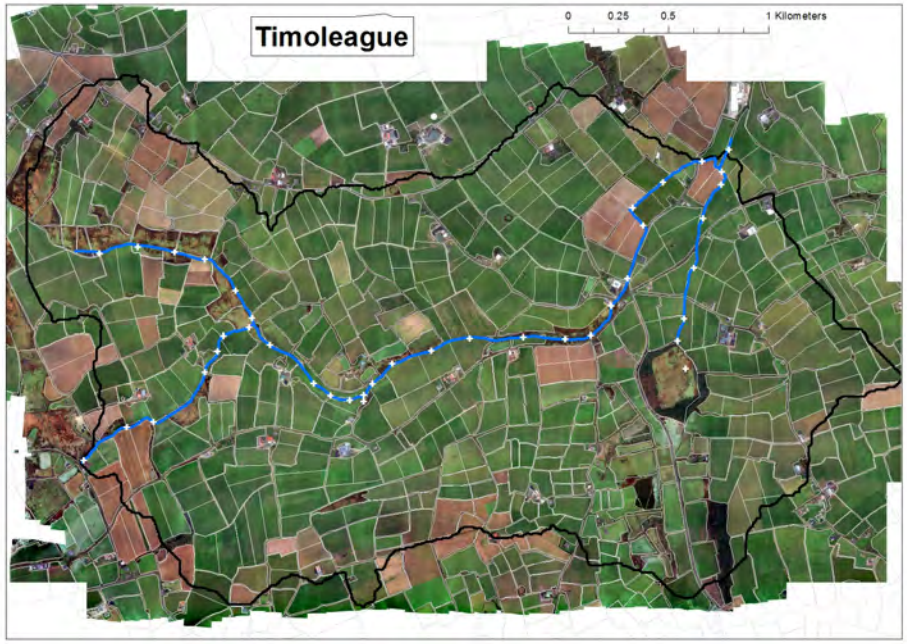
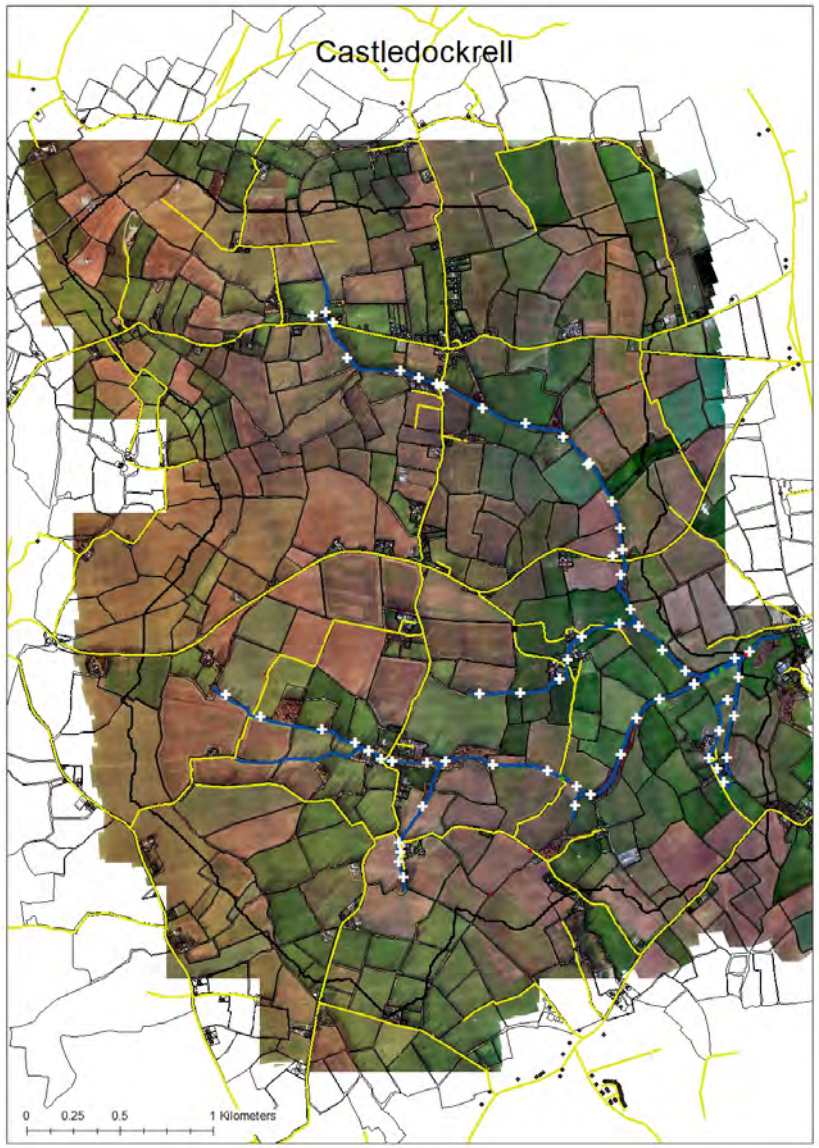
Sample for:

- Phosphorus – Total P, Ortho P (RP), Total Dissolved P (TDP), Dissolved Reactive P (DRP)
- pH, Temperature, Conductivity, Redox Potential (ORP)
- Bed sediment at 7 points per catchment (Summer & Autumn)
  - » Al:P ratios (Daly et al., 2017)
  - » Fingerprinting (Sherriff et al., 2018)
- Field observations of land use & point sources

Our Catchments

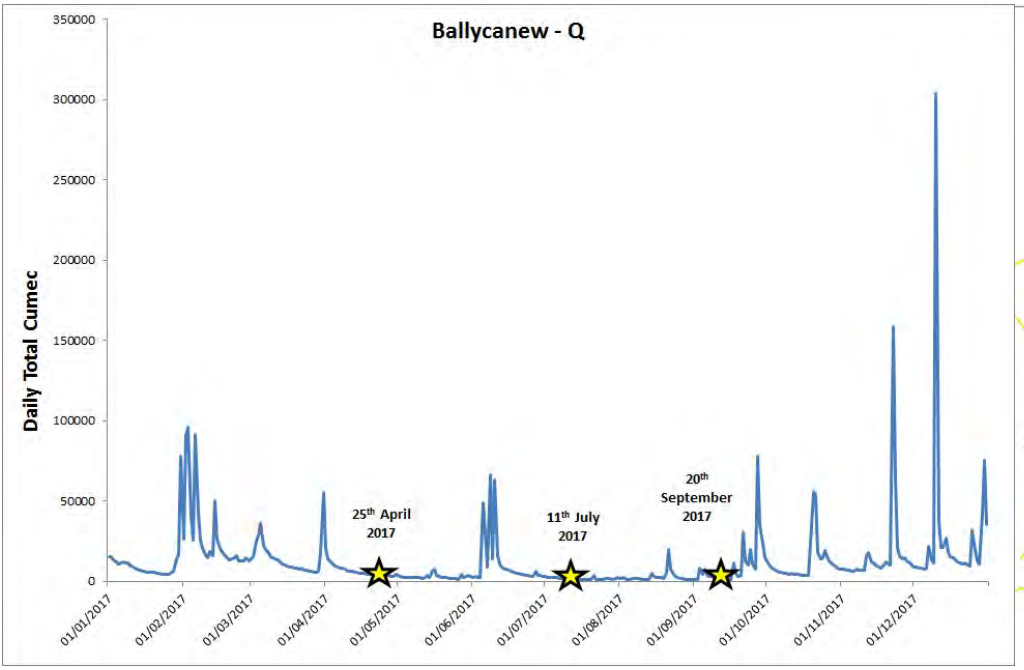


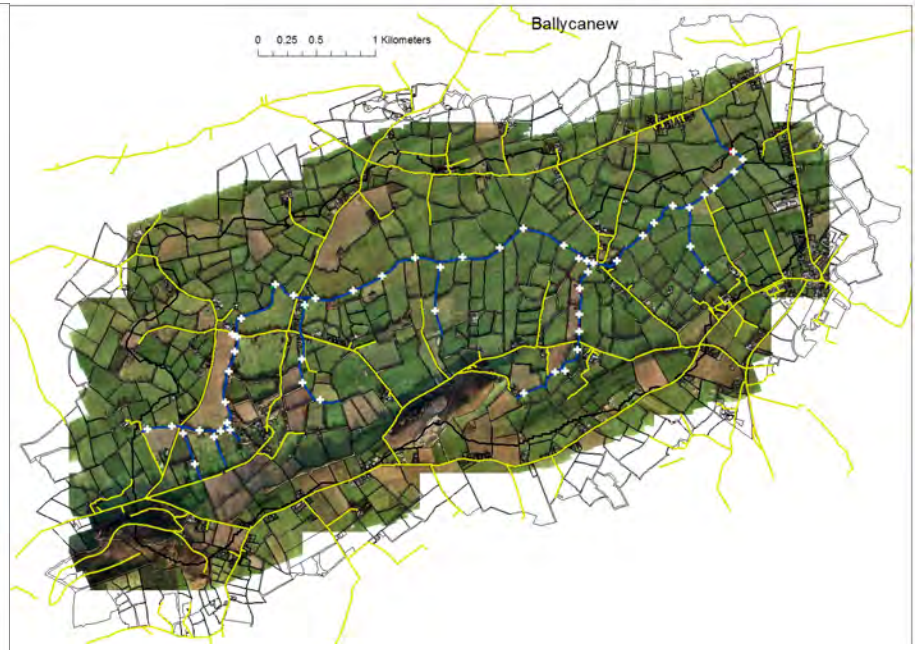




Sampling

Poorly Drained Arable – Ballycanew	
Grassland, some arable	11.9 km^2
One-off residences - various ages	Annual precip – c. 1078 mm
Poorly drained – overland flow	'P-Risky'





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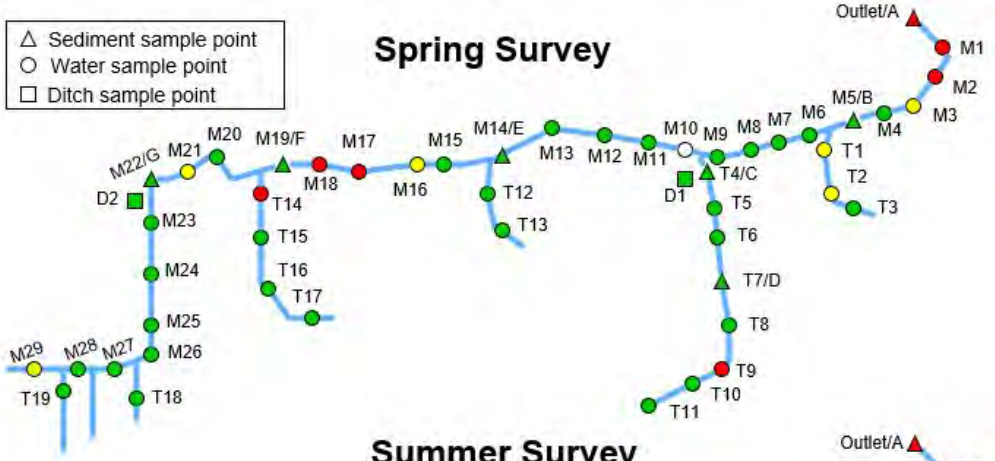

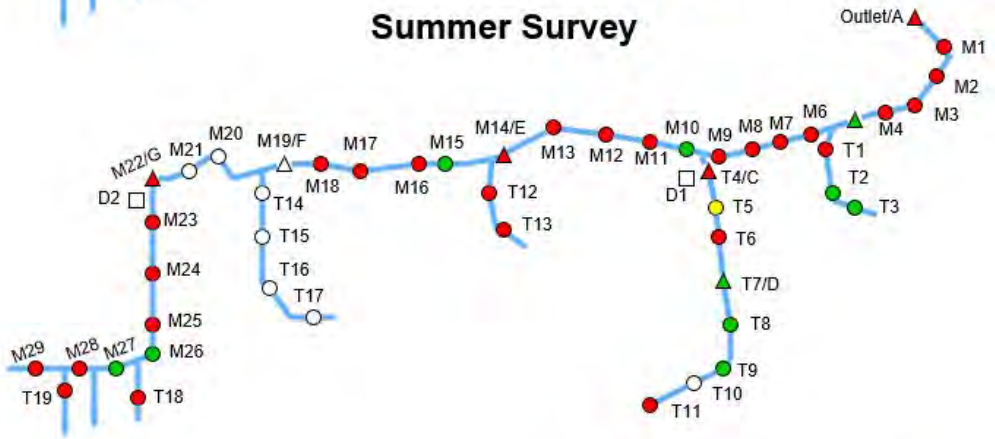

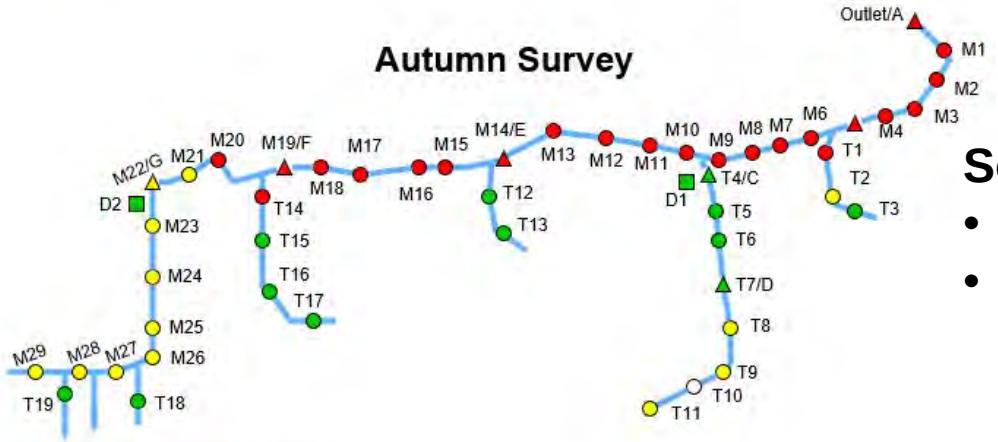

High | Good | Poor | No Sample

Patterns

- Relatively low P in spring reflecting over-winter flushing
- Highest P across watercourse in Summer, declining during Autumn but not as marked as other catchments
- Highest concentrations at outlet = cumulative loading
- Low sediment Al:P ratios suggesting minimal attenuation in-stream

Sources/Pathways

- Runoff (4.1-5.6% catchment area = CSA)
- Persistent point sources
  - Septic tanks
  - Cattle access
  - Yards

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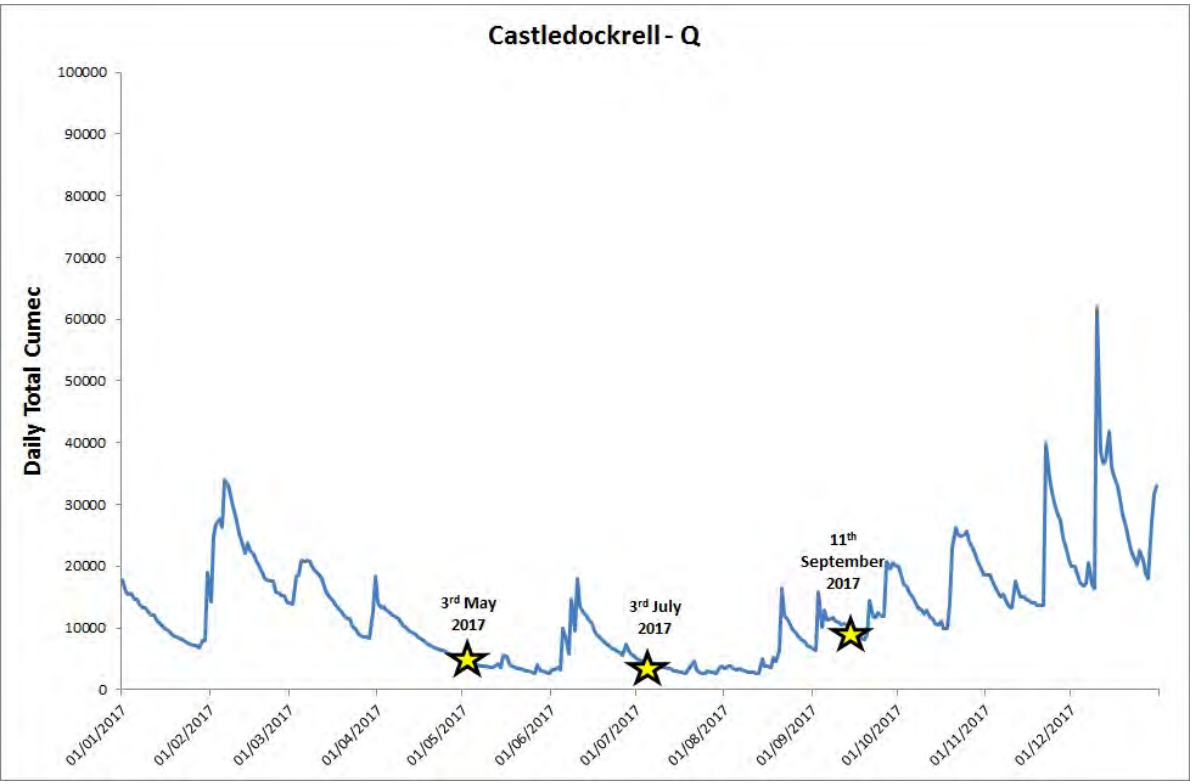
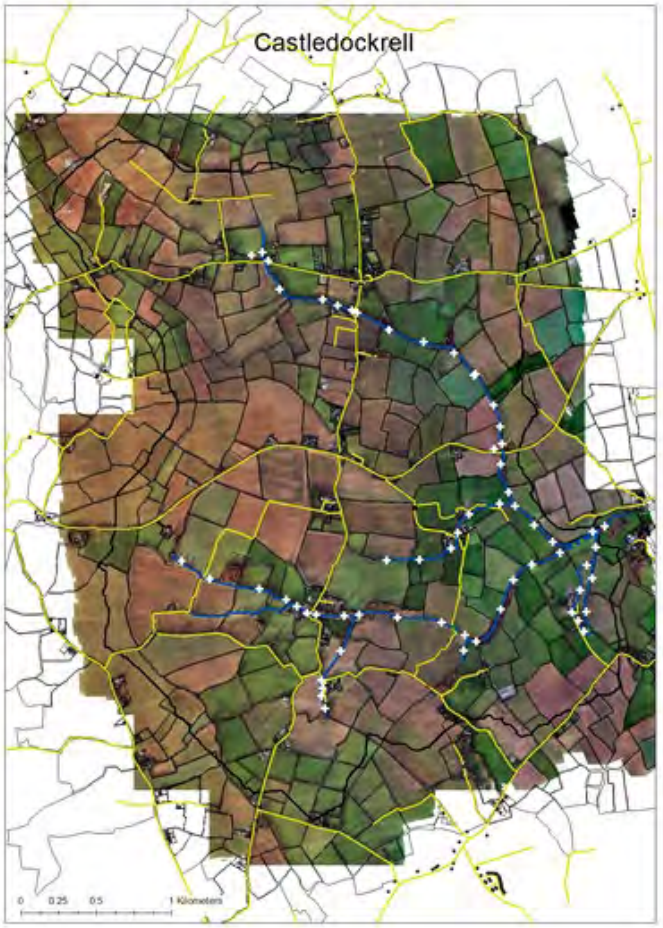
Sampling

Well Drained Arable – Castledockrell

Arable production (spring barley)	11.2 km^2
Some residential housing and a village	Annual precip – c. 1021 mm
Well drained	'N-Risky'





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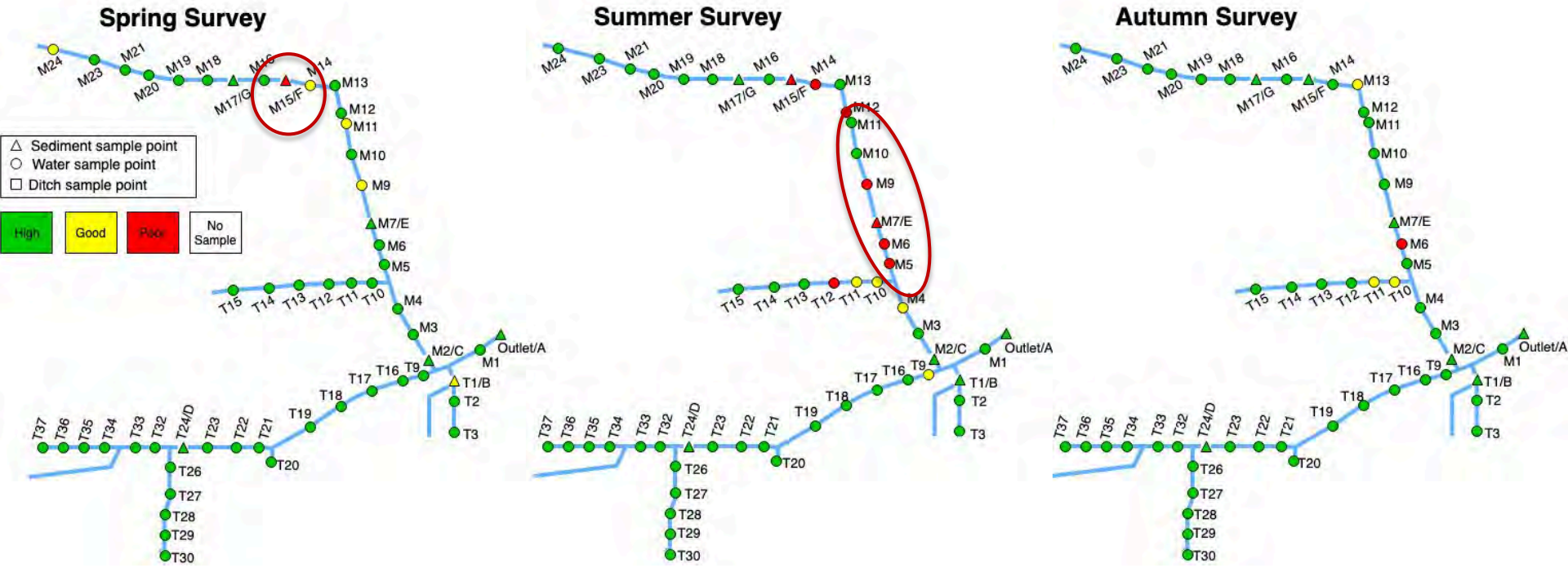

Patterns

- Lowest TRP of all three catchments
- WWTP at point M15/F overcoming any potential attenuation
- Different sediment patterns across the catchment and changes over time indicating sediment deposition
- Elevation in Summer, return to baseline by Autumn – can't be flushing
  - Fingerprinting indicated sediment input from upstream

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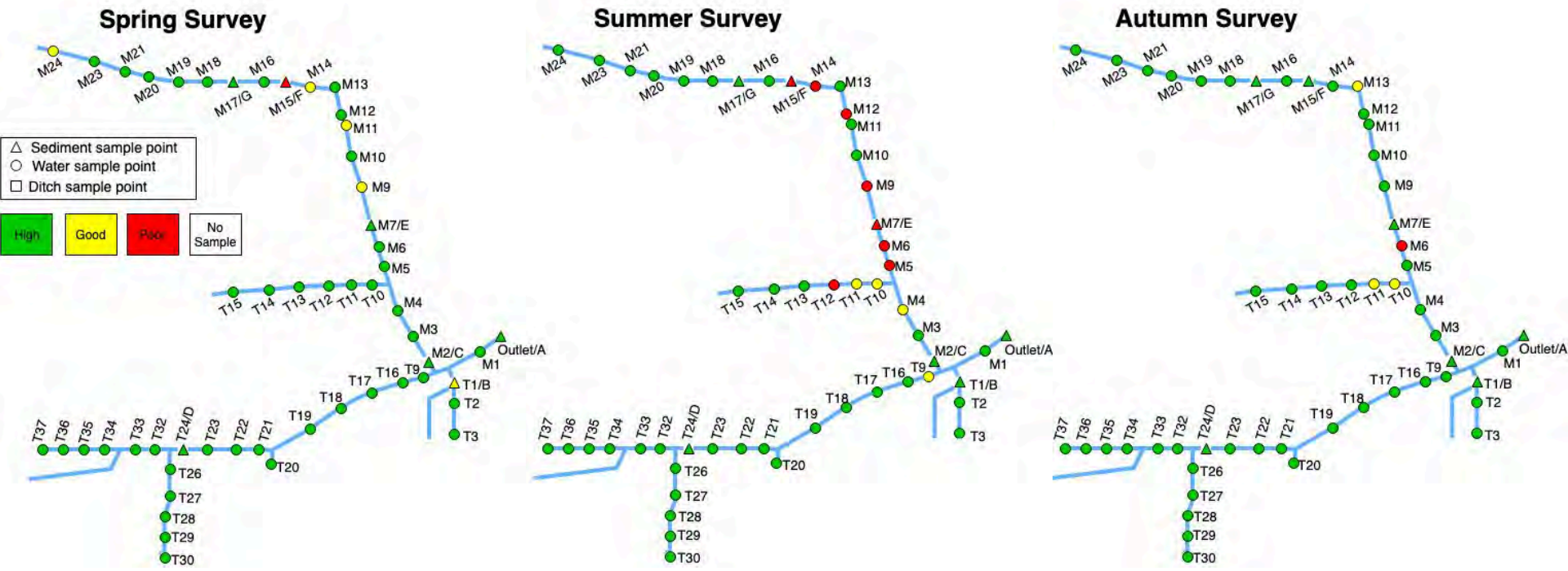

Sources/Pathways

- Major persistent point source – WWTP
- Mobilization in summer from in-stream sediments
- Arrival of sediment from various areas of catchment (inc. public roads)

	Al:P Ratio						
Sample Point	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Summer	11.16	3.78	10.66	16.34	10.90	3.77	12.60
Autumn	12.09	8.48	17.59	15.97	8.89	4.23	13.84

Al:P ratio	Potential
>11.7	Attenuating
<11.7	Mobilizing/Non-attenuating

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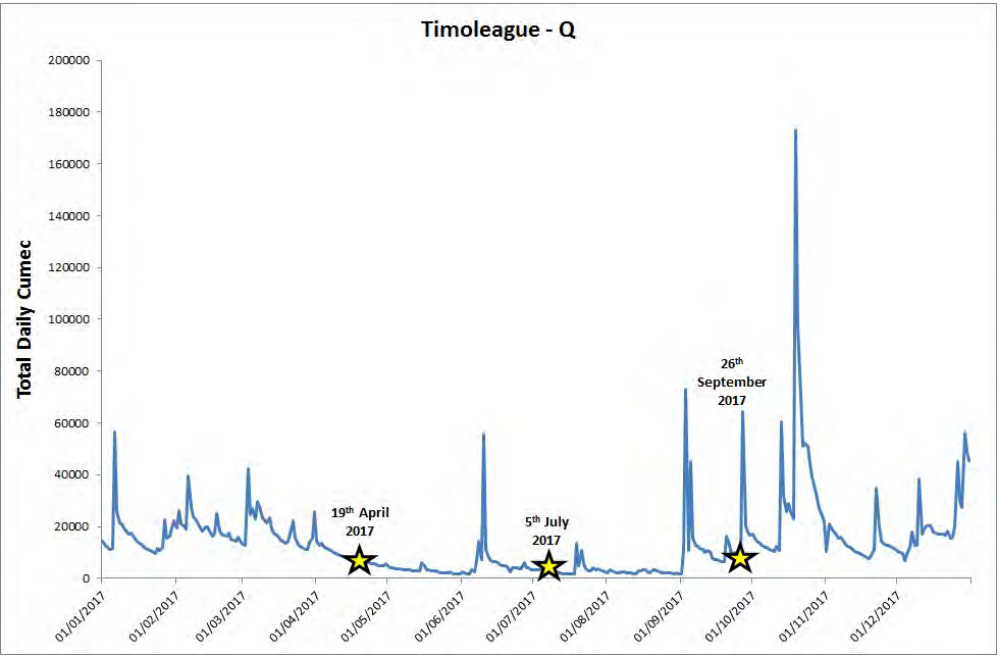
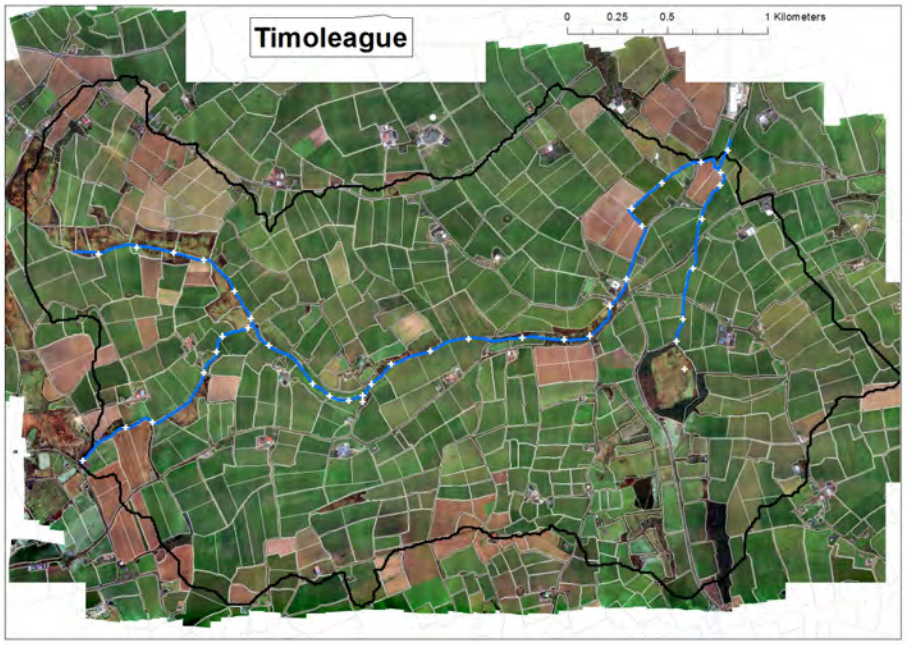
Sampling

Well Drained Grassland – Timoleague	
Intensive dairy production	7.5 km^2
Some residential housing	Annual precip – c. 1000mm
Well drained	‘N-Risky’





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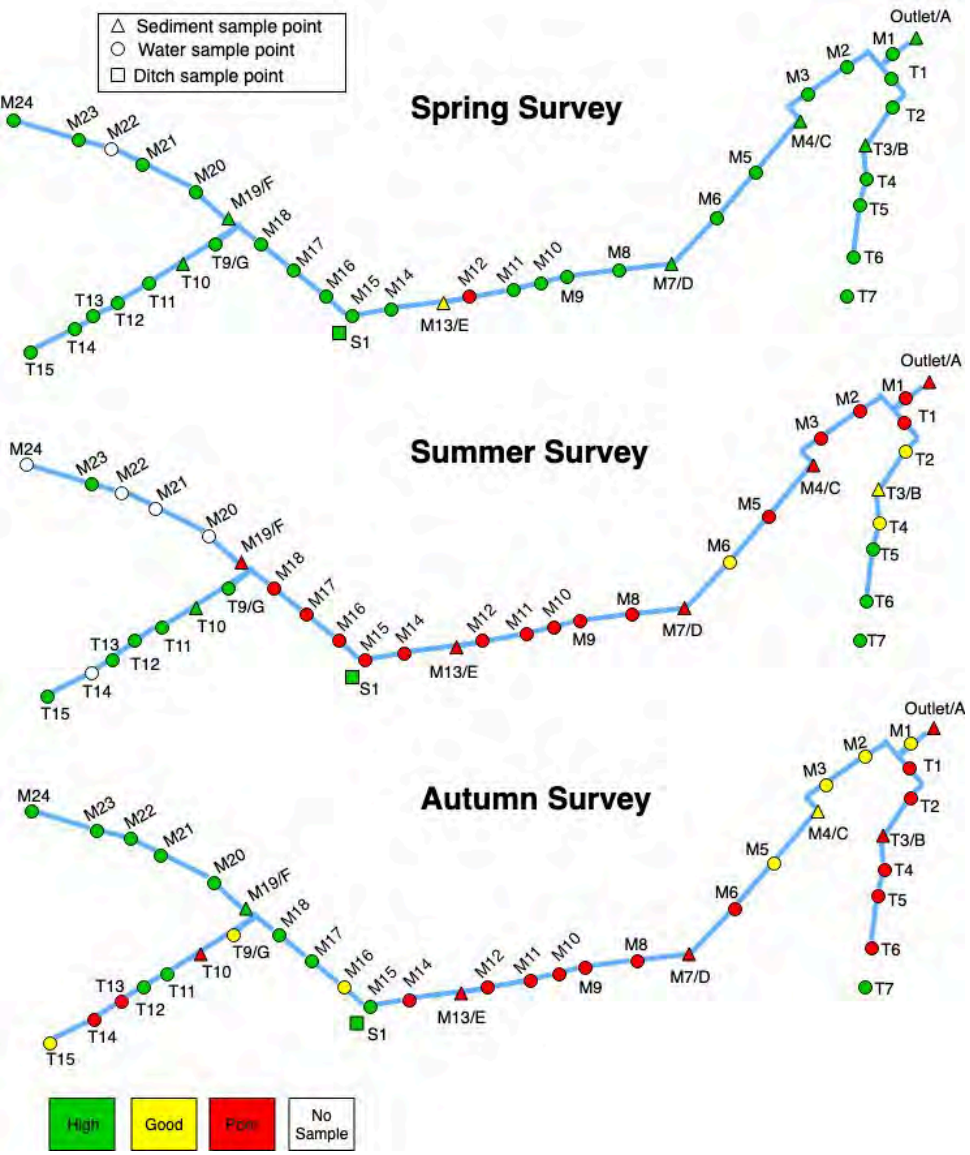

Patterns

- Generally consistent patterns across entire catchment
- Few obvious point sources
- Low in-stream P attenuation (all sample points <11.7 Al:P)
- Spike midstream in summer – associated with nutrient application

Sources/Pathways

- Diffuse pathway through groundwater
- Leaching of P associated with translocation of colloids through the subsurface

Hydrologic and biogeochemical time lag

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A) Causative factors

Physico-chemical

Catchment Scale
- Geology
- Meteorology
- Hydrology

Sub-catchment Scale
- Soil structure/quality
- Soil minerology
- Soil nutrient status

Anthropogenic

Agricultural
- Land-use type
- Land-use intensity
- Fertiliser use
- Farmyard management

Domestic/Urban
- Wastewater treatment
- Housing density/age

$$[\text{Physico-Chemical} \pm \text{Anthropogenic}]t^{0} + [\text{Physico-Chemical} \pm \text{Anthropogenic}]t^{-n} + = P$$

Vero, S.E., Daly, K., McDonald, N.T., Leach, S., Sherriff, S.C. and Mellander, P-E. 2019. Sources and Mechanisms of Low-Flow River Phosphorus Elevations: A Repeated Synoptic Survey Approach. *Water*. 11, 1497; doi:10.3390/w11071497

B) Catchment-specific Examples

Well-Drained Grassland

Source = Primarily agricultural

Pathway = Diffuse transport via groundwater

Implication = Relatively long remediation timescales, dependent upon soil nutrient balance and subsurface time lag

Poorly-Drained Grassland

Source = Agricultural, some domestic

Pathway = Overland flow (diffuse) and persistent point sources

Implication = Agricultural measures must focus on breaking hydrologic pathways
Rapid improvements possible by eliminating persistent point sources

Well-Drained Arable

Source = Bed sediment, WWTP

Pathway = In-situ mobilisation. Persistent point source

Implication = Mobilisation not possible to prevent and some increase in P likely during Summer periods. Limiting WWTP source will reduce replenishment of P in the streambed

Point sources – potential ‘easy wins’




Farmyards – assumed to be important point sources but rarely quantified

- Suitable for infrastructural modifications
- Site for management
- Added wins – safety, efficiency, does not impact stocking rates
- Many different management and structural factors within each yard

We want to ascertain if, why, when & how P is lost from within the farm yard

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Level of Importance

No	V. Low	Low		Moderate			High	V. High	Critical
0	1	2	3	4	5	6	7	8	9	10