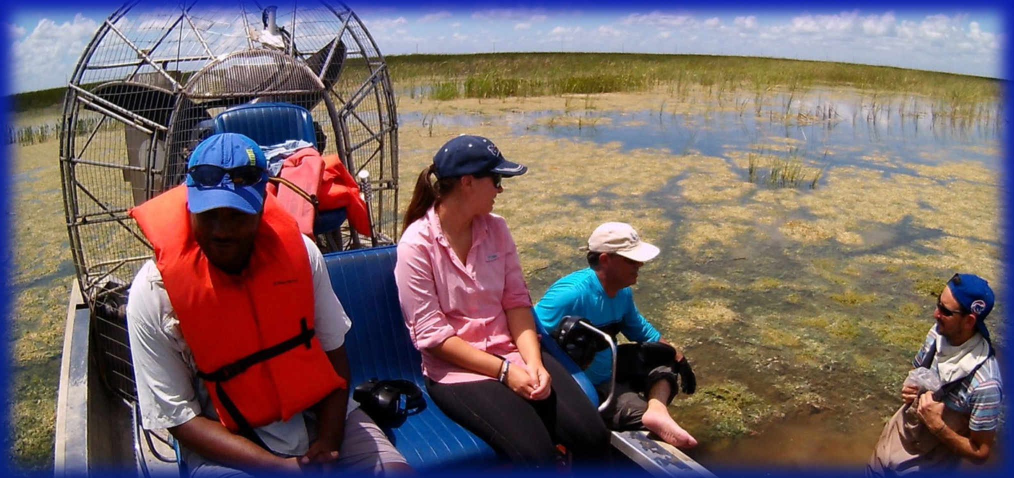
GEER 2019
Greater Everglades Ecosystems Restoration

Settling and Entrainment Properties of Stormwater Treatment Area Particulates



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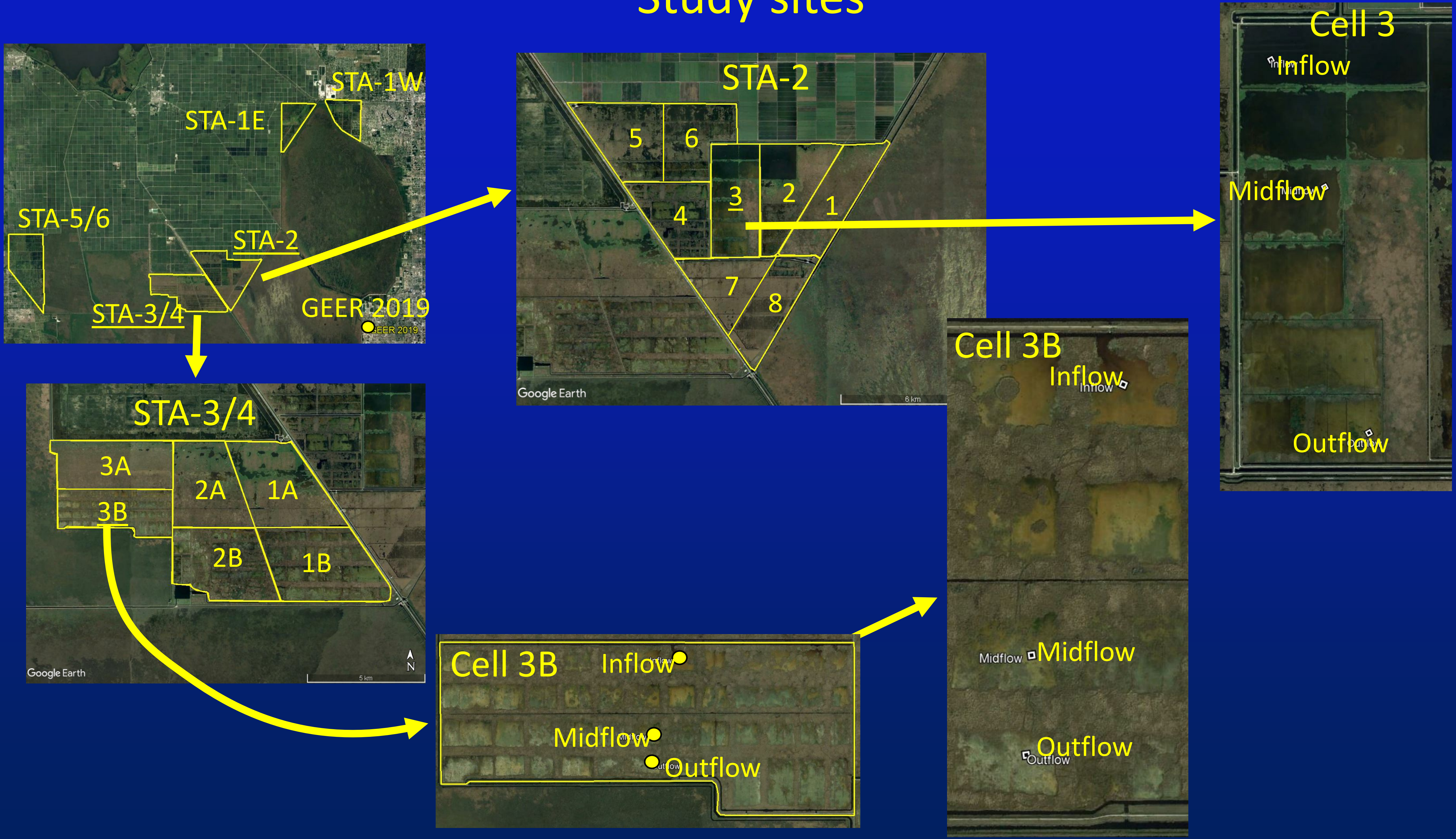
Objectives

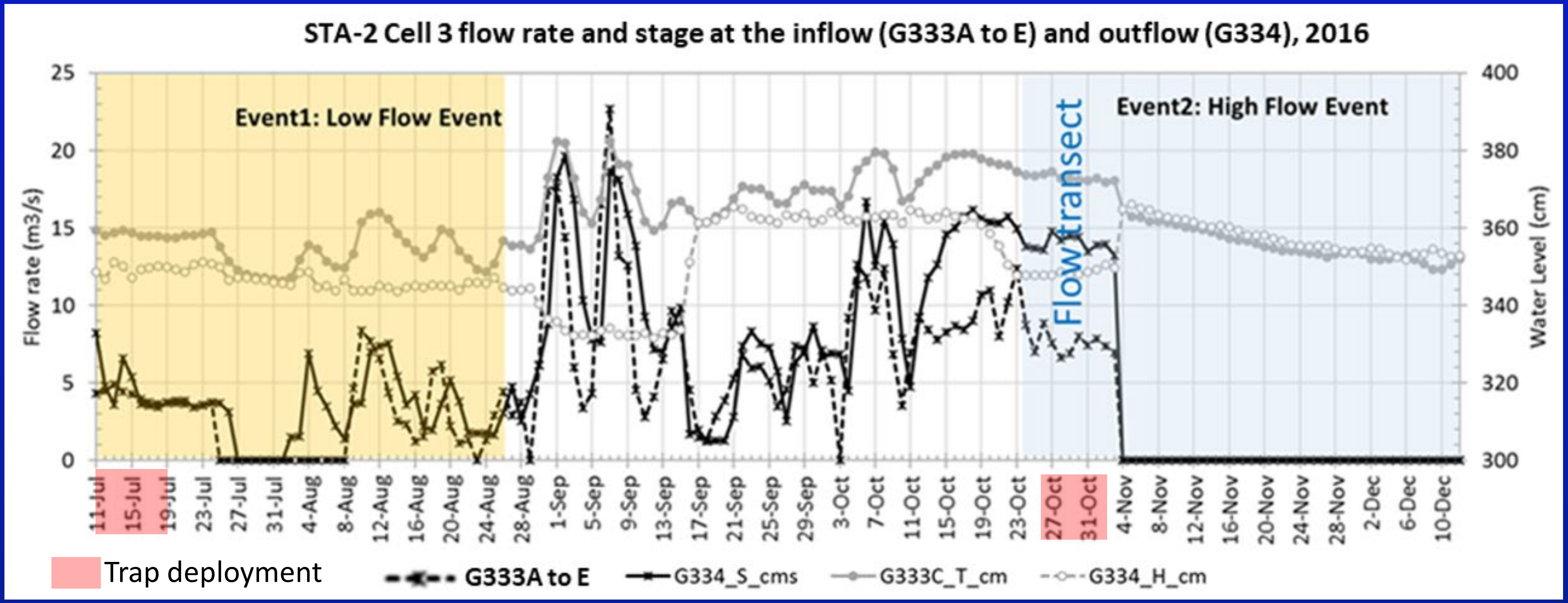
- To what extent do flow fields near outflow areas exhibit velocities sufficient to entrain particles? (Task 2)
- How fast do STA-derived particles settle? (Task 3);
- What is the background concentration of particulates that do not settle? (Task 3 and 4)
- What velocities or shear stress are required to: (a) entrain particles and (b) to allow deposition? (Task 4)
- What are the quantitative correlations between particulate load and hydrologic and meteorological conditions that resuspend particles? (Task 5)

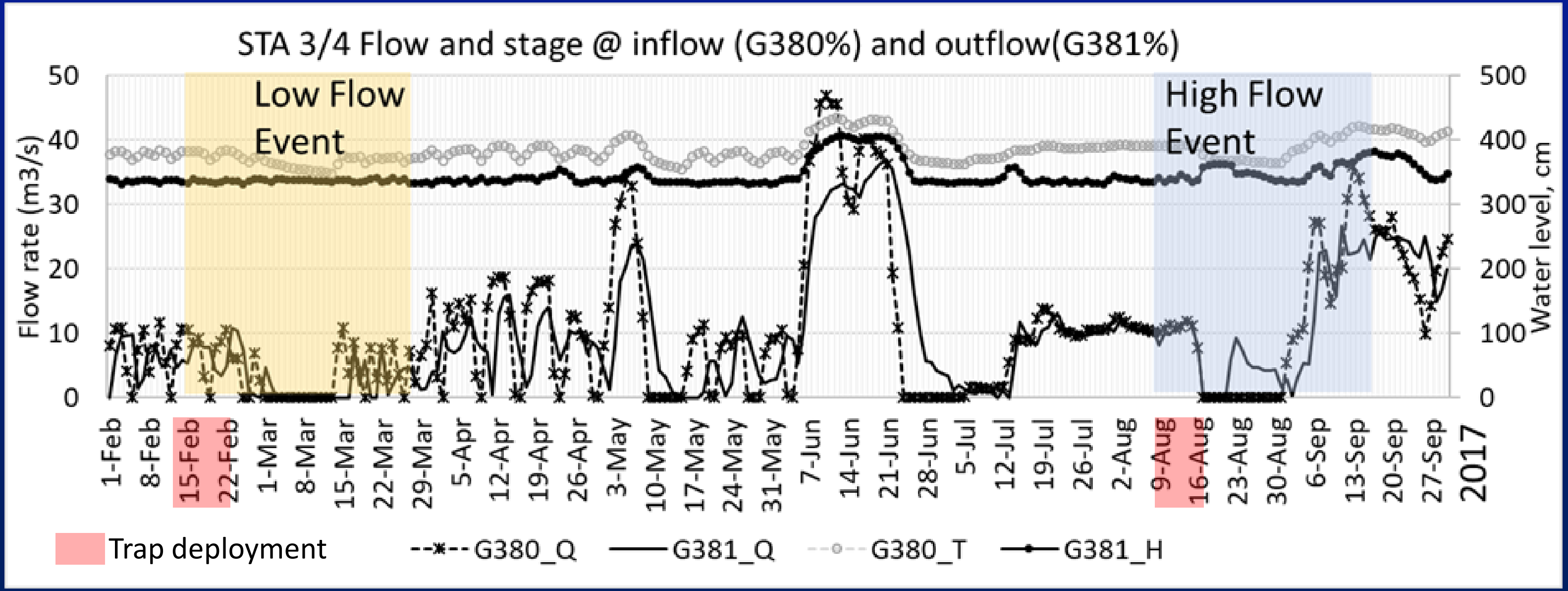
Study sites



STA-1W
STA-1E
STA-5/6
STA-2
STA-3/4
GEER 2019
STA-2
5
6
4
3
2
1
7
8
Google Earth
6 km
STA-3/4
3A
2A
1A
3B
2B
1B
Google Earth
5 km
N
Cell 3B
Inflow
Midflow
Outflow
Cell 3B
Inflow
Midflow
Outflow
Cell 3
Inflow
Midflow
Outflow

Study periods and hydrology



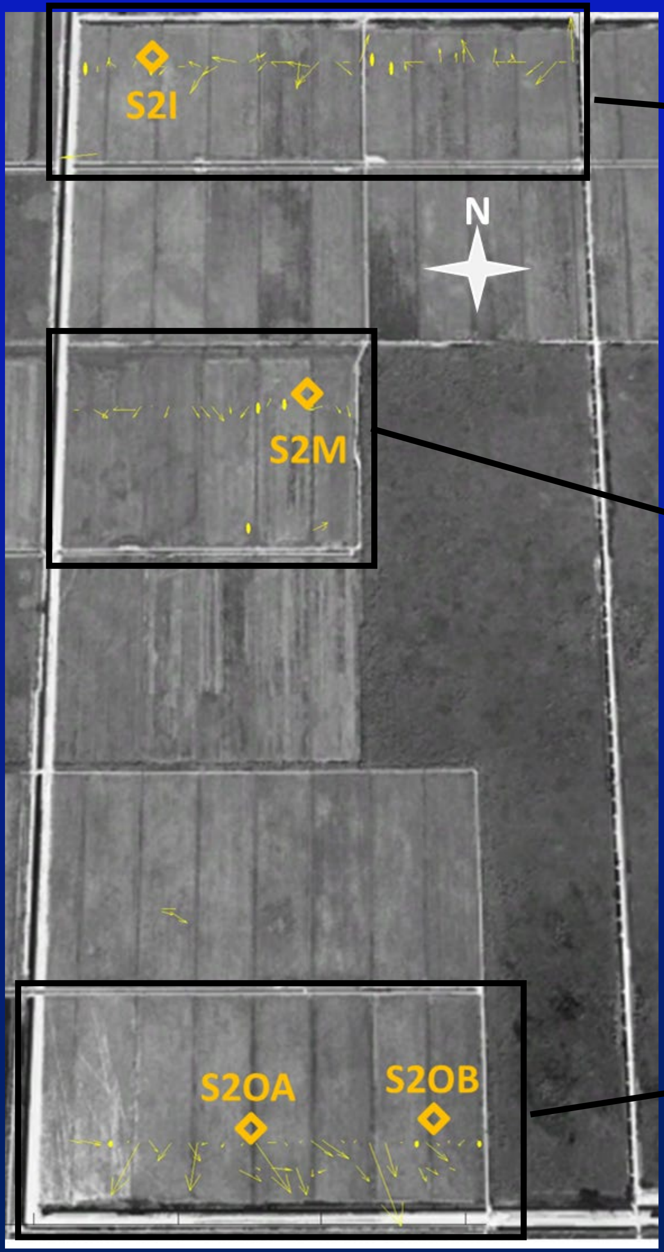


Planned experimental flow schedule proved to be difficult to implement:

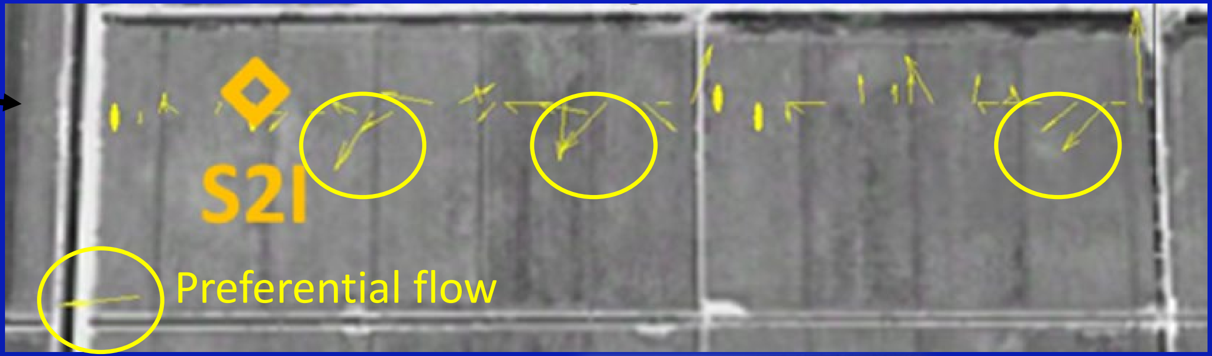
- STA-2 Cell 3, low flow (Event 1)
  - Experimental low flow (3.5 m^3/s)
  - one week of stagnant flow vs. two
  - Effect of wind velocity
- STA-2 Cell 3, high flow (Event 2)
  - Experimental high flow (7.5 m^3/s)
  - Because of dry conditions, no flow after the period of stagnation
- STA-3 Cell 3B, low flow (Event 1)
  - Experimental low flow (4.0 m^3/s)
  - No flow at midflow and outflow
- STA-3 Cell 3B, high flow (Event 2)
  - Experimental low flow (10 m^3/s)
  - No flow at midflow and outflow
  - ADVs “dry” at midflow and outflow during stagnant schedule
  - Hurricane Irma (09/10)

STA performance: hydrology

12/16/2018 overlay



Pre-STA overlay



STA-2 Cell 3: Vector of flow velocity (High flow, October 28 and 30, 2016)

STA performance: hydrology

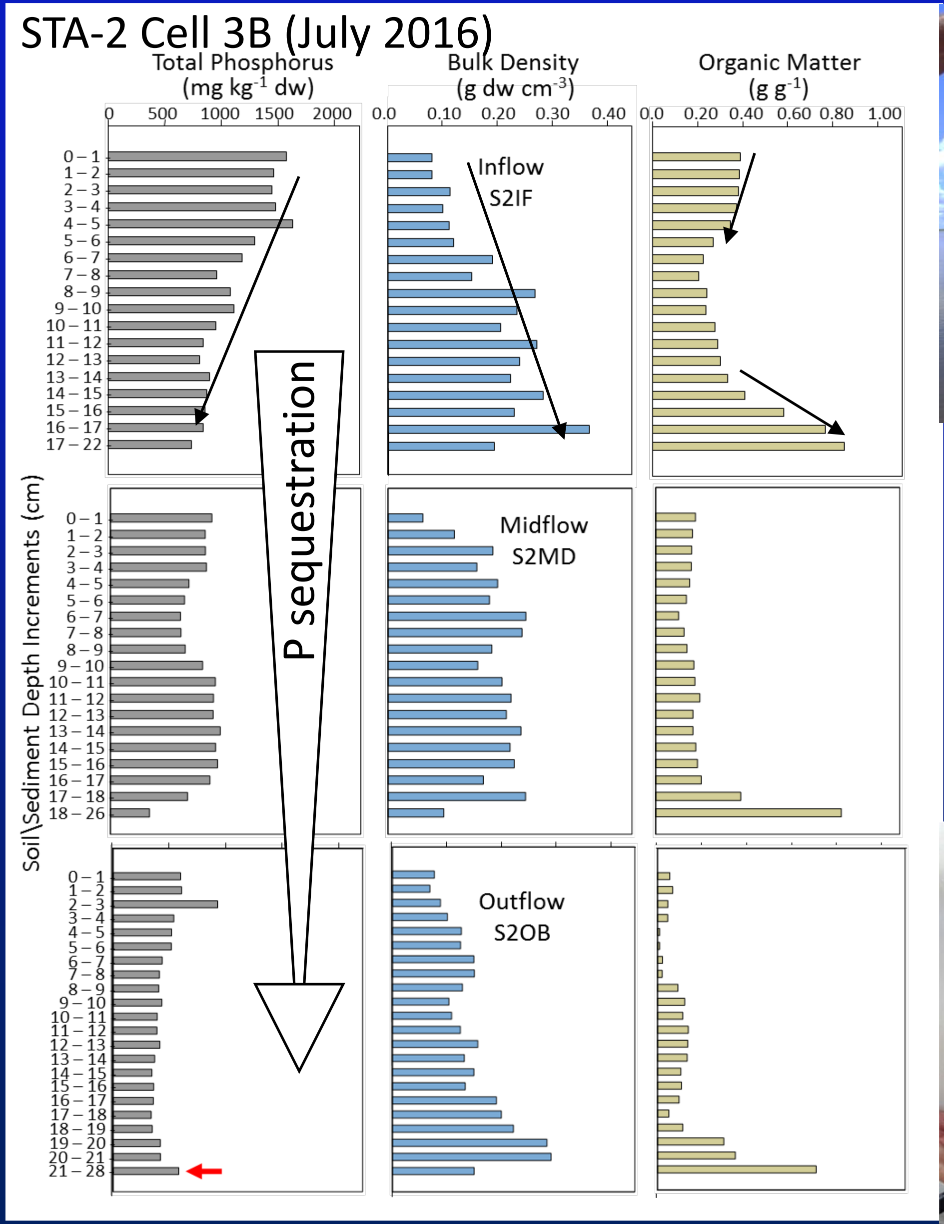
STA 3/4 Cell 3B

No vector flow velocity transects were performed

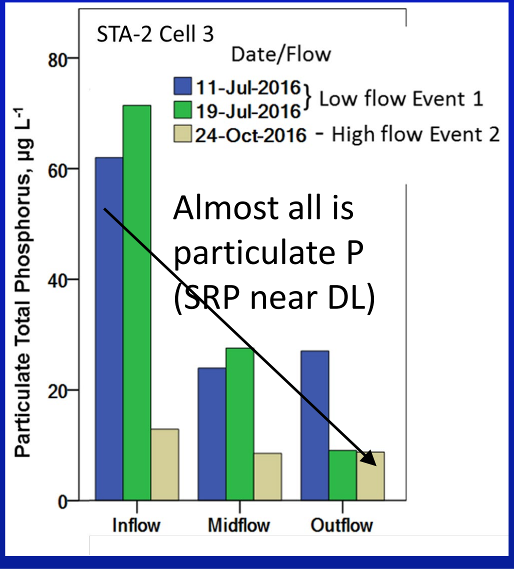
- Flow could only be measured at inflow as vegetation and very low water depth dampened flow at midflow and outflow

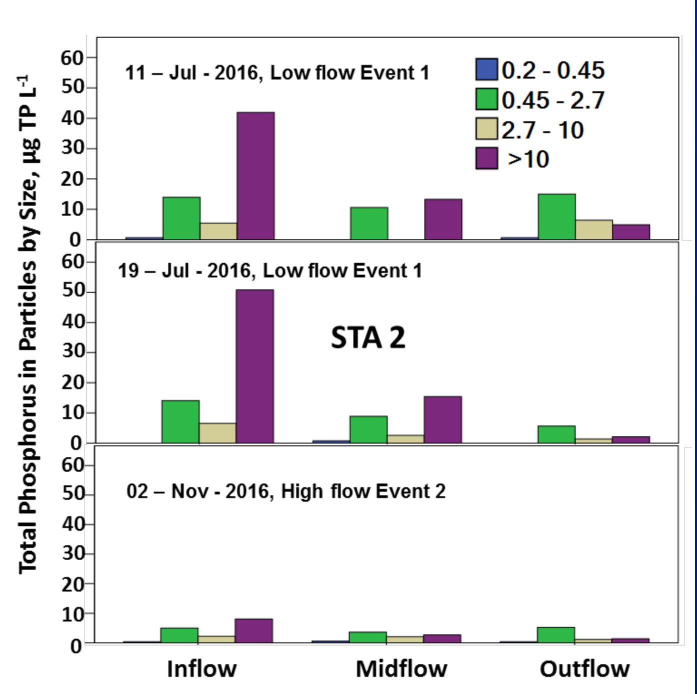
STA performance: P sequestration

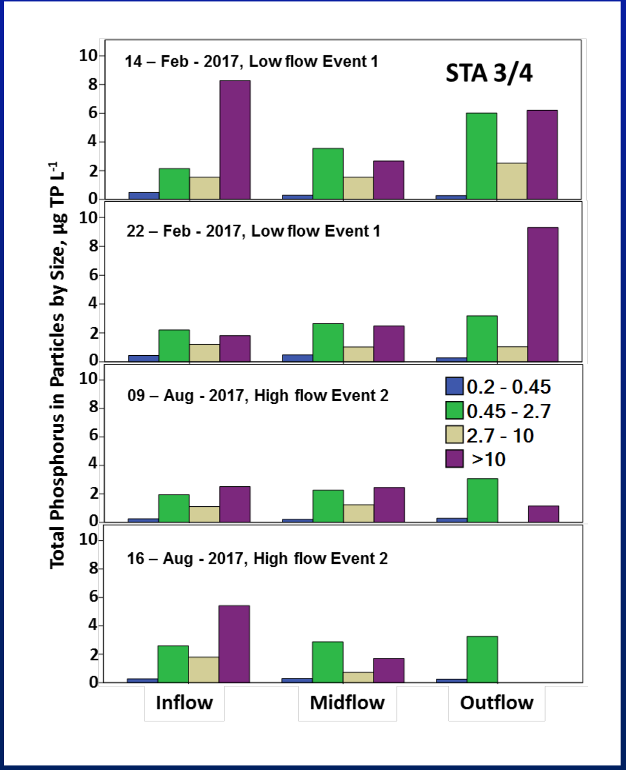
Sediment



Water







Particulate settling velocity and size

Digital floc camera

1.25ml
of sediment

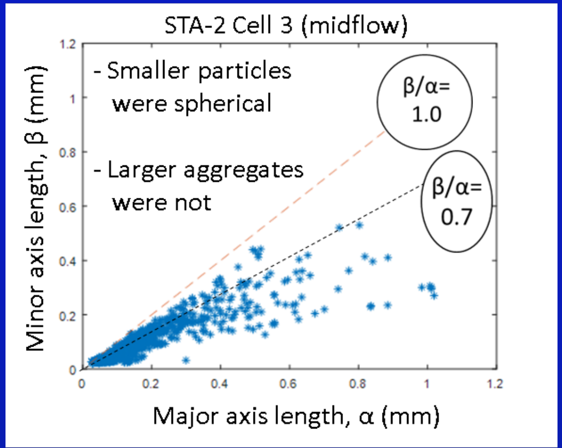
$$w_s = \frac{\alpha}{18\beta}\frac{(\rho_s - \rho_w)g}{\mu} D_p^{3-n_f}\frac{D^{n_f-1}}{1+0.15Re_p^{0.687}}$$

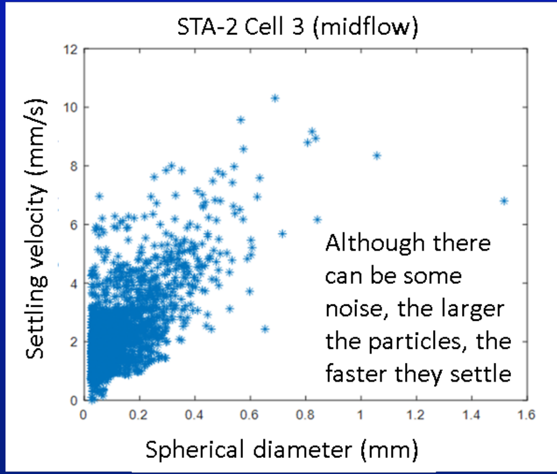
$$w_s = \frac{(\rho_s - \rho_w)gD^2}{18\mu}$$

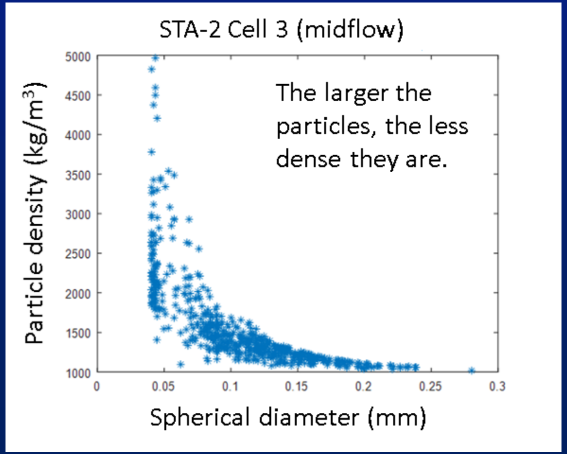
Determine aggregate densities using Stoke's law

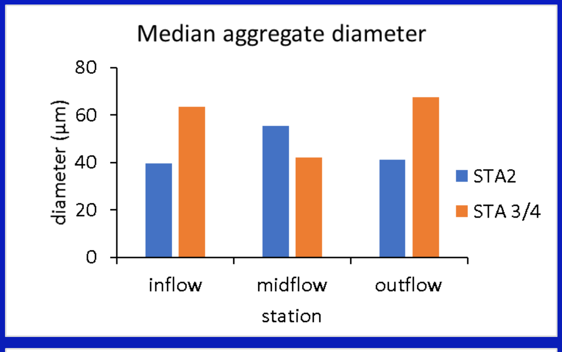
camera
strobe light
1' videos taken @
1', 2', 4', 8', 16', 32'

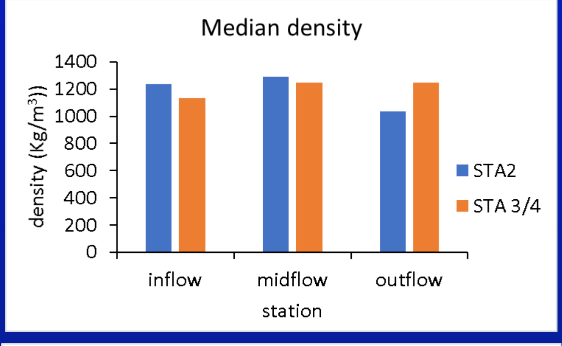
videos analyzed using particle tracking algorithms (Smith & Friedrichs, 2015)

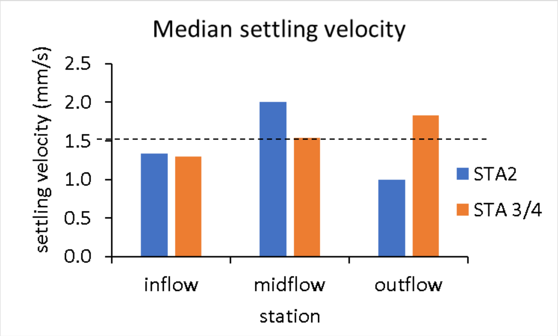


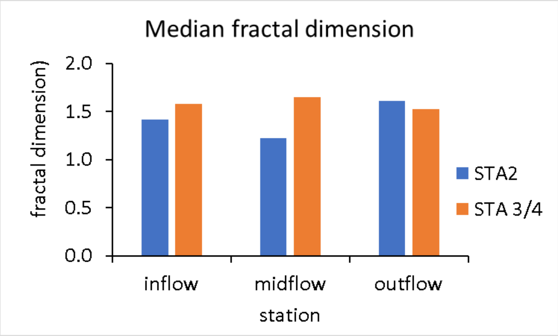






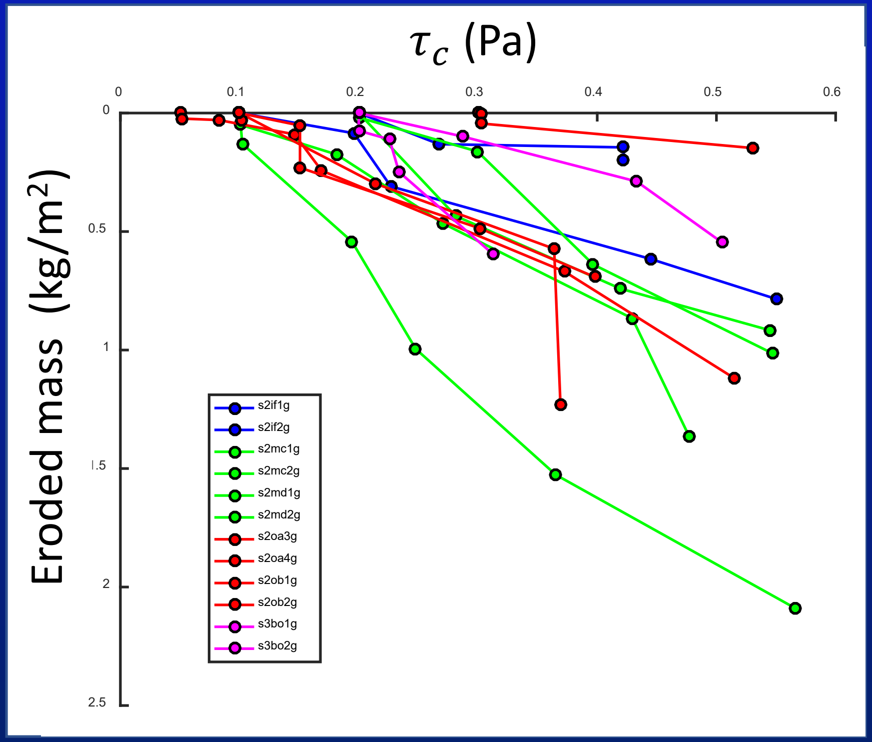


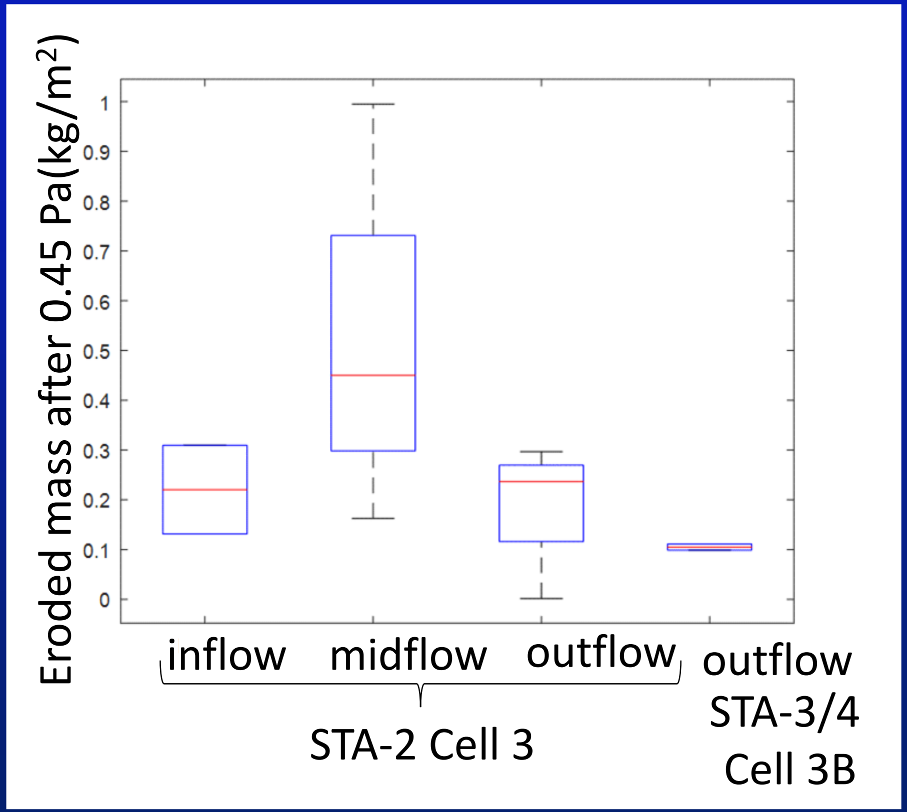


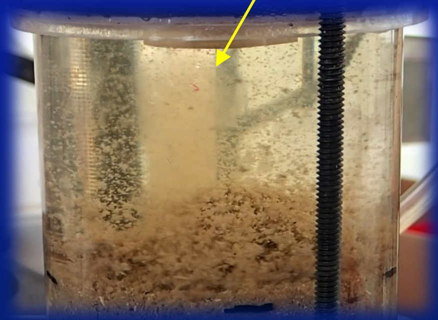


Laboratory experiments: determining the critical shear stress necessary to entrain sediment

GUST chamber method: critical shear stress necessary to achieve suspended sediment in the water column 10 cm above the surface







Midflow might accumulate a thicker layer of floc (although seems to be driven by one outlier)

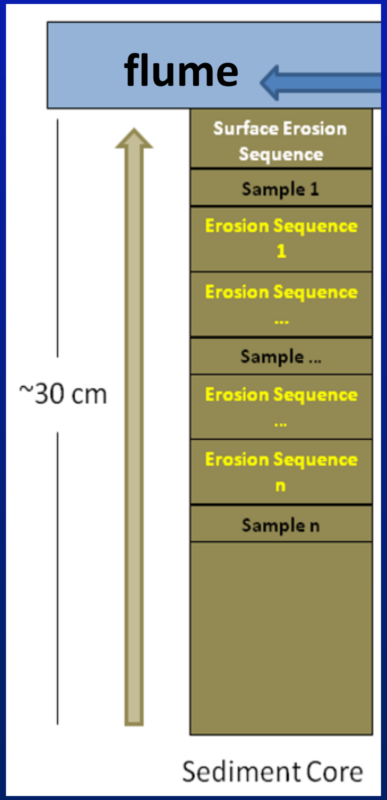
Median critical shear stress at sediment surface was similar amongst sites and stations (0.1-0.2 Pa), a two order of magnitude of what was measured *in situ*.

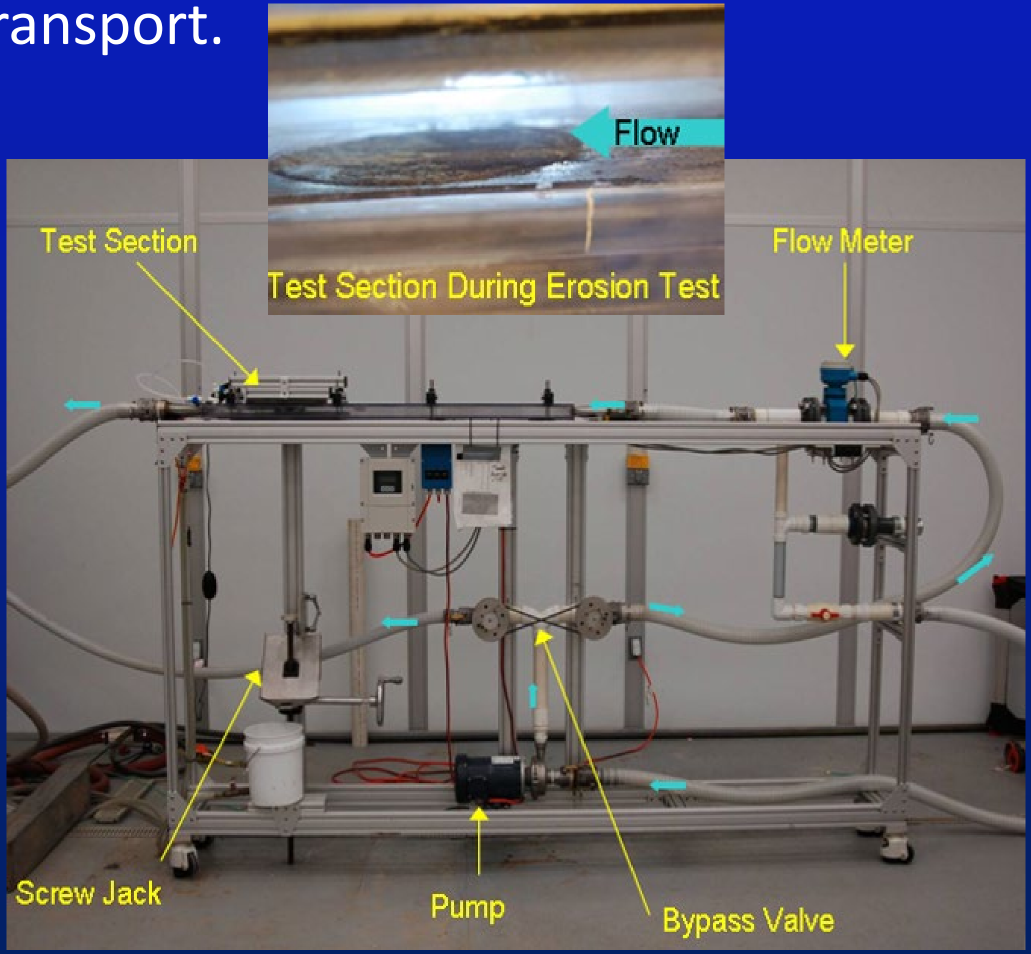
Laboratory experiments: determining the critical shear stress necessary to entrain sediment

SedFlume method:
Measures the critical shear stress to achieve bedload transport.

- The surface critical shear stresses for all sample locations was generally less than 0.1 Pa (range of 0.02-0.15 Pa), i.e. much lower stress than to resuspend particulate.

- Bedload transport relevant since it may help keep the bed unconsolidated, and perhaps aid in P flux to the water column (e.g. breaking aggregates).

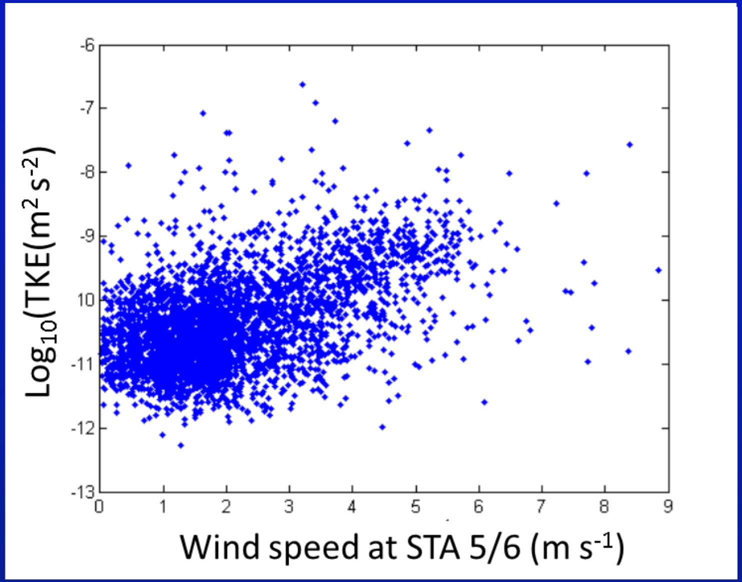


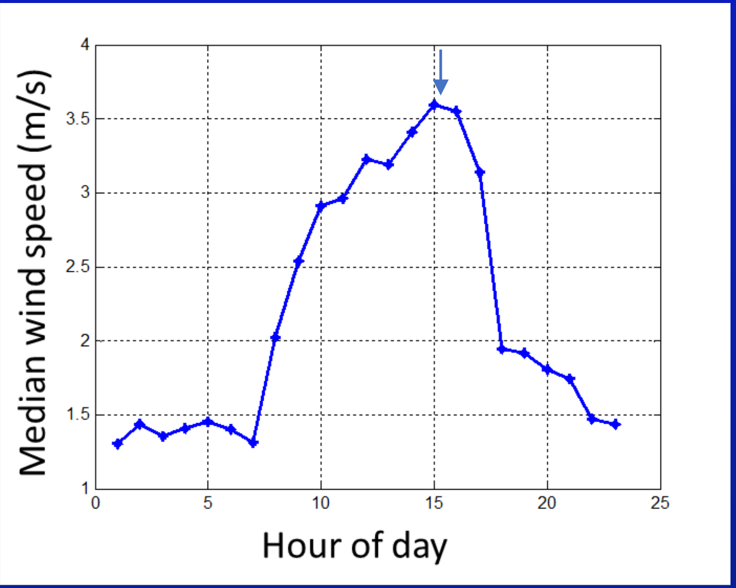


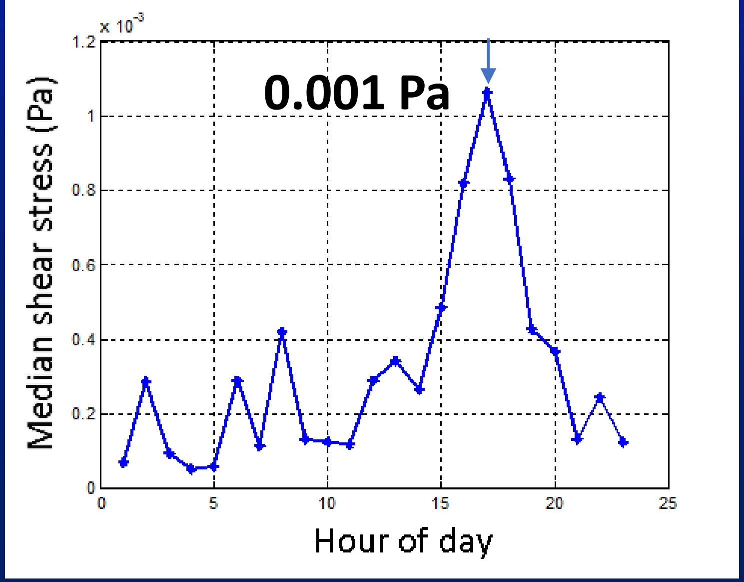
STA-2 Cell 3 midflow (July and August 2016): Shear stress and turbulent kinetic energy (TKE)

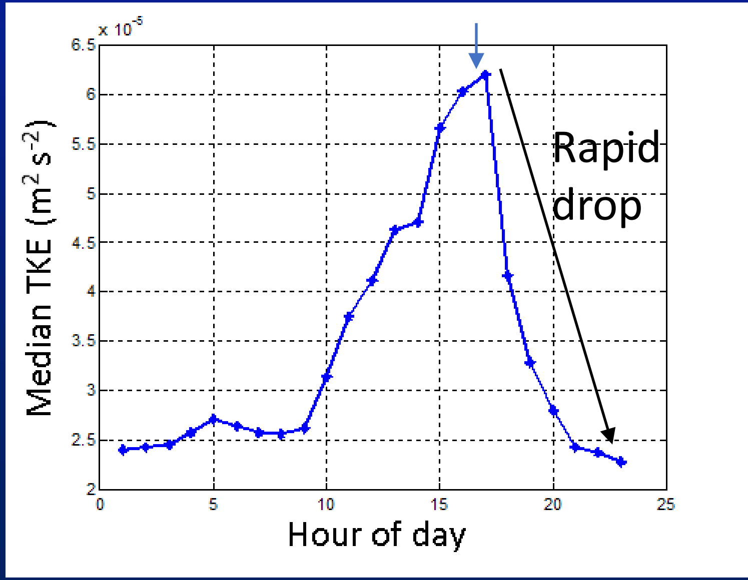
- Most of the turbulences and stress in the water column comes from winds in the afternoon rather than mean flow. 40% of the mean horizontal flow explained by wind

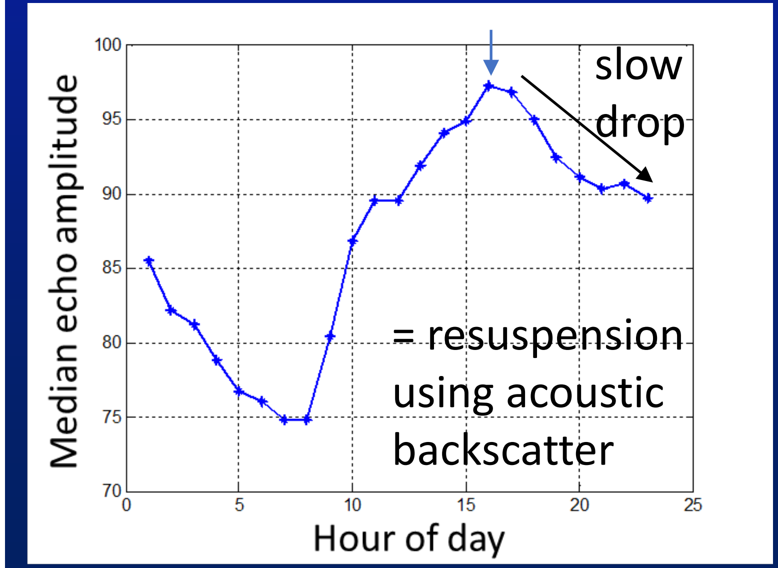
- Works at midflow where mean flow is minimal compared to inflow and outflow



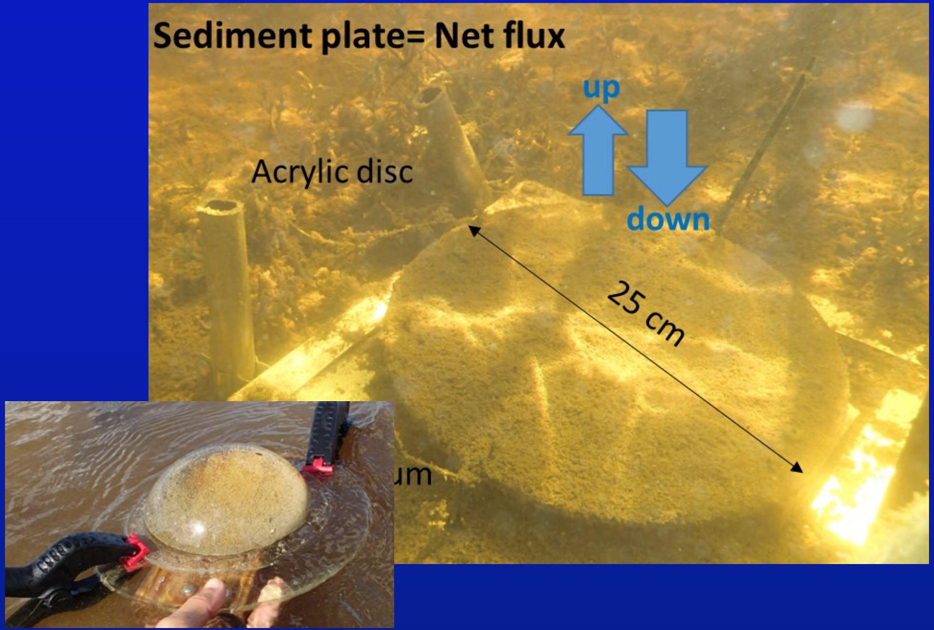


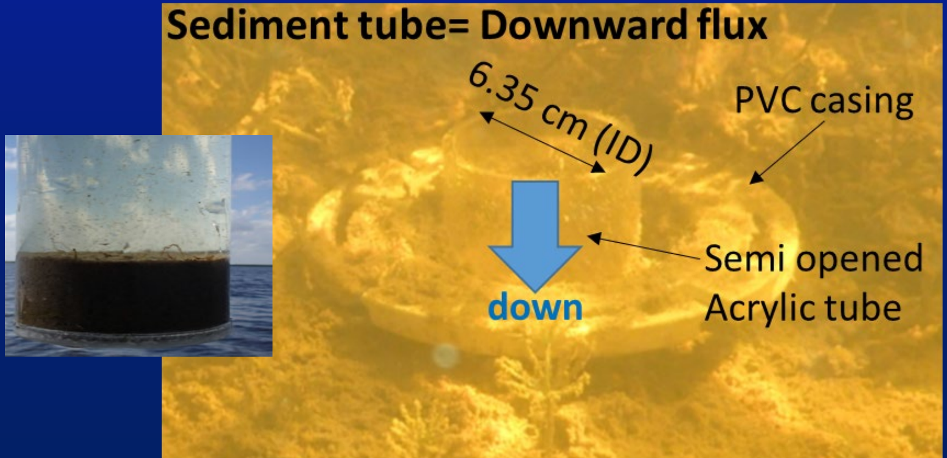






Estimation of downward, net and upward sediment fluxes using traps

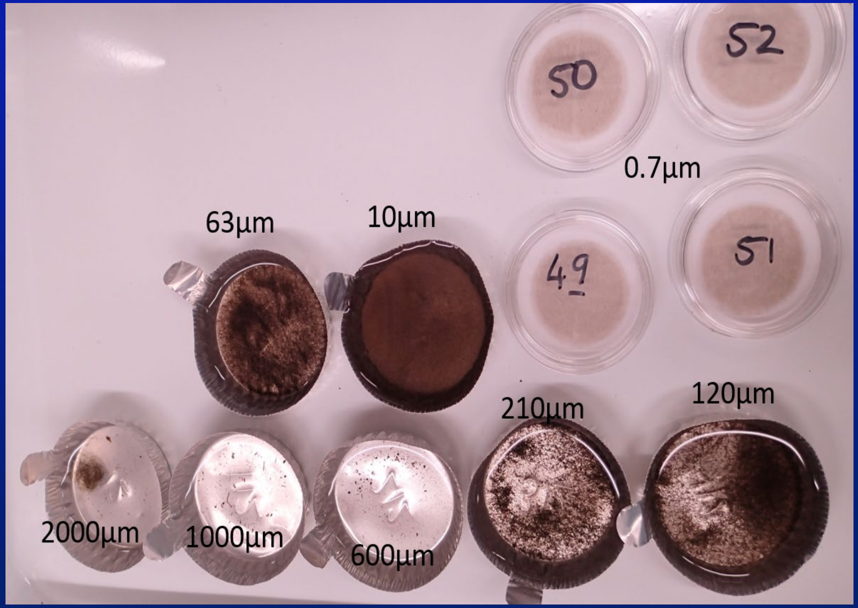




Triplicates traps of each type at each site deployed for one week

Sieving/filtering

Drying, ashing, analyzing TP, TN, TC, TOC



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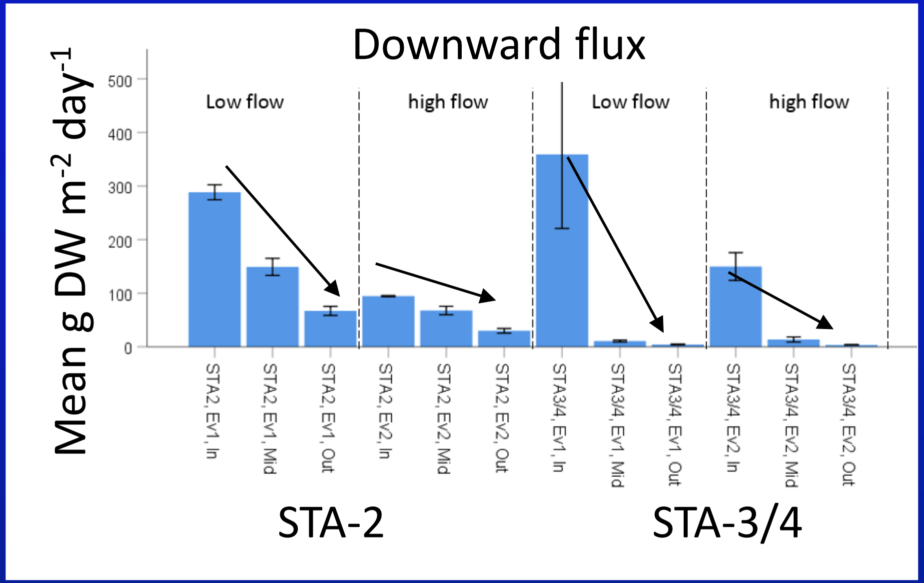
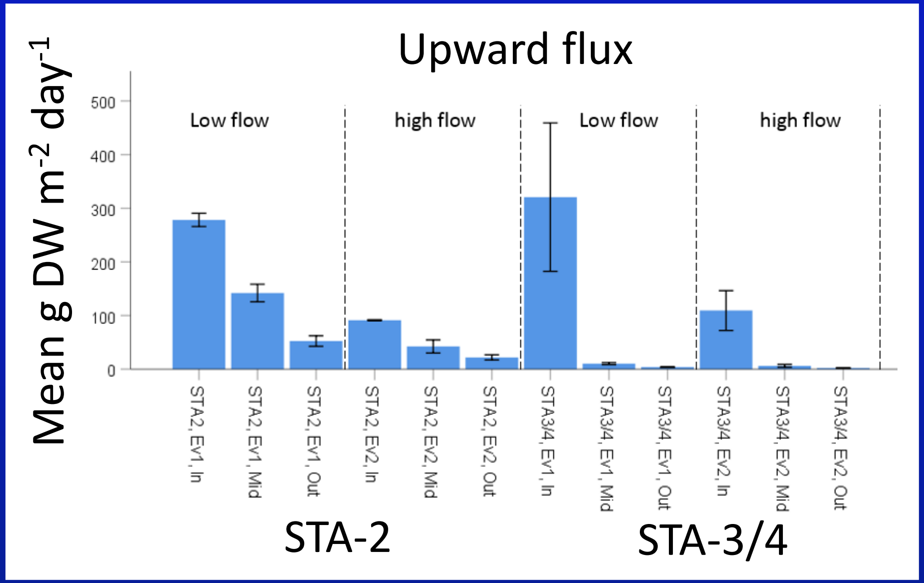
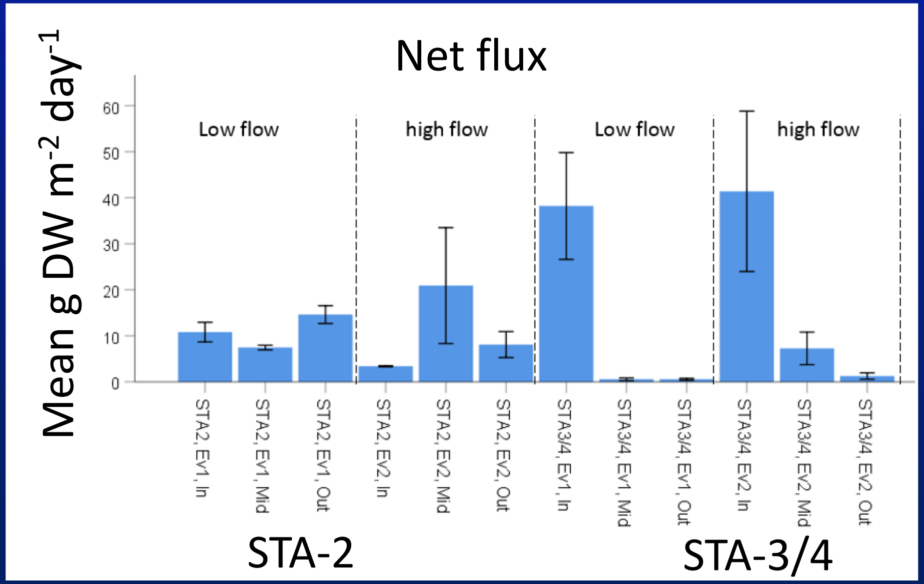


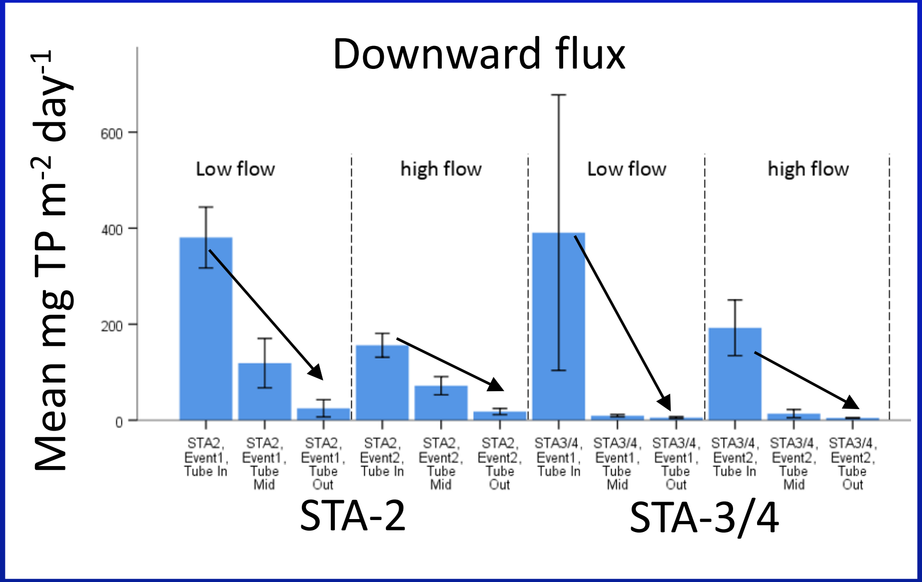


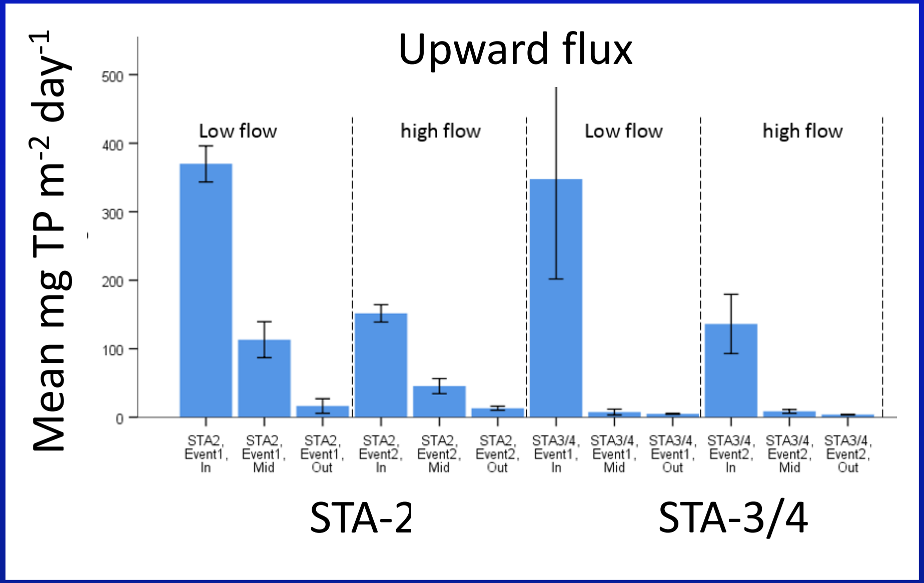
Dry weight fluxes



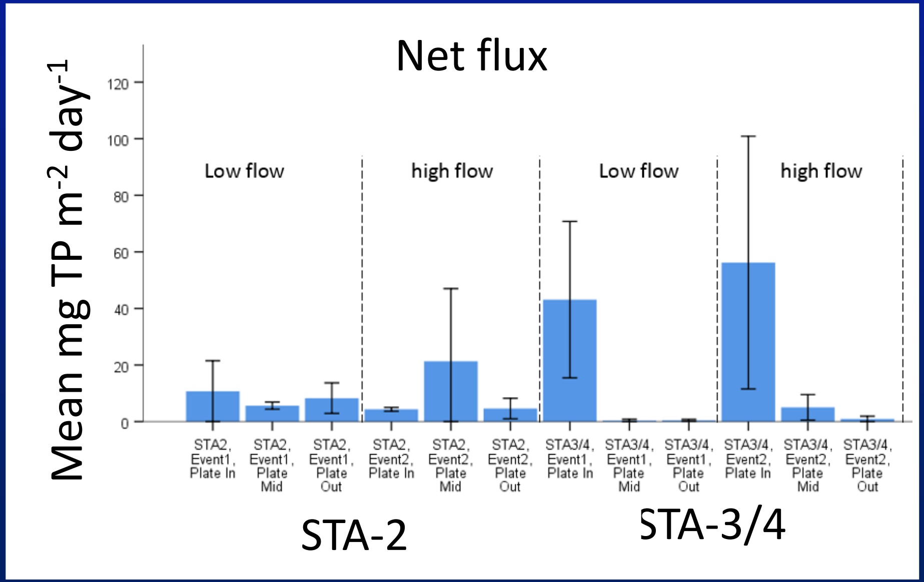
- Decrease in fluxes from inflow to outflow (sharper in STA-3/4)
- Net fluxes are 10% (STA-2) and 25% STA-3/4 of downward fluxes
- Upward fluxes driven by downward fluxes
- Larger downward and upward fluxes during low flow than high flow

Estimation of downward, net and upward sediment fluxes using traps





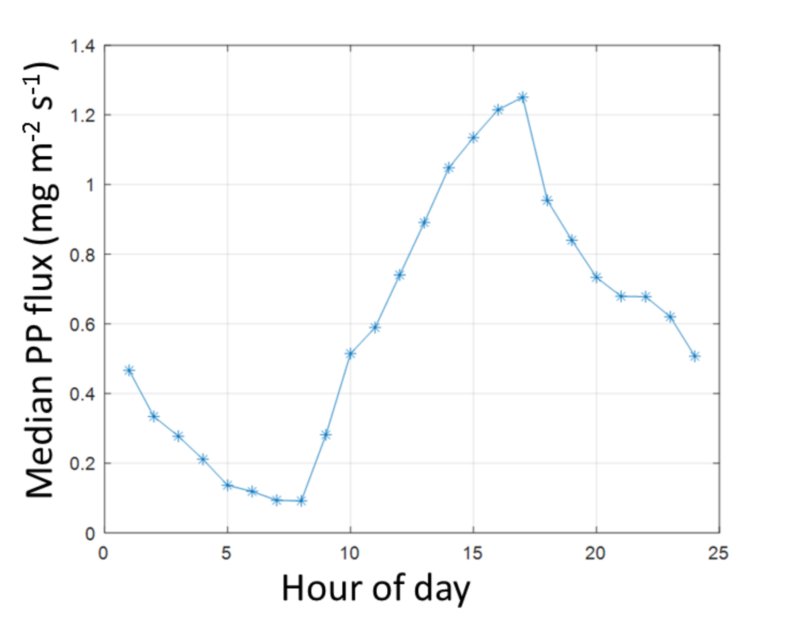
Particulate P fluxes

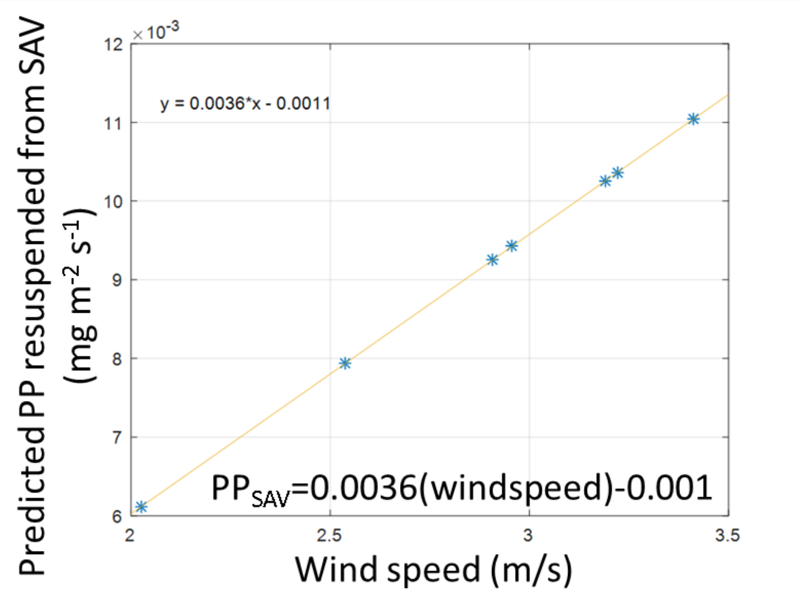


- DW fluxes drove TP fluxes

STA-2 Cell 3 midflow (July and August 2016): P horizontal fluxes & P fluxes from surrounding SAV

- Calibrated the acoustic backscatter to min and max TSS from the water grabs (log-log).
- Used the TP:TSS ratio with a median of 0.0056 to change TSS into particulate P.
- Since these are horizontal fluxes, the fluxes were divided by the length of the STA to get a daily flux of 30.5 mg m^{-1} d^{-1} (from 51.9 g TP m^{-2} d^{-1})
- Since there is not enough shear stress to resuspend bed particulates, we coarsely applied shear stress to the surrounding SAV's periphyton which is shallower.
- PP_{SAV}=0.0036 x windspeed (m/s) -0.001





Conclusions and food for thought

Various methods did not address the same fluxes

- Gust chamber looked at the upward flux
  - w/ a shear stress of 0.1-0.2 Pa to erode surface floc vs. 0.001 Pa as measured on the bed. So the floc should never resuspend once settled. Although wind generated waves, even when under the base could potentially resuspend bottom floc.
  - SAV periphyton sloughing could greatly contribute to upward fluxes (very coarse solution provided)

- SedFlume looked at the bedload
  - Could deconsolidate aggregates
  - Should we use the shear stress (<0.1 Pa) for periphyton sloughing as well?

- Sediment traps
  - Mixture of upward flux and bedload (low aspect ratio traps)
  - Net resuspension was influenced by fish bioturbation (traps acted as a fish attractor?). This could have increase upward fluxes

Lab experiments could be biased: floc and periphyton can host live organisms and especially autotrophic organisms. As such, temperature and light could have affected the buoyancy as well as the cohesion of the aggregates. Further, seasonality and its effect on the floc/periphyton was not assessed.

Conclusions and food for thought (cont'ed)

How should we deal with floating mats?

Some scoured areas seemed to change over time, what initially looked like a scoured area was no longer one at the end of the study.


Thank You!