Temporal Variability of Phosphorus Concentration in the stream to Squam Lake, New Hampshire during Storm Events

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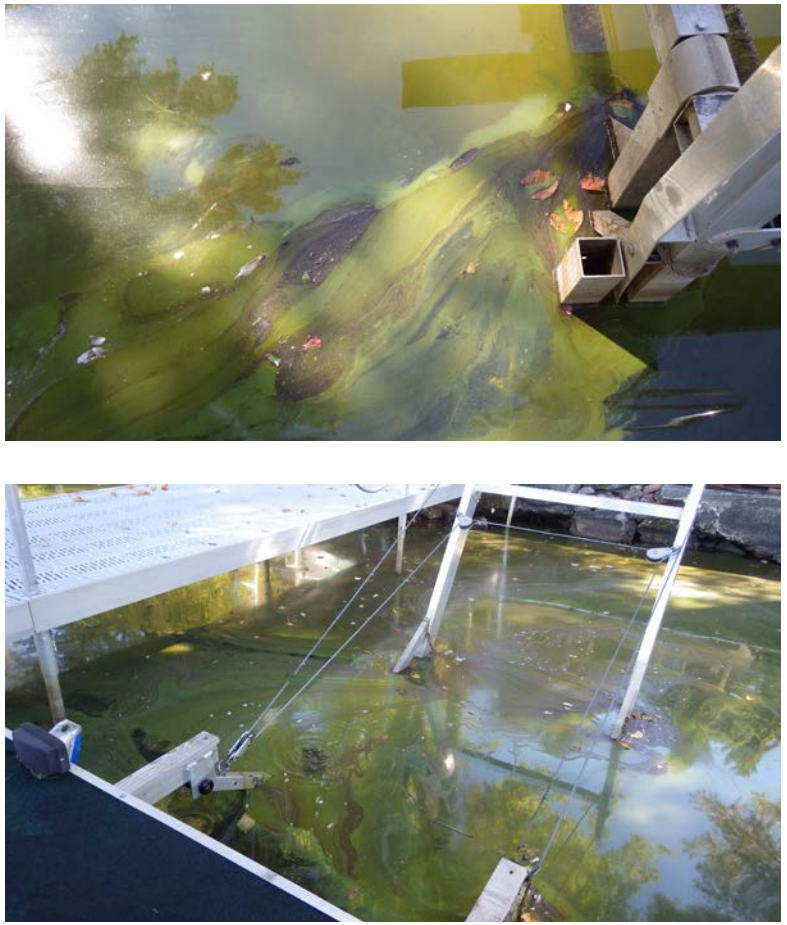
Introduction

- Phosphorus (P) is the primary limiting nutrient
- Essential for the growth of algae in most freshwater aquatic systems
- Eutrophication
- Non point Sources contributes more P to stream and lake
- Storm water runoff is major sources of P
- Large knowledge gap about the concentration of P in streams and its relation with flow during storm event in Northern New England region



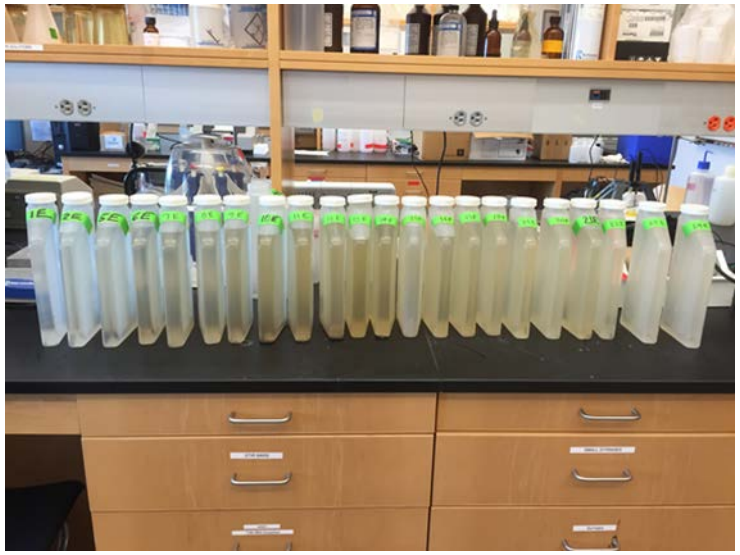
Bank of Webster Lake with Cyanobacteria bloom (Photo by : Anju Shrestha)

Objectives

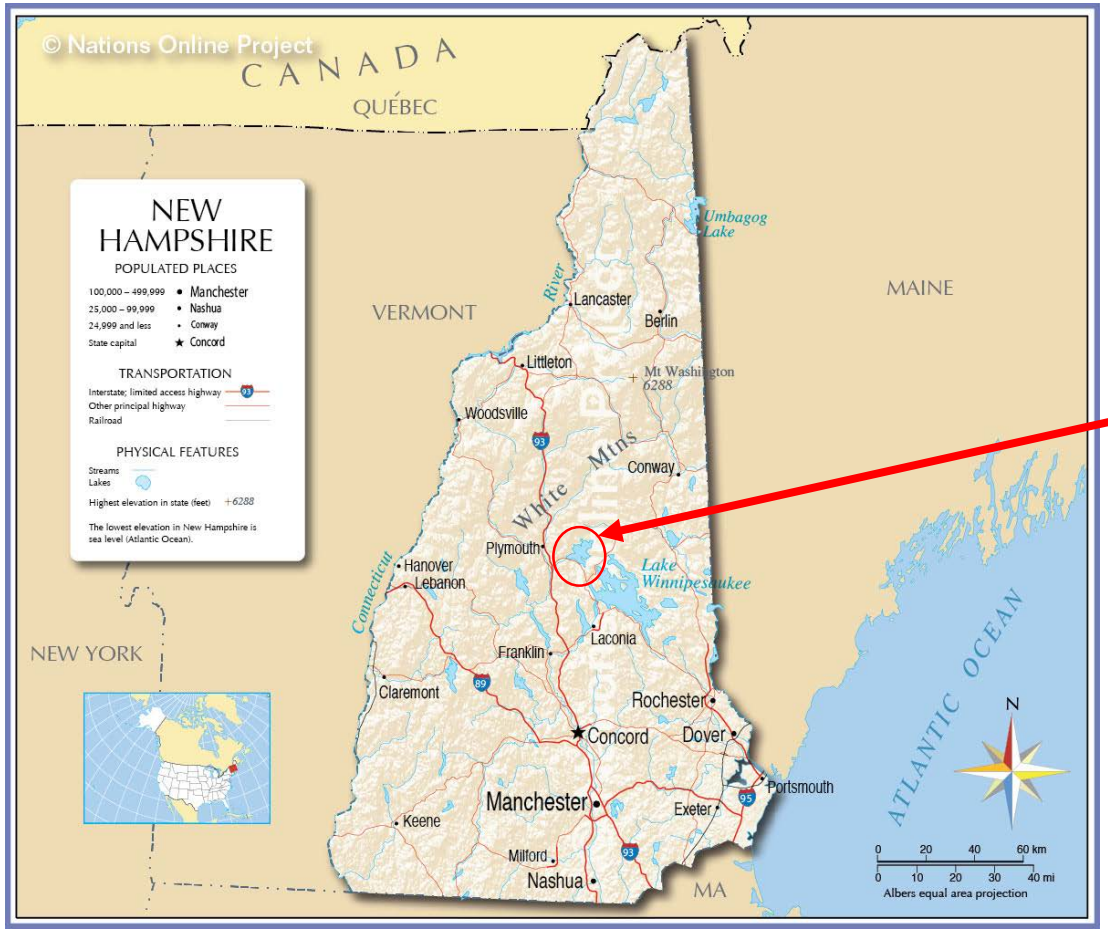
1. To measure the P concentration in the stream at hourly resolution during storm events

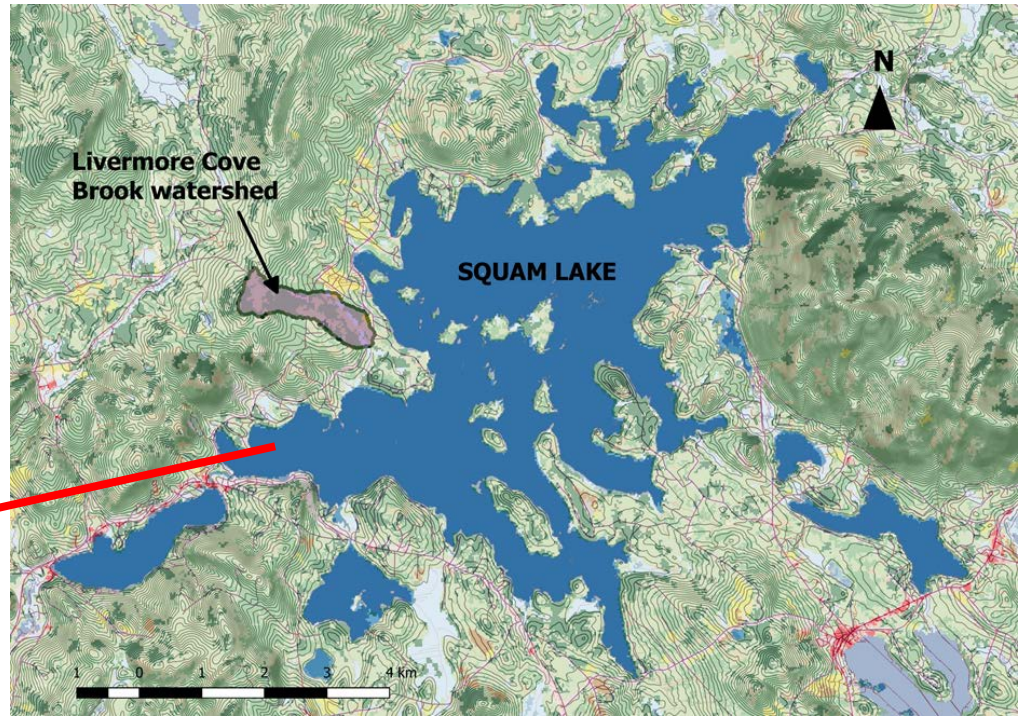
2. To measure the temporal variability of different P species during storm events

3. To explore the contribution of different flow paths to P concentration and species during the event



Study Sites





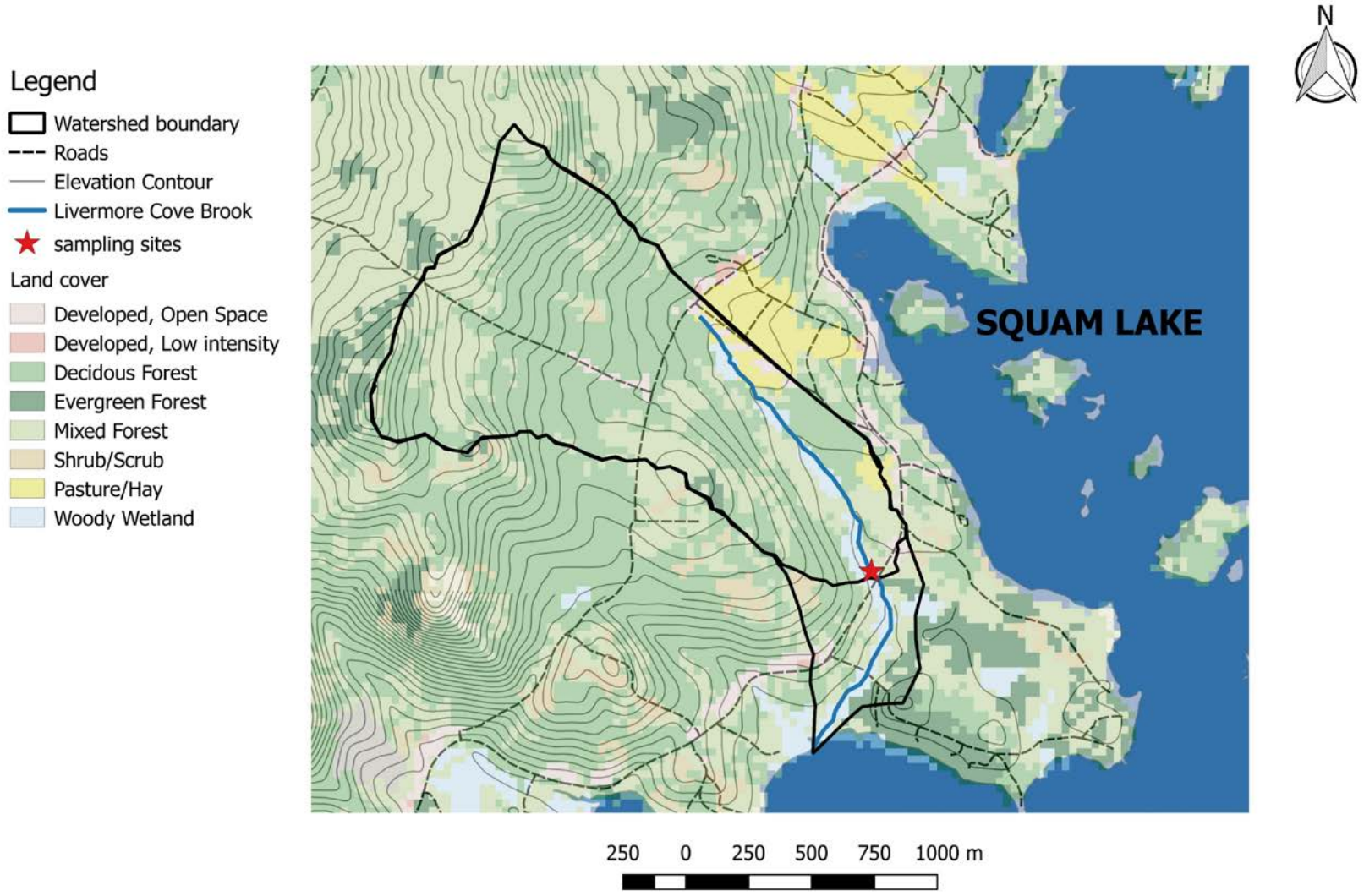
Source: http://map.opcguide.com/map-of-new-hampshire-2/

Livermore Cove Brook

- Drainage area = 1.77 Km^2

- **Forested land = 91.7 %**
  - Deciduous Forest = 60.9 %
  - Evergreen forest = 29.6 %
  - Mixed forest = 1.2 %

- **Wetland = 3.4 %**
- Developed open space = 2.1 %
- Slightly developed area with houses= 0.05 %
- Pasture land = 2.5 %
- Shrub land = 0.4 %



Map of Livermore Cove Brook watershed with its land cover types

Methods

1. Event Sampling

Sampling Sites	Storm event of 06/05/2016	Storm event of 07/09/2016	Storm event of 08/12/2016
Livermore Cove Brook	Done	Done	Done

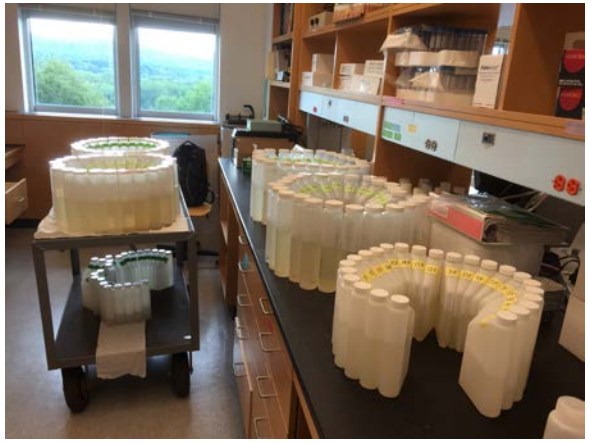
- ISCO sampler
- Hourly basis

Total number of samples

LMC = 47 + 48 + 48 = **143**

Setting ISCO sampler to catch storm event

ISCO Sampler



Samples in Laboratory

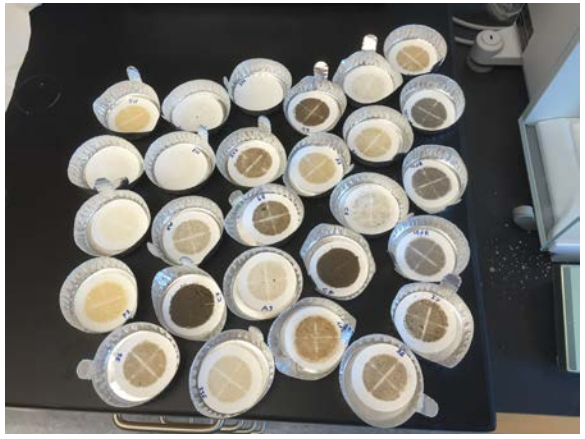
2. Lab Analyses

- Specific conductivity (SC, µS cm^{-1})
- Turbidity (Turb, NTU)
- Total suspended solid (TSS, mg L^{-1})

Samples in the Laboratory

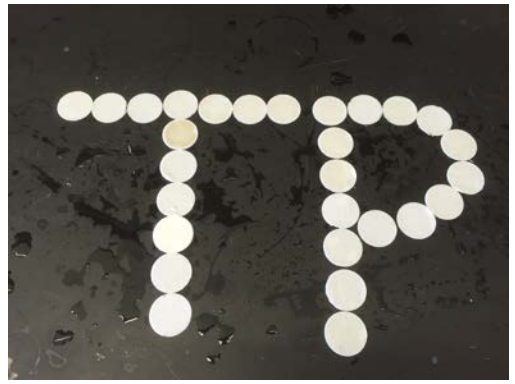
Conductivity meter

Turbidity meter



TSS after being measured

3. Phosphorus Analyses



Total P (TP)

Total dissolved P (TDP)

Total particulate P (TPP)

Soluble reactive P (SRP)

Dissolved organic P (DOP)

TPP = TP -TDP

DOP = TDP - SRP

4. Stable isotope analysis

- Concentration of deuterium isotope (^2H) was used in two-component mixing analysis to calculate % of new water (%NW)

$$x = \frac{C_t - Co}{C_n - Co} * 100$$

Where, X = % of new water

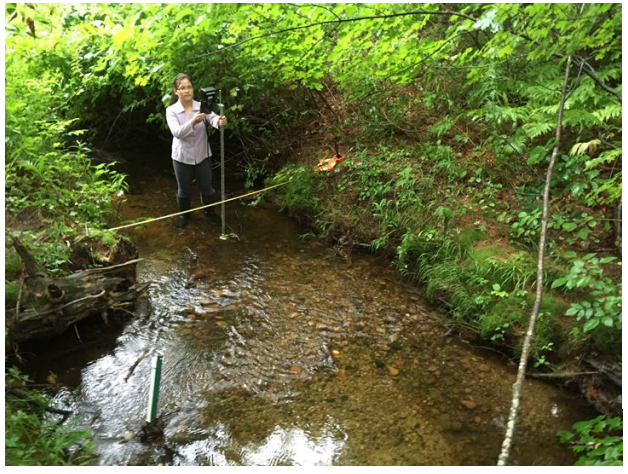
C_t = Concentration of deuterium isotope of sample

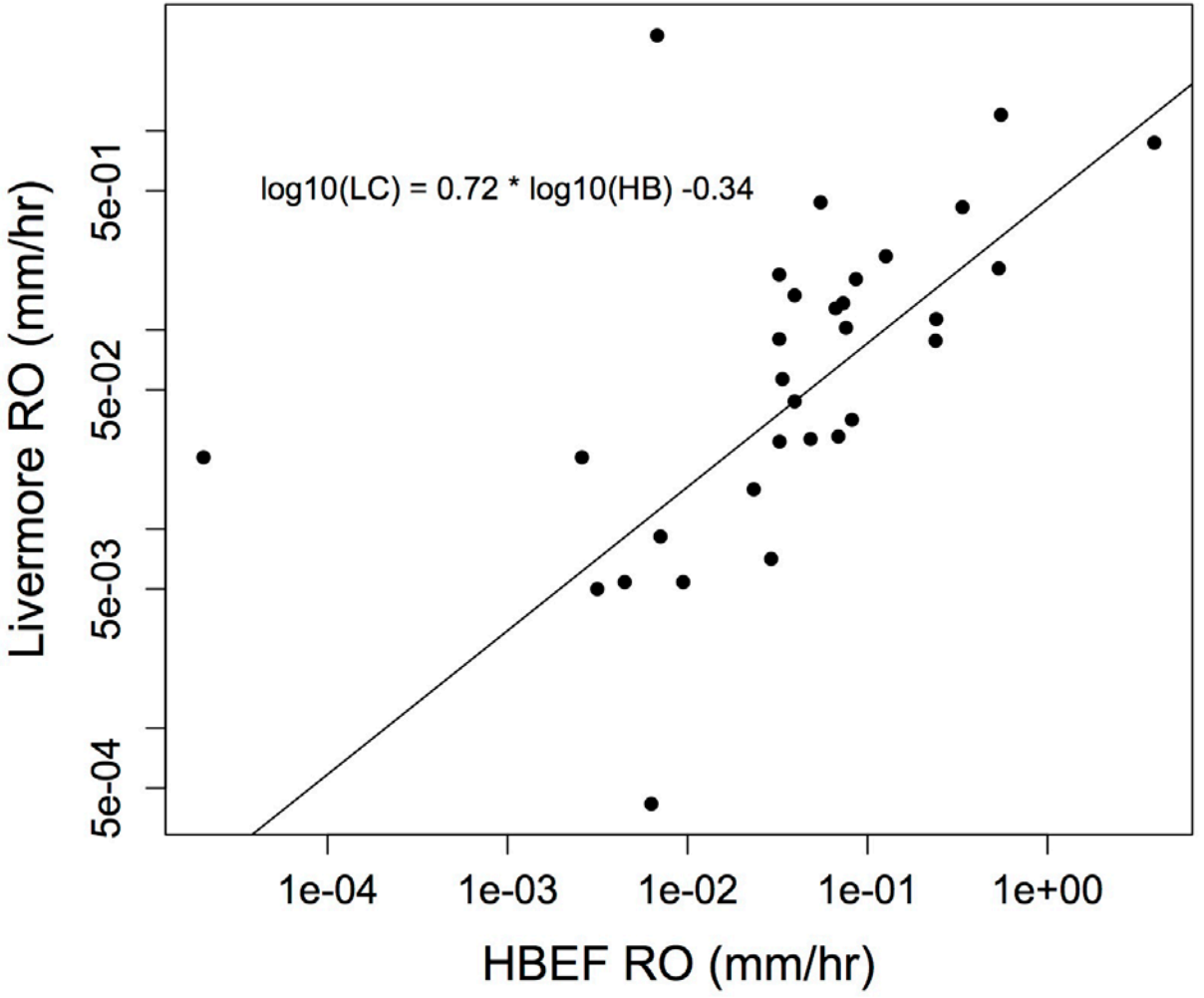
C_o = Concentration of deuterium isotope of stream water during pre-storm flow

C_n = Concentration of deuterium isotope of rain water

5. Unit Discharge

- Flow meter
- Discharge in Hubbard Brook
- Discharge measured by Jeff Schloss in Livermore



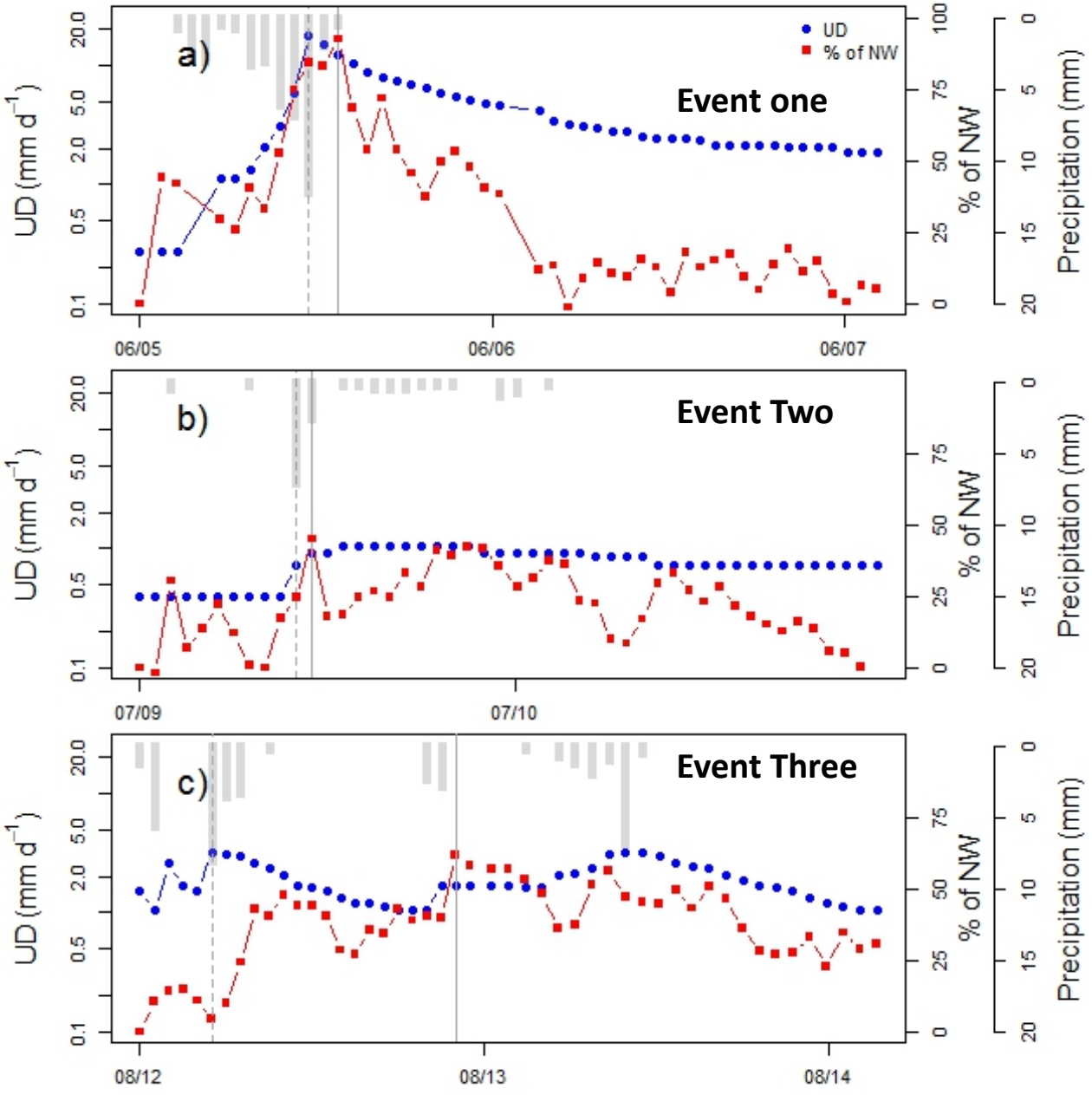


Results

Are the three events similar??
NO, not at all

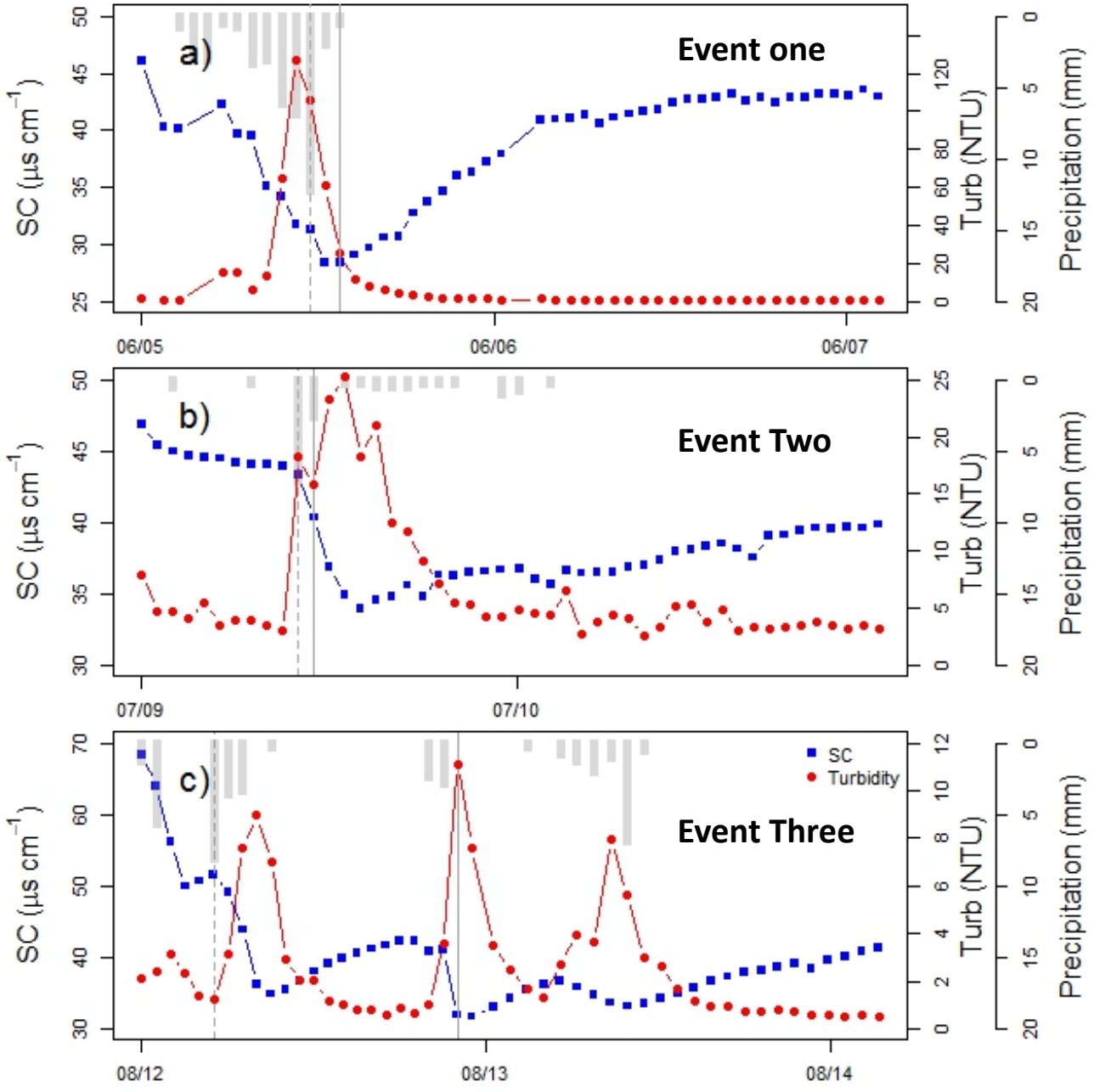
	Event One	Event Two	Event Three
Total rain (mm)	41.91	19.6	39.87
Max. %NW	92.6	45.01	61.69
Max. UD (mm d^{-1})	17.82	1.05	3.22

- Storm generates higher Discharge and high % of New Water (%NW)



Specific conductivity (SC) and Turbidity

- Higher the %NW higher is the turbidity
- Higher the %NW lower is the SC
- SC decreased with increase in turbidity



TSS vs Turbidity

Event one

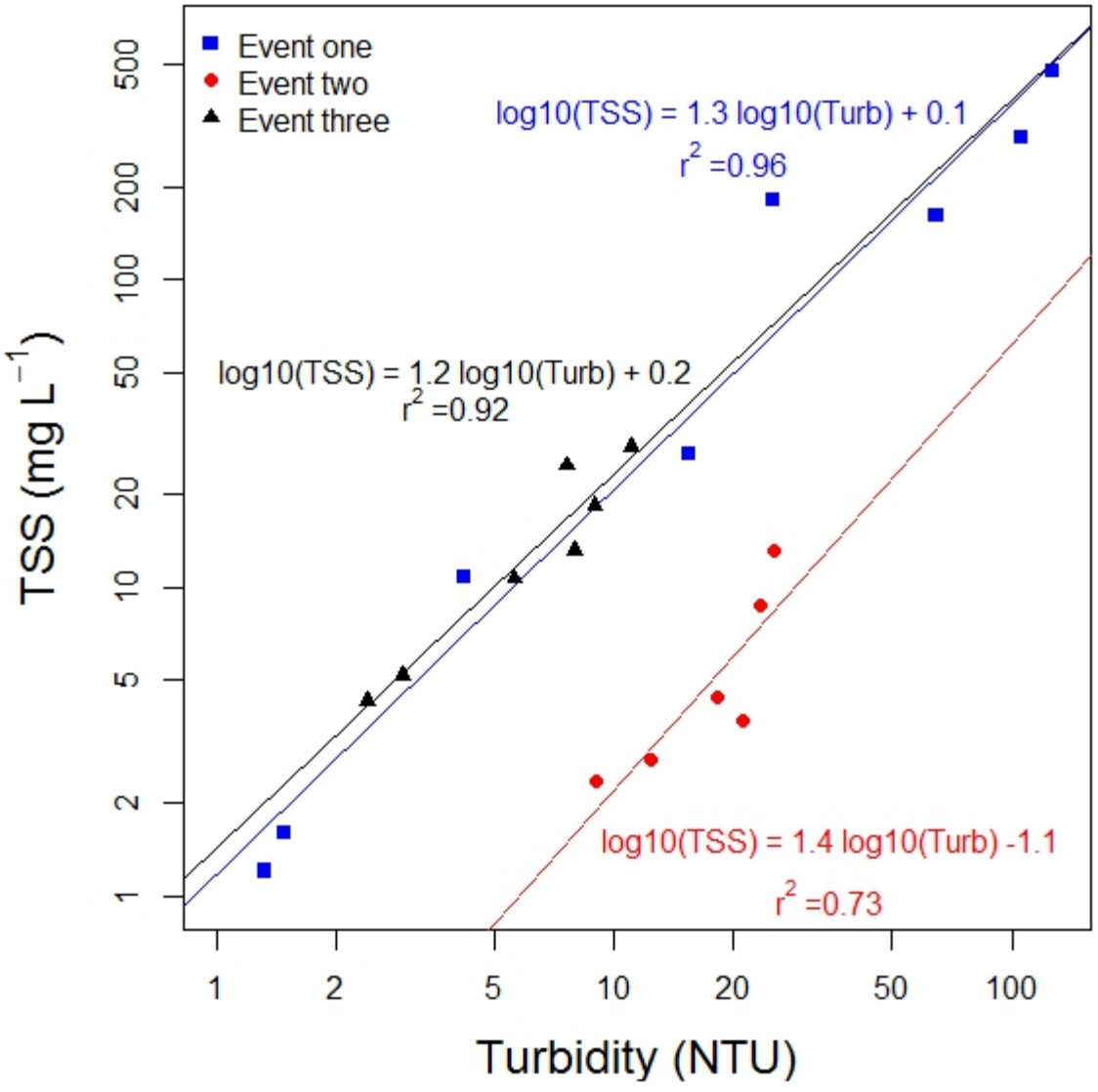
- Highly significant relation
- Higher mobilization of sediments

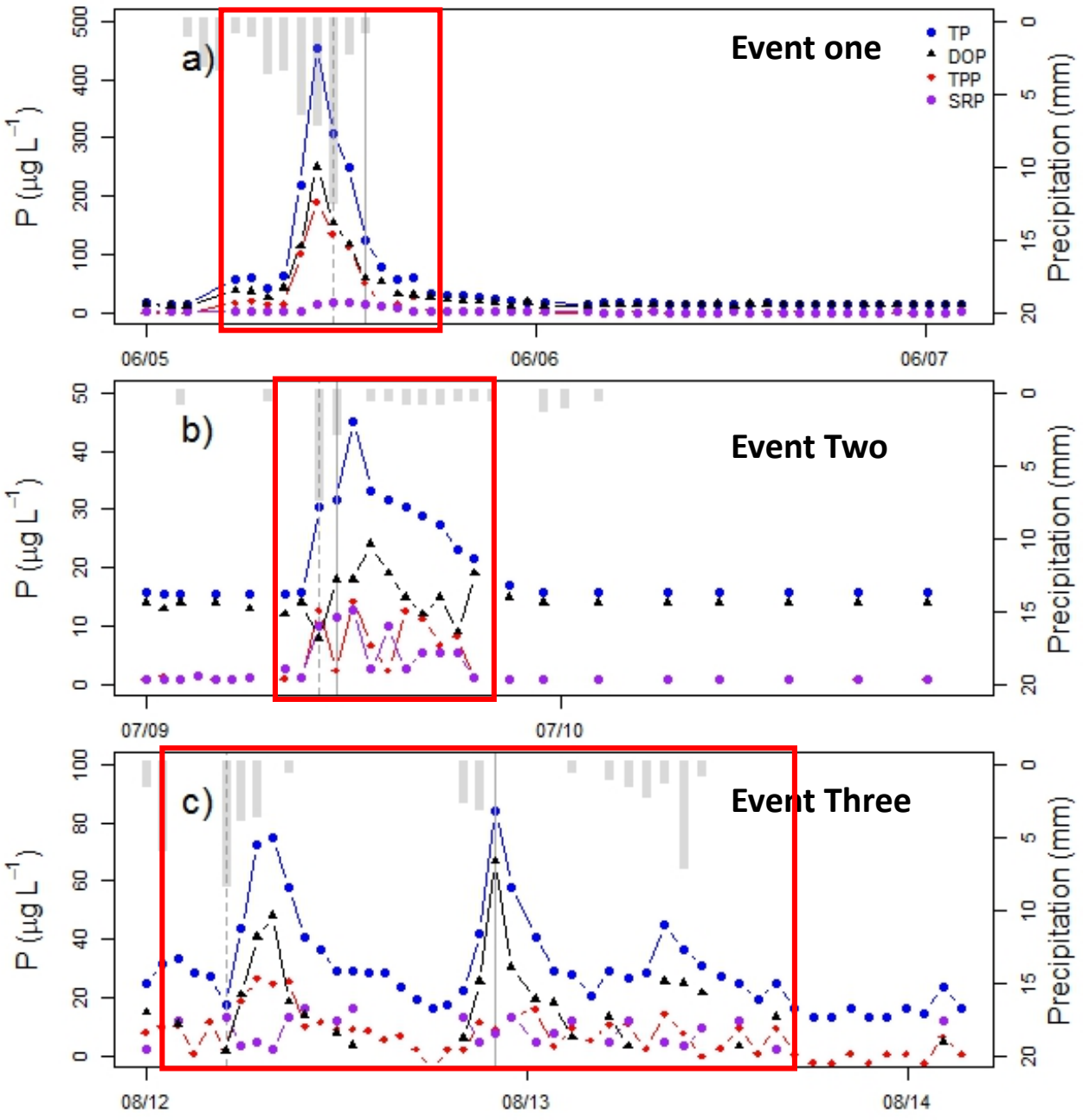
Event two

- Less significant relation
- Mobilization of finer sediments

Event three

- Highly significant relation
- Higher mobilization of sediments



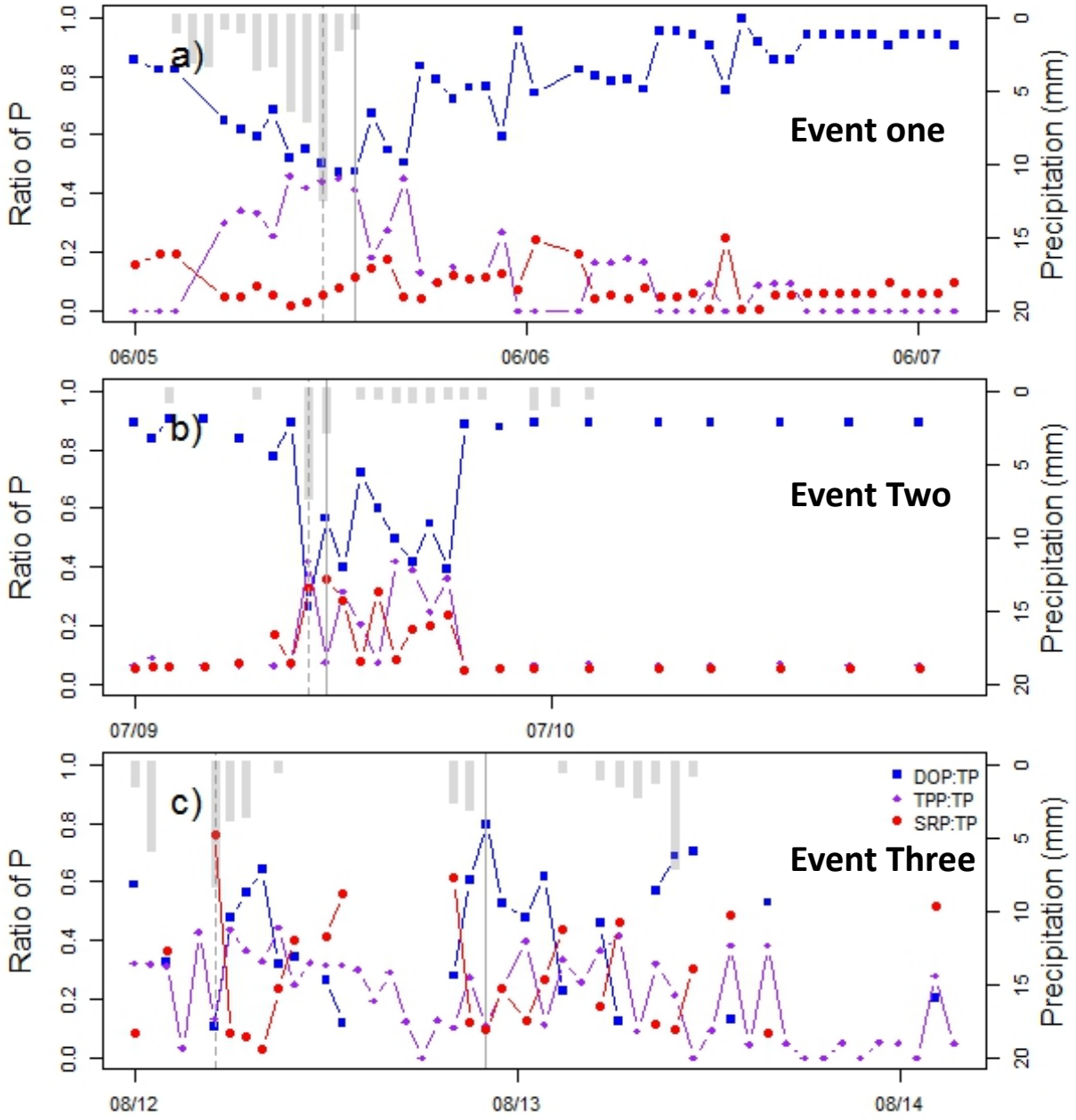


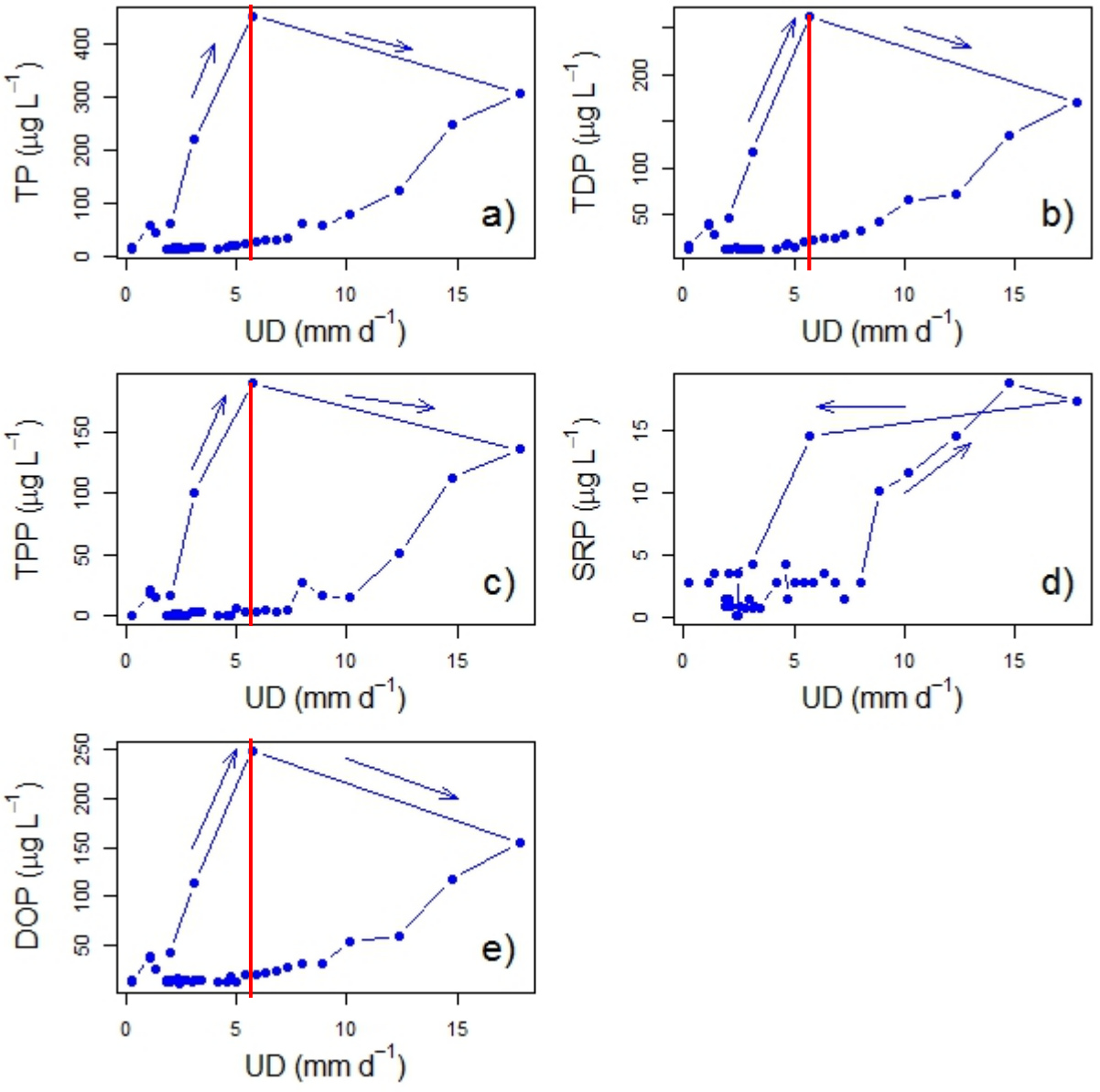
Time series of P

- Storm generates higher concentration of P
- The SRP was minor component during event but was more significant during baseflow periods.
- SRP also lagged Discharge, suggesting its more consistent groundwater source.

Ratio of P

- Most of TP is in the form of DOP, at all times, fluctuating between 95% (baseflow) to 50% (event flow).
- TPP becomes a significant component (up to 46%) during high event flows.
- SRP is ~15-20% of TP during baseflow but declines in contribution during event flows because of disproportionate inputs of DOP & TPP.

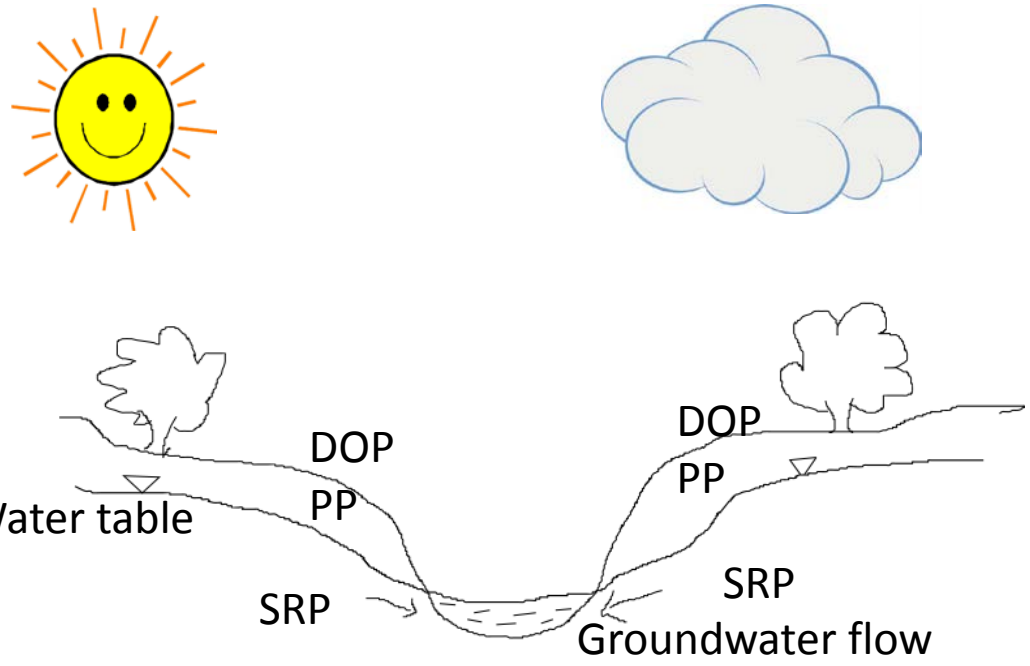




Hysteresis Between P and Discharge in Event One

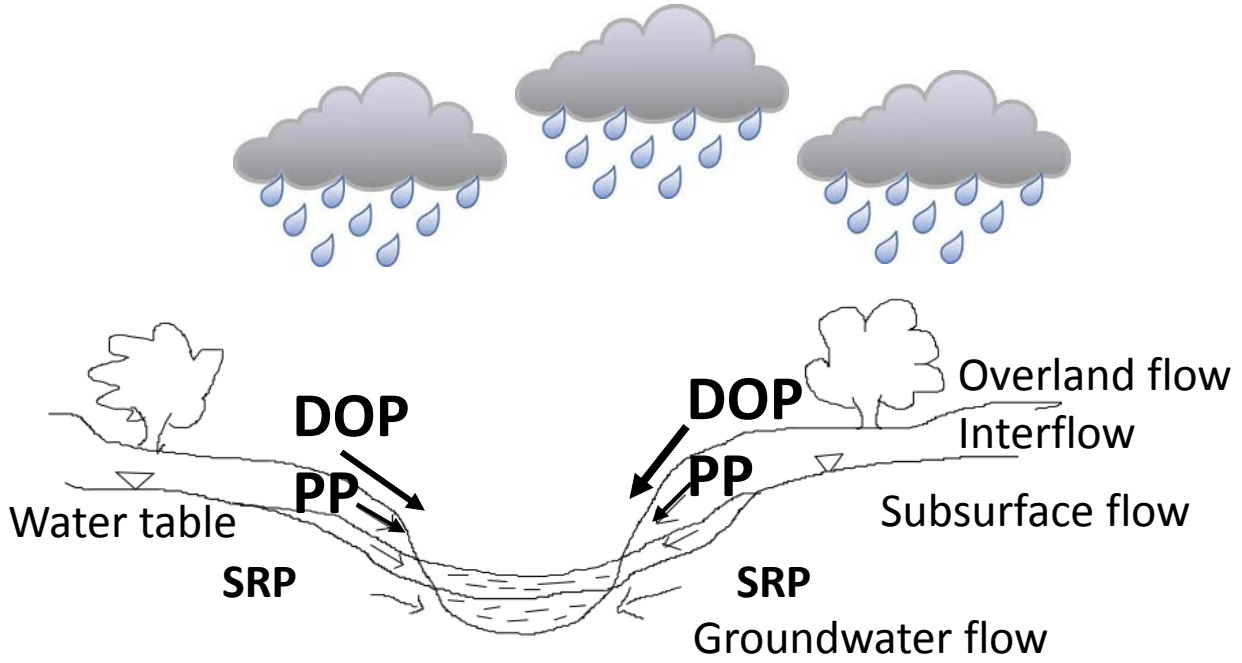
- TP, TDP, TPP and DOP had made clockwise hysteresis
- P concentrations on rising limb of hydrograph were much higher than on falling limb which resulted in clockwise hysteresis.
- SRP had made anticlockwise hysteresis indicating that it was from different source.

Before Storm Event



- Suspended sediments are settled down on the stream

During Storm Event



- Sediments are mobilized
- SRP moves to stream from subsurface flow
- DOP and PP moves through surface flow and overland flow

Conclusions

- Storms generate higher Discharge, concentration and yield of P in the stream.
- Dissolve P is more dominant than particulate P and among dissolved P, organic P is more dominant than inorganic P.
- Storm events contribute a disproportionate amount of P to Livermore Cove Brook load.

Conclusions (contd..)

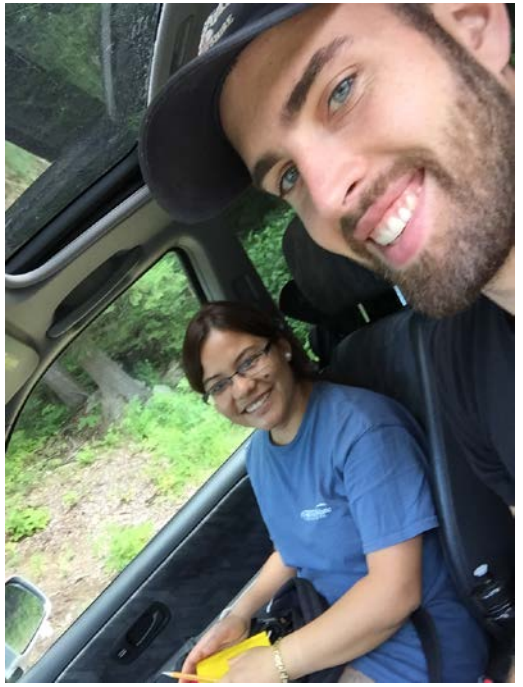
- The SRP was minor component during event but was more significant during baseflow periods. SRP also lagged Discharge, suggesting its more consistent groundwater source.

- P concentrations on rising limb of hydrograph were much higher than on falling limb which resulted in clockwise hysteresis. SRP had made anticlockwise hysteresis indicating that it was from different source.

- This study is useful to find the approximate natural P loading in other watersheds of Squam Lake nearby and control the anthropogenic P loading in the stream.

Acknowledgements

- Dr. Lisa Doner, my research committee member
- Todd Dickinson for helping me in field and lab work
- Jeff Schloss since I used the discharge measured by him
- Hubbard Brook Experimental Forest (HBEF) for discharge
- Donovan King and Daniel Evans for teaching how to use logging sensors
- Faculty members from ES&P and CFE
- Friends from Graduate studies
- Family



Questions ??

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TP Yield

Events	TP yield (kg/ha/event)
One	0.0075
Two	0.0003
Three	0.0012
Total	**0.009**

- The 3 events had made 5-10% annual TP yield.

Methods

1. Event Sampling

Sampling Sites	Storm event of 06/05/2016	Storm event of 07/09/2016	Storm event of 08/12/2016
Livermore Cove Brook	**Done**	**Done**	**Done**
North Brook	Not Done	**Done**	**Done**
Eagle Cliff Brook	Not Done	Not Done	**Done**

Setting ISCO sampler to catch storm event

Total number of samples

LMC = 47 + 48 + 48 = 143

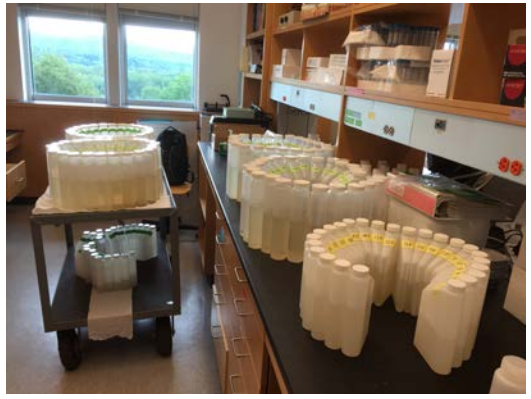
NB = 2 + 48 + 48 = 98

EC = 48

Total = **289**

- Hourly basis
- ISCO sampler

ISCO Sampler



Samples in Laboratory