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What water quality benefits does a constructed brackish marsh provide when receiving nutrients from agricultural drainage waters?

Randall Etheridge, Mike Burchell, François Birgand

Problems in Coastal Areas

- Loss of marshes

- Eutrophication

A Potential Solution

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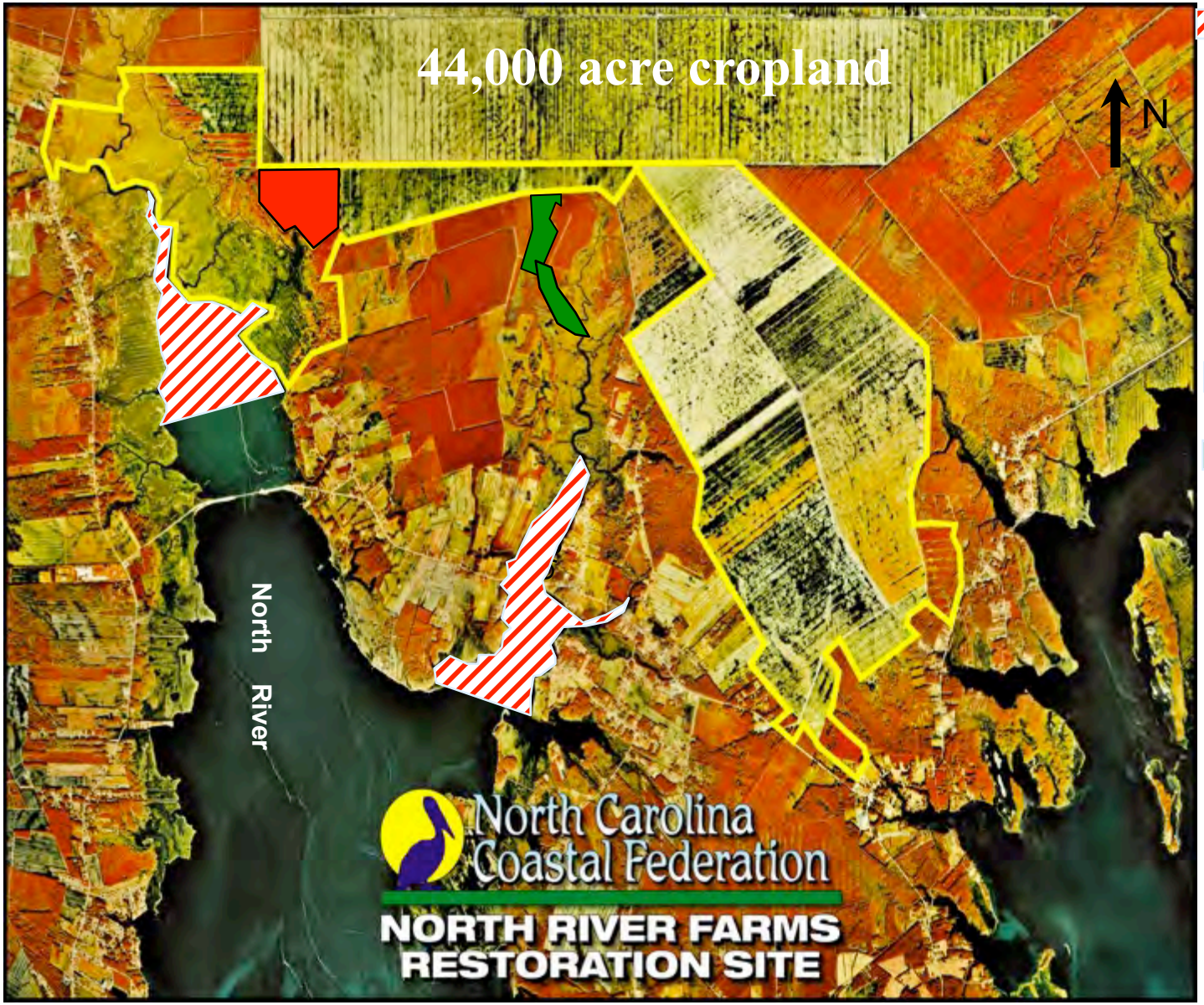

Closed to shellfishing

Phase II restoration
110 acres (45 ha)

Wetland references

Ecosystem Enhancement Program

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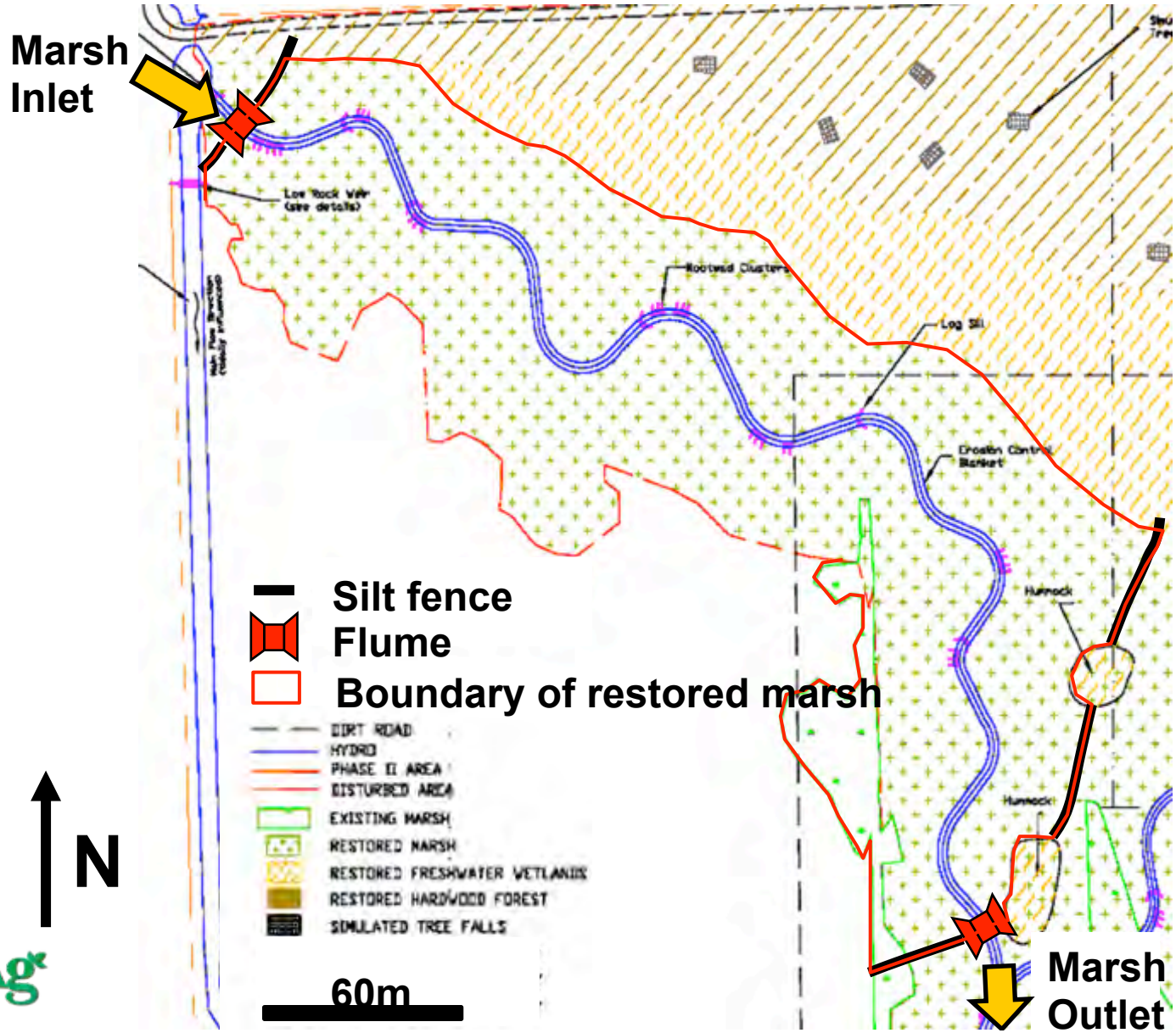
Project Goals

- Demonstrate non-traditional design techniques for restoring wetlands to an agricultural landscape
- Create a stable tidal creek and marsh ecosystem that integrated into surrounding marsh
- Reduce exports of agricultural pollutants to the North River estuary
- **Conduct research studies to evaluate stability of the design and other ecosystem services provided (specifically NO_3-N retention)**

Methods



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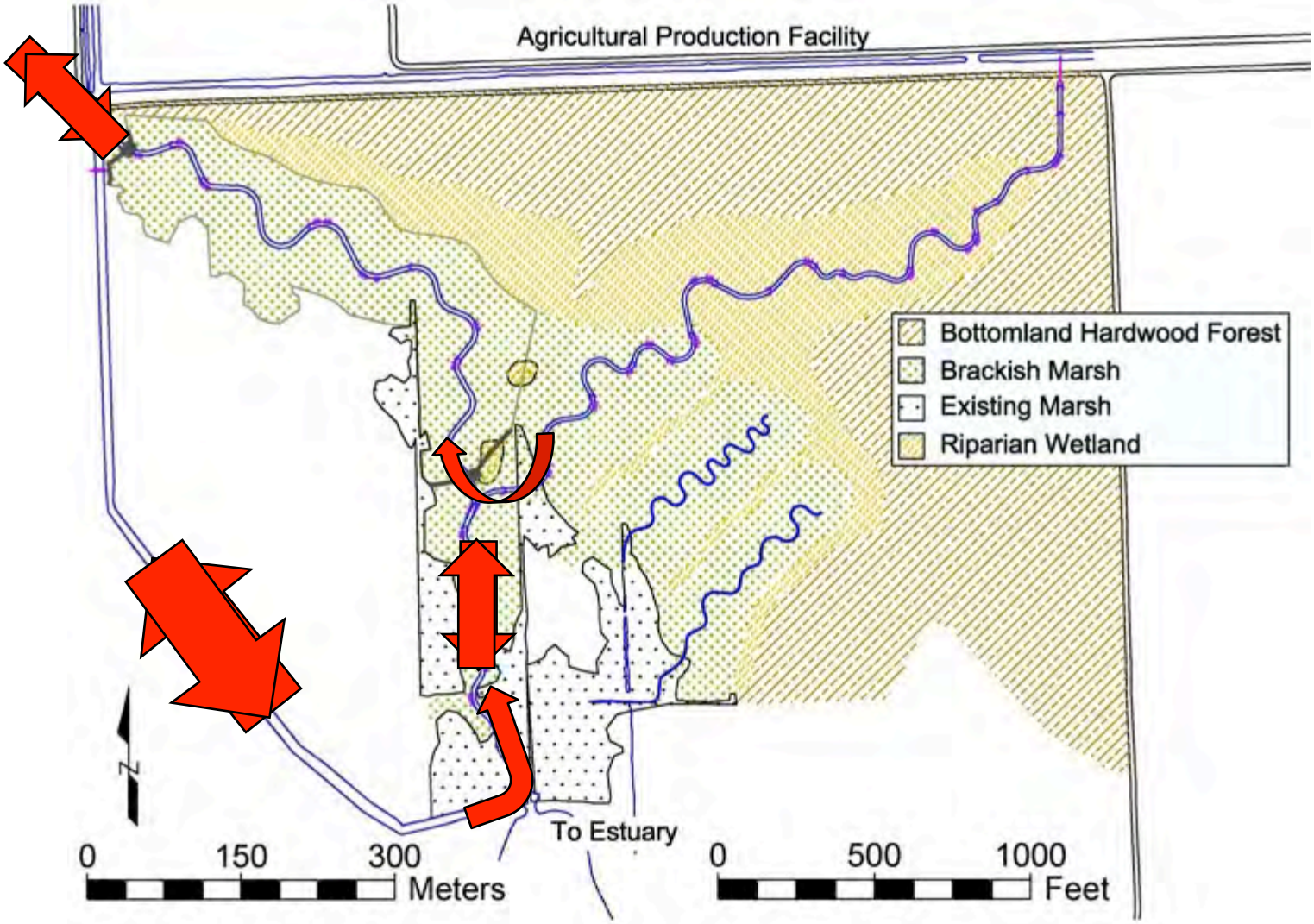
Water Movement in the Marsh



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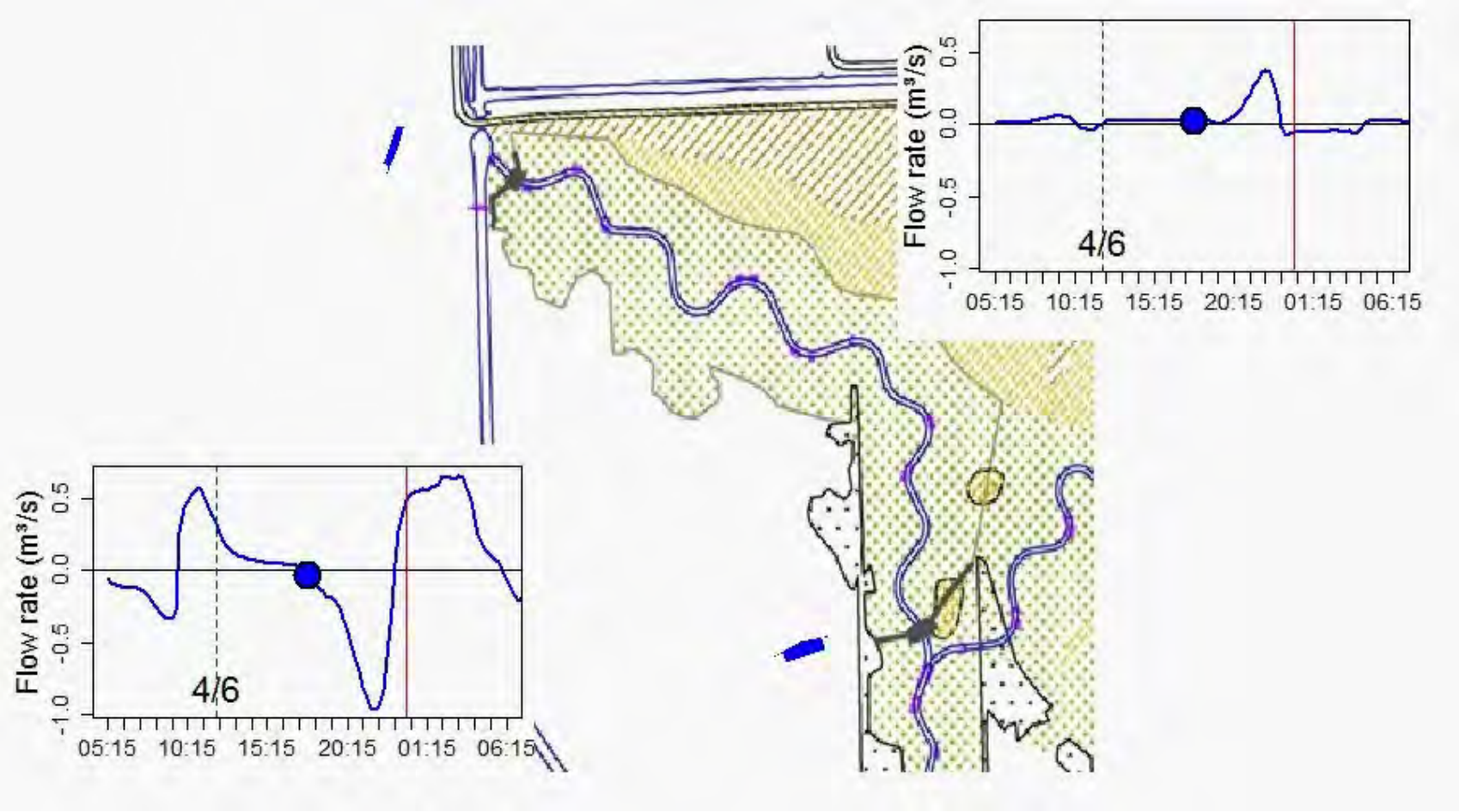
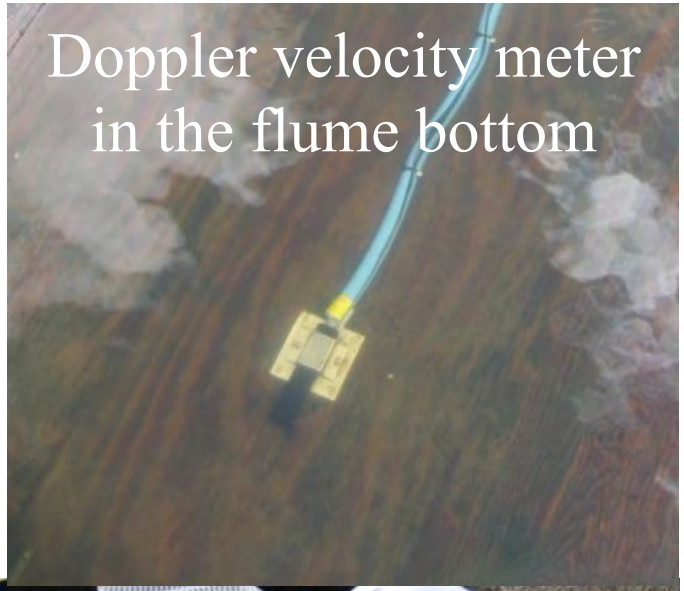
Flow dynamics



Flow Monitoring

- Doppler velocity meter records velocity and water depth in flume
- Velocity and water depth recorded every 15 minutes
- Use manual stream gauging to relate Doppler velocity to actual flow in the flume



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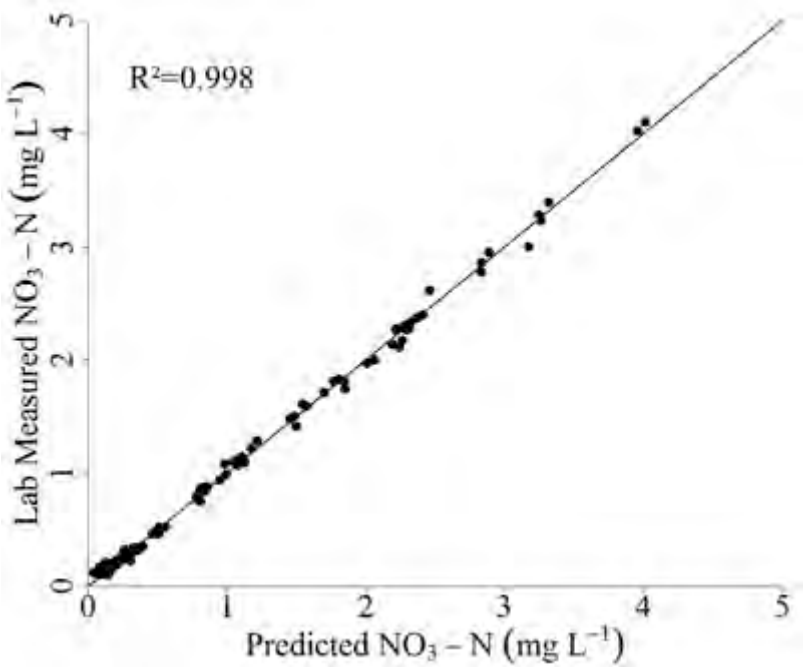
Nutrient Monitoring



Parameter	R^2	RMSEP (mg L^{-1})
NO_3-N	0.998	0.1
TKN	0.91	0.3
DOC	0.94	1
TSS	0.92	7
PO_4-P	0.66	0.01
TP	0.73	0.02
Salinity	0.97	2

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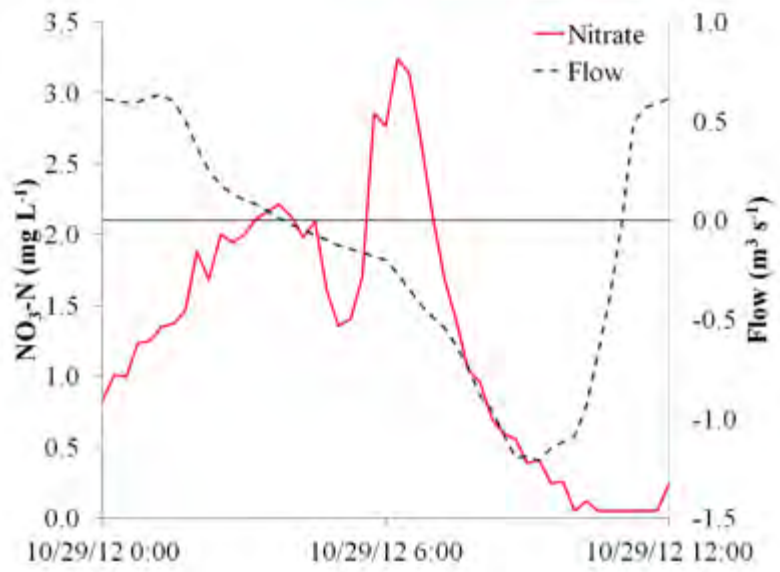
Mass Balance

$$M = k\sum_{i=1}^{i=t} q_i c_i \Delta t$$



- M = total mass of N either exported or imported (kg)
- t = time (min)
- k = constant for converting units
- q_i = water flow at time i (m^3 s^{-1})
- c_i = concentration at time i (mg L^{-1})

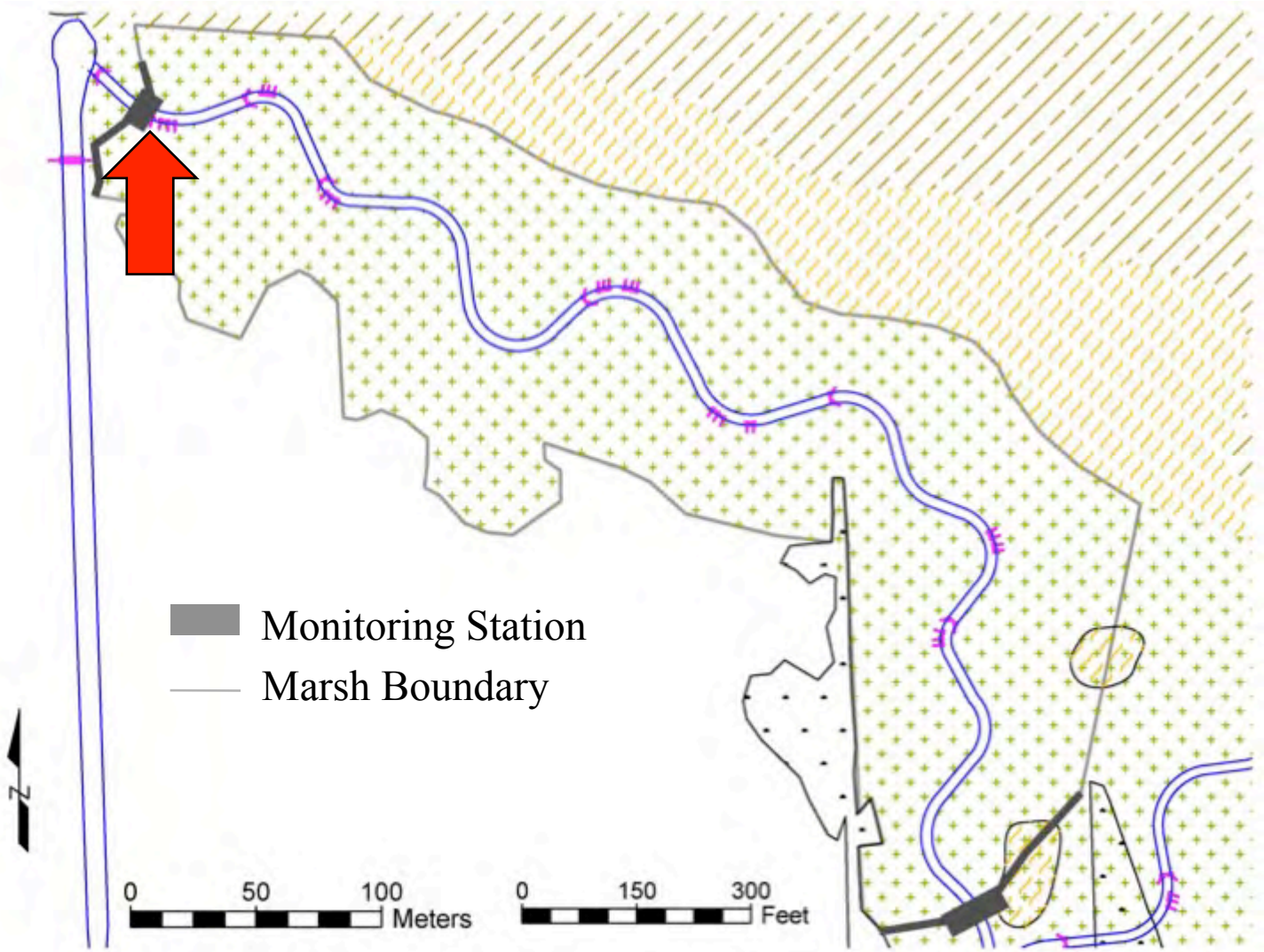
Mass Balance

Positive Mass Balance = Retention

Negative Mass Balance = Release

Upstream Station:

Single storm event example



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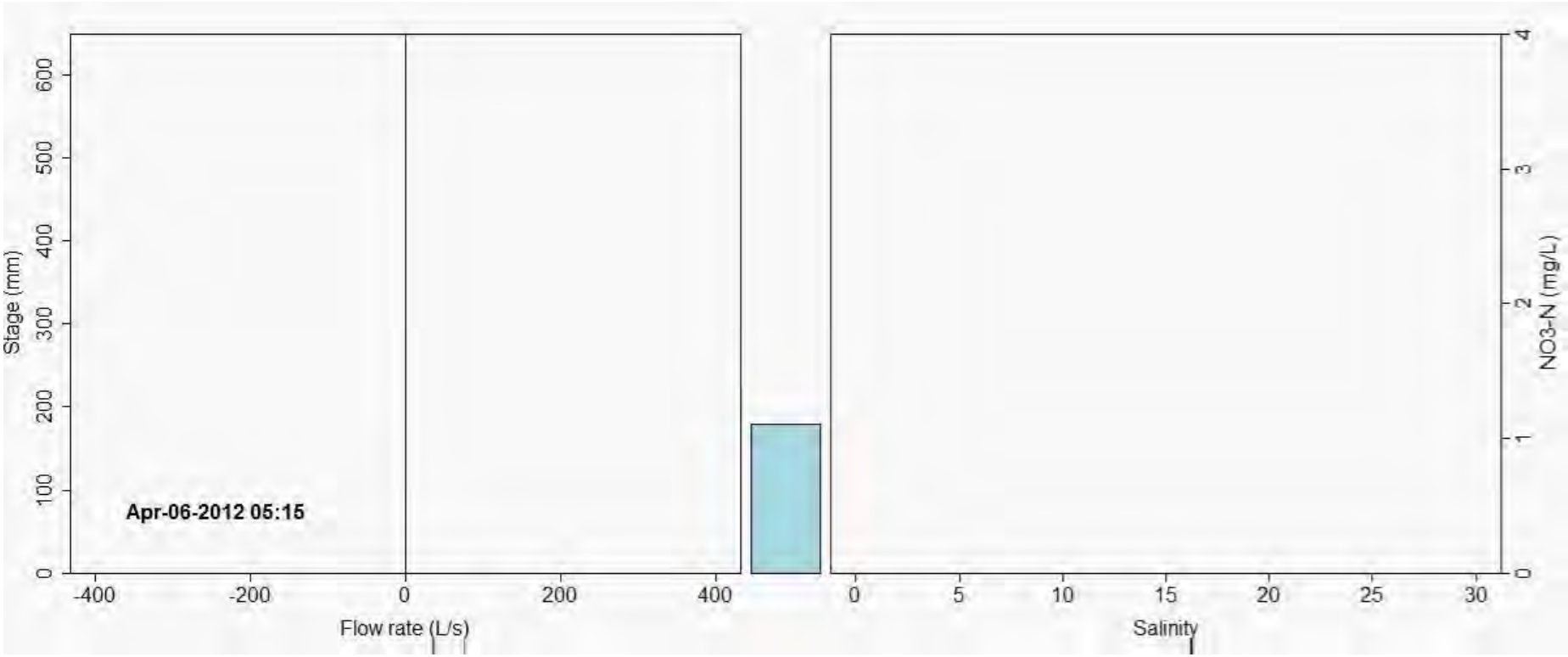
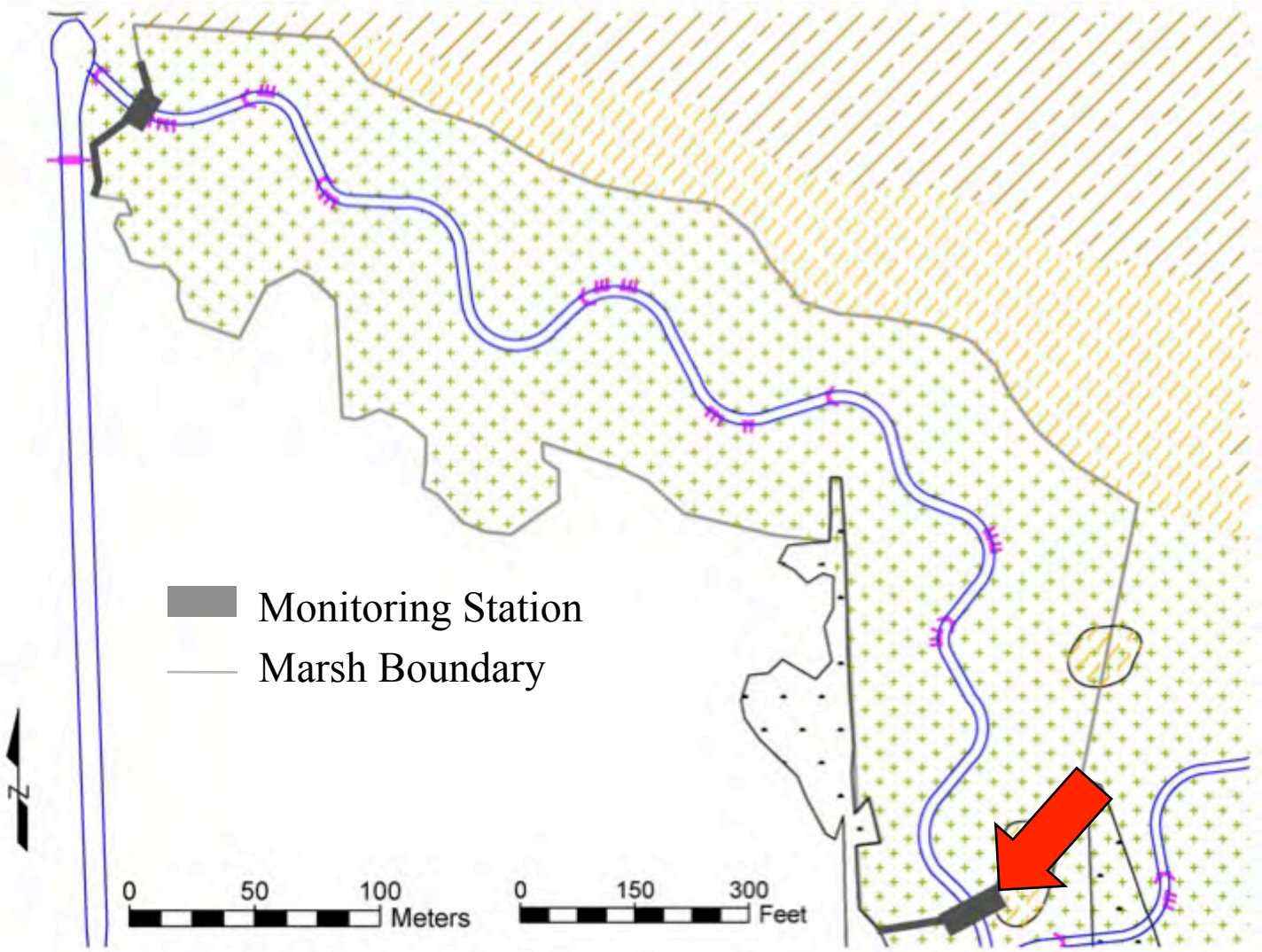
Upstream Station



Downstream Station

Long-term results



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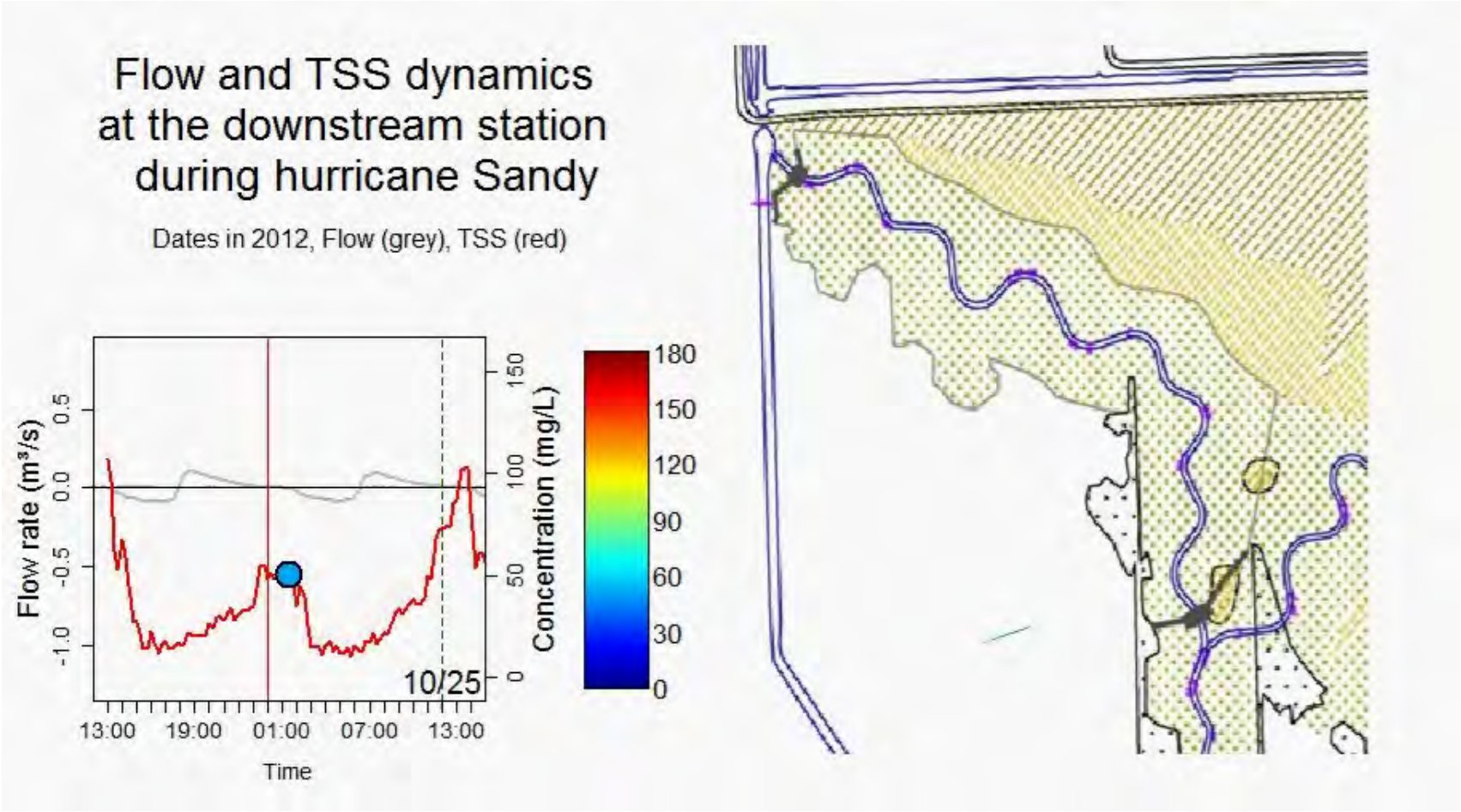
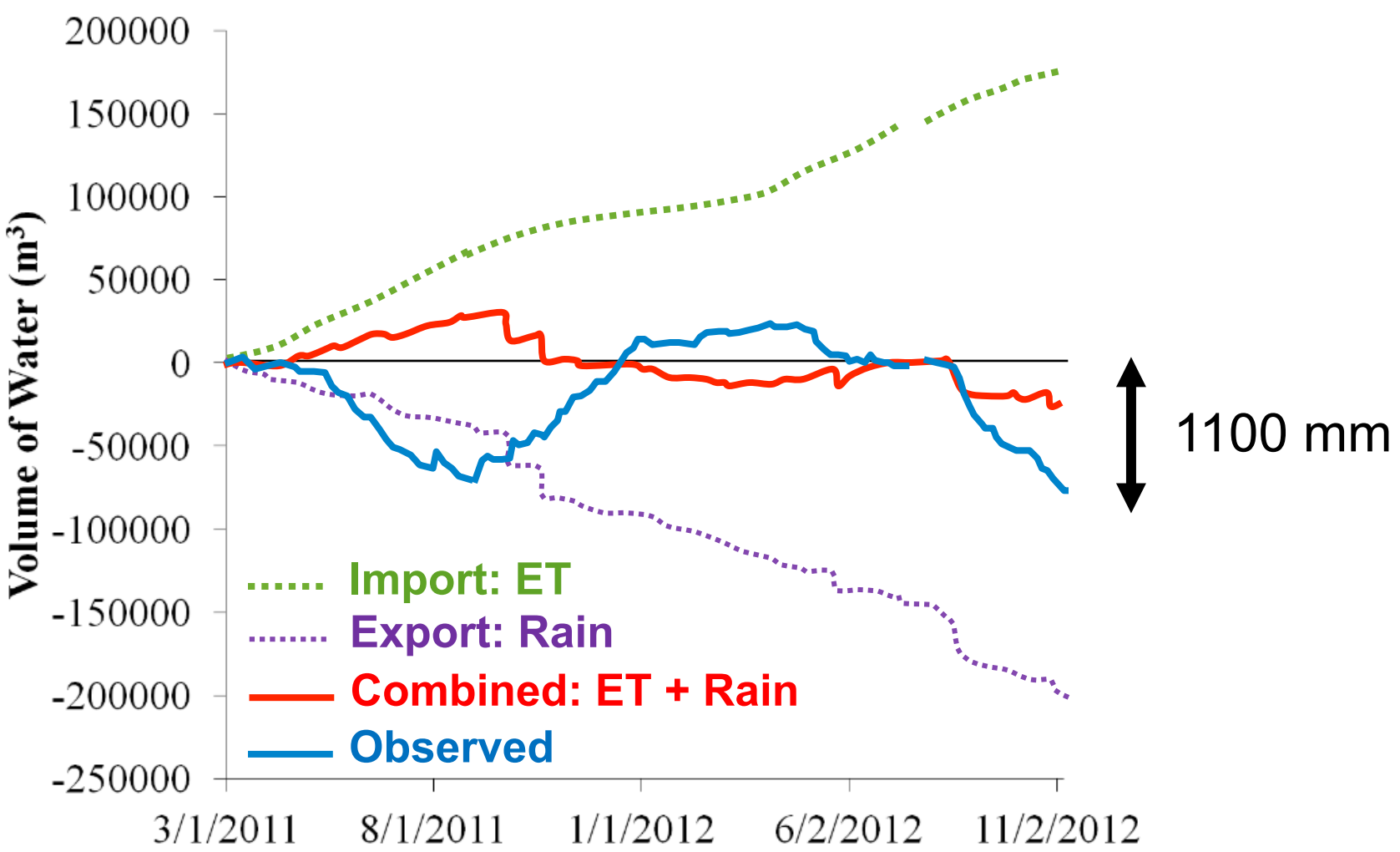
TSS dynamics



Water balance intrigue…



2-way water pump!

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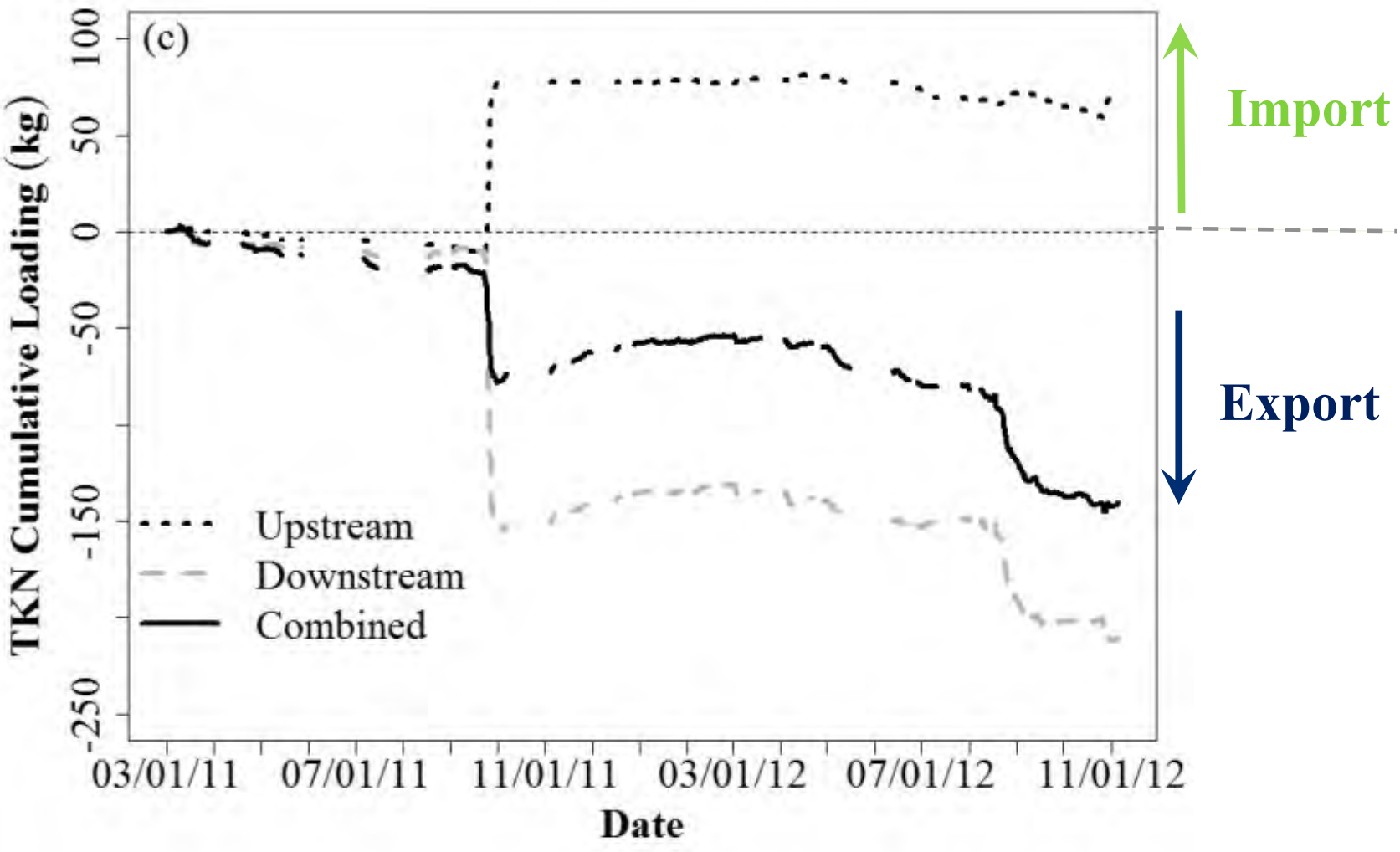
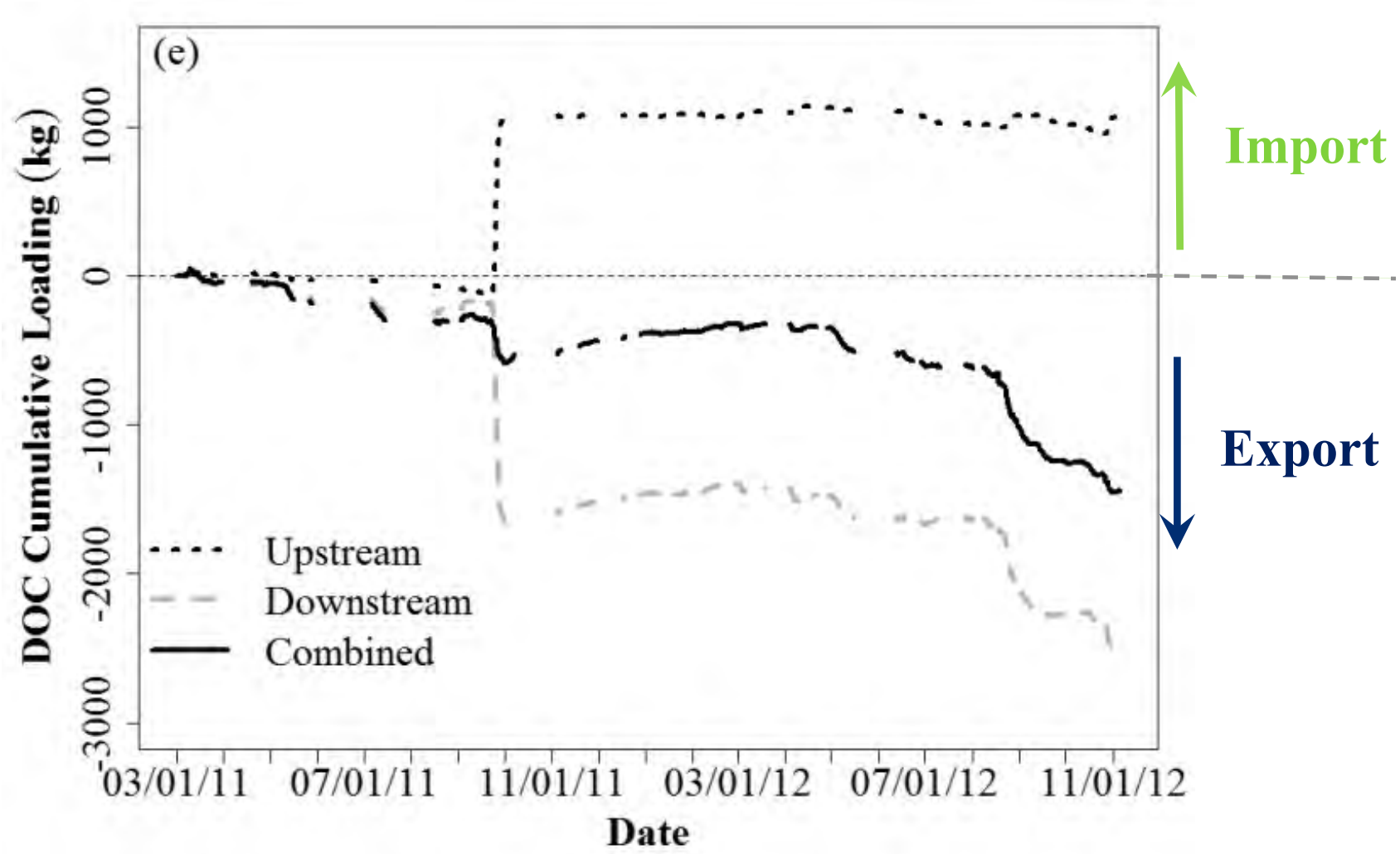
TKN balance: net export



DOC balance: net export



1-way nutrient pump!

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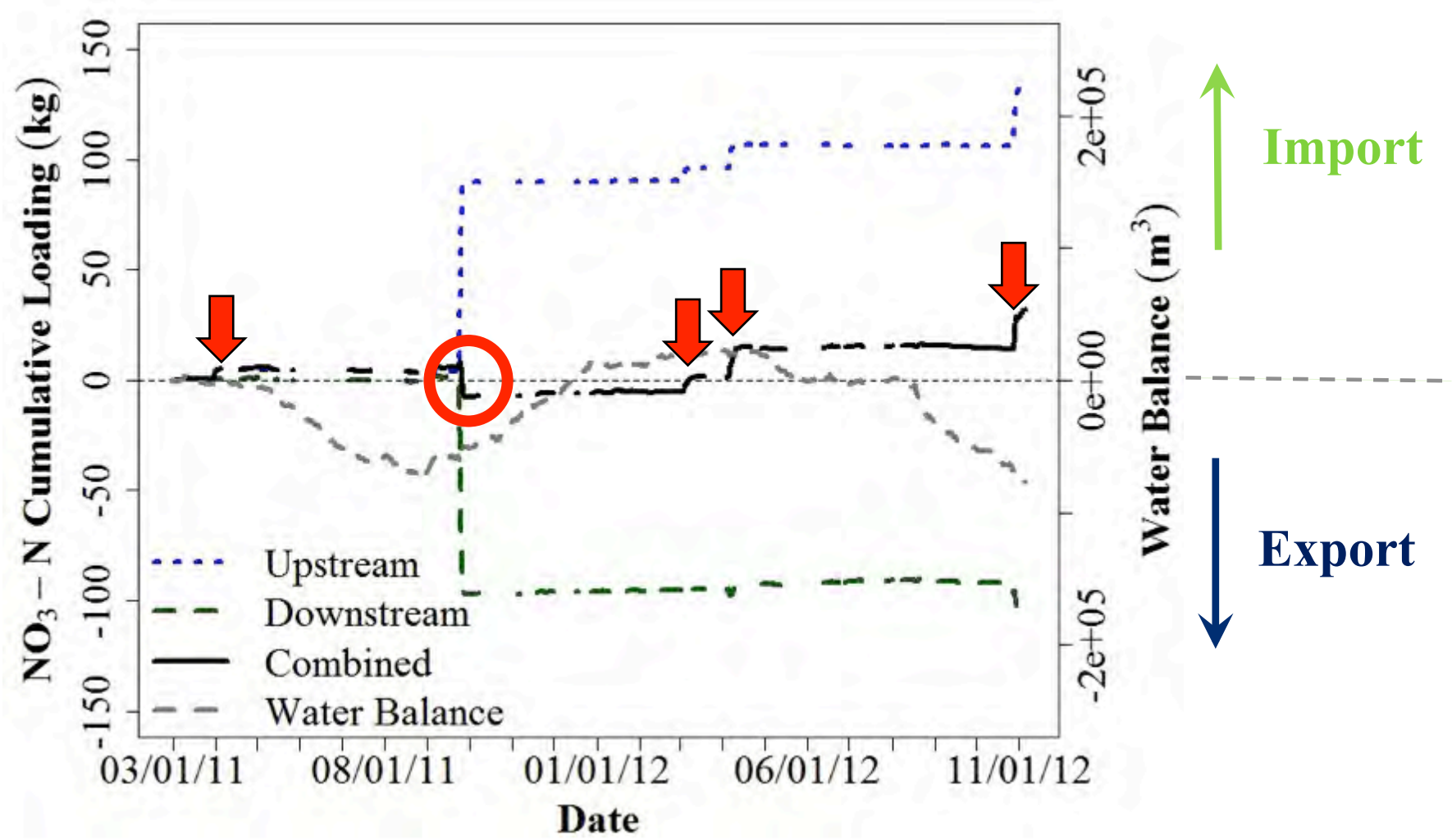
Nitrate Mass Balance



Mass Balance Summary

Parameter	Input Mass (kg)	Output Mass (kg)	Mass Balance (kg)	Percent Retention
NO_3-N	**470**	**430**	**40**	**9%**
TKN	1,290	1,410	-120	-9%
TN	1,760	1,840	-80	-5%
DOC	18,000	19,400	-1,400	-8%
PO_4-P	57	59	-2	-4%
TP	117	125	-8	-7%
TSS	48,000	51,000	-3,000	-6%

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Conclusion

- Long-term 15-min data: essential to make meaningful conclusions
- Nitrate retention values mid-way between stream and non-tidal wetlands
- Marsh: 2-way water pump, 1-way nutrient pump
- Nutrient outwelling confirmed?

Questions?

Marsh Creation Goals

- Create lost habitat
- Improve water quality in the North River
- Provide design guidance for future salt marsh projects in coastal North Carolina

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September 2007

November 2012

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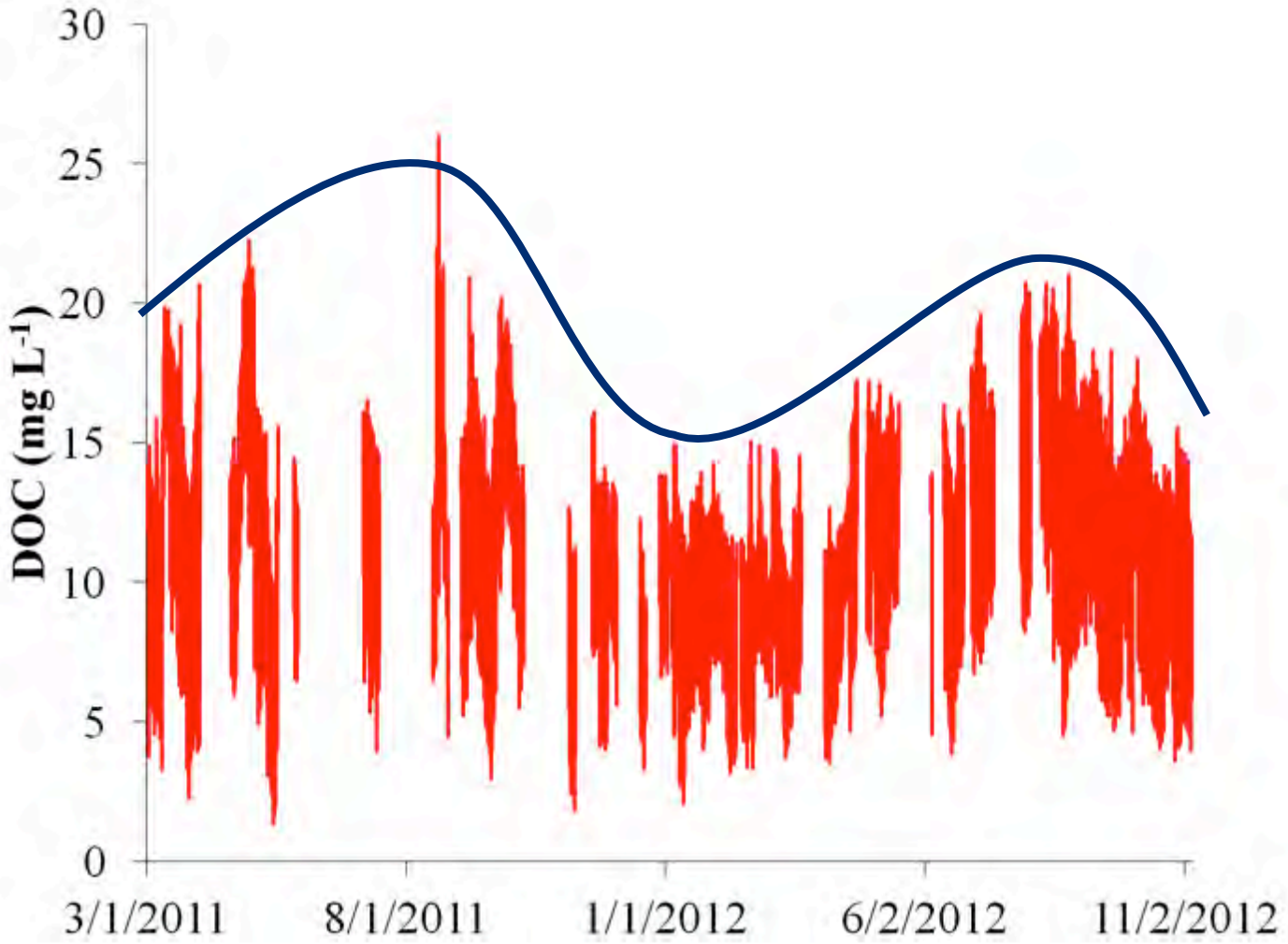
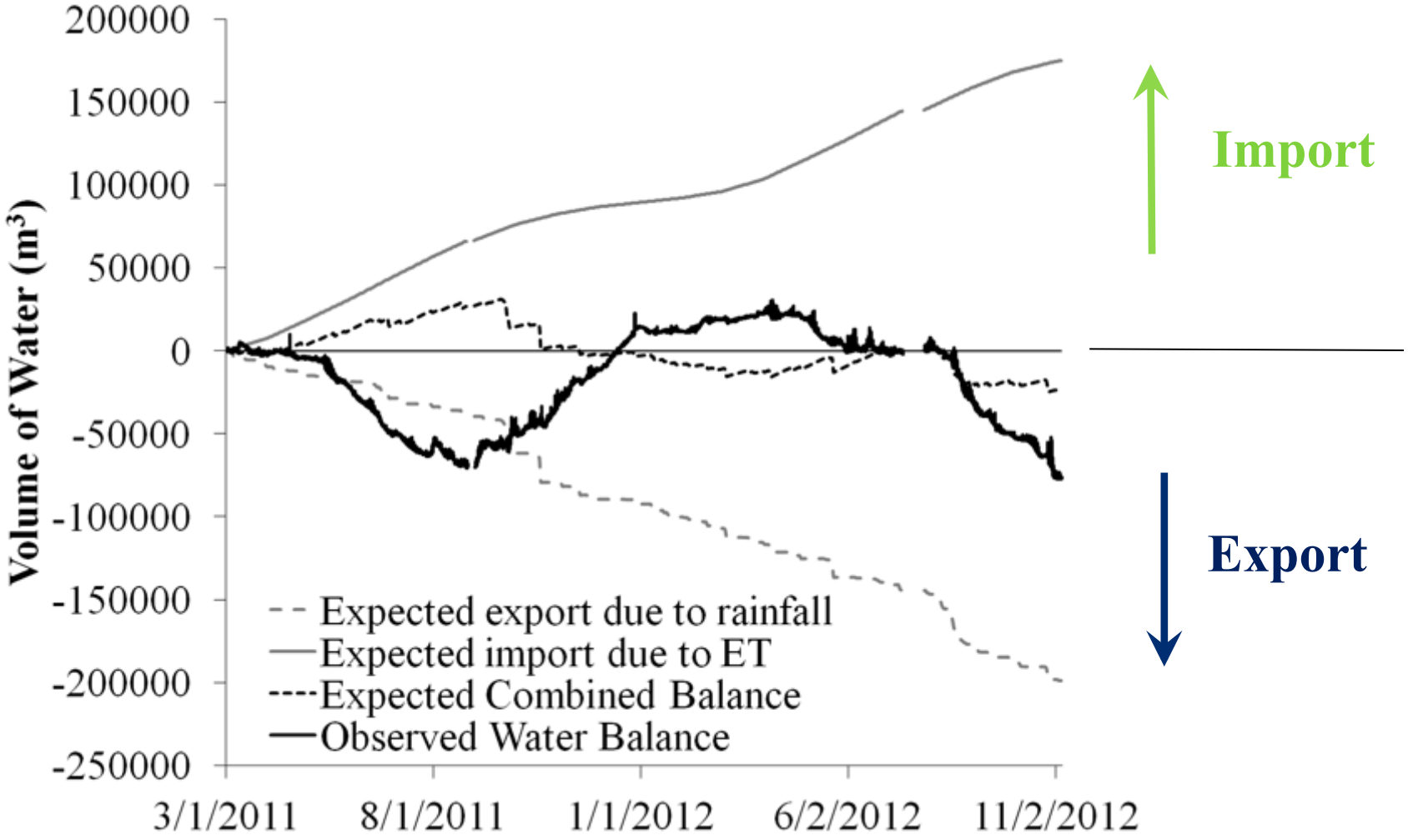
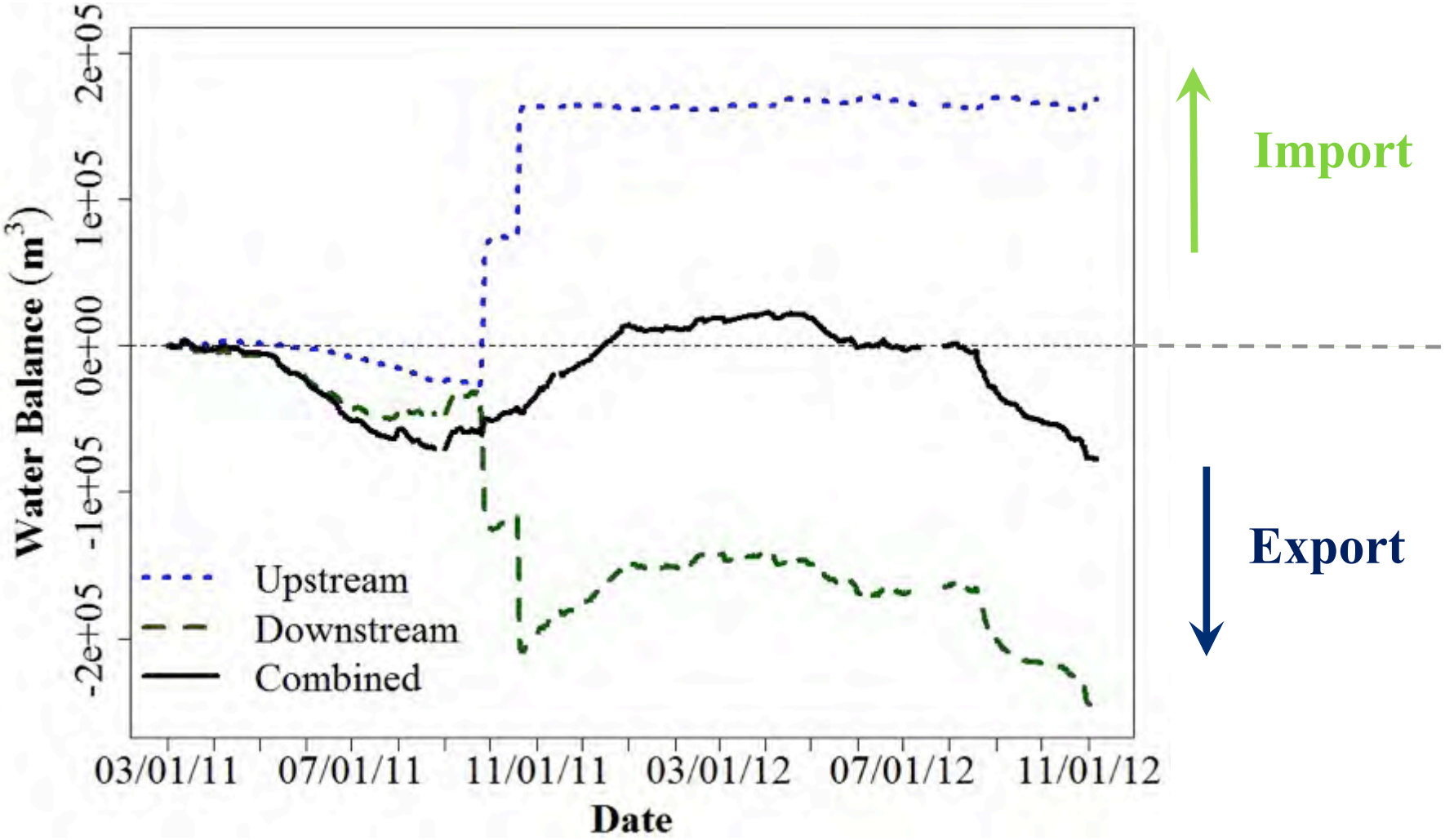
DOC


30
25
20
15
10
5
0
DOC (mg L-1)
3/1/2011
8/1/2011
1/1/2012
6/2/2012
11/2/2012

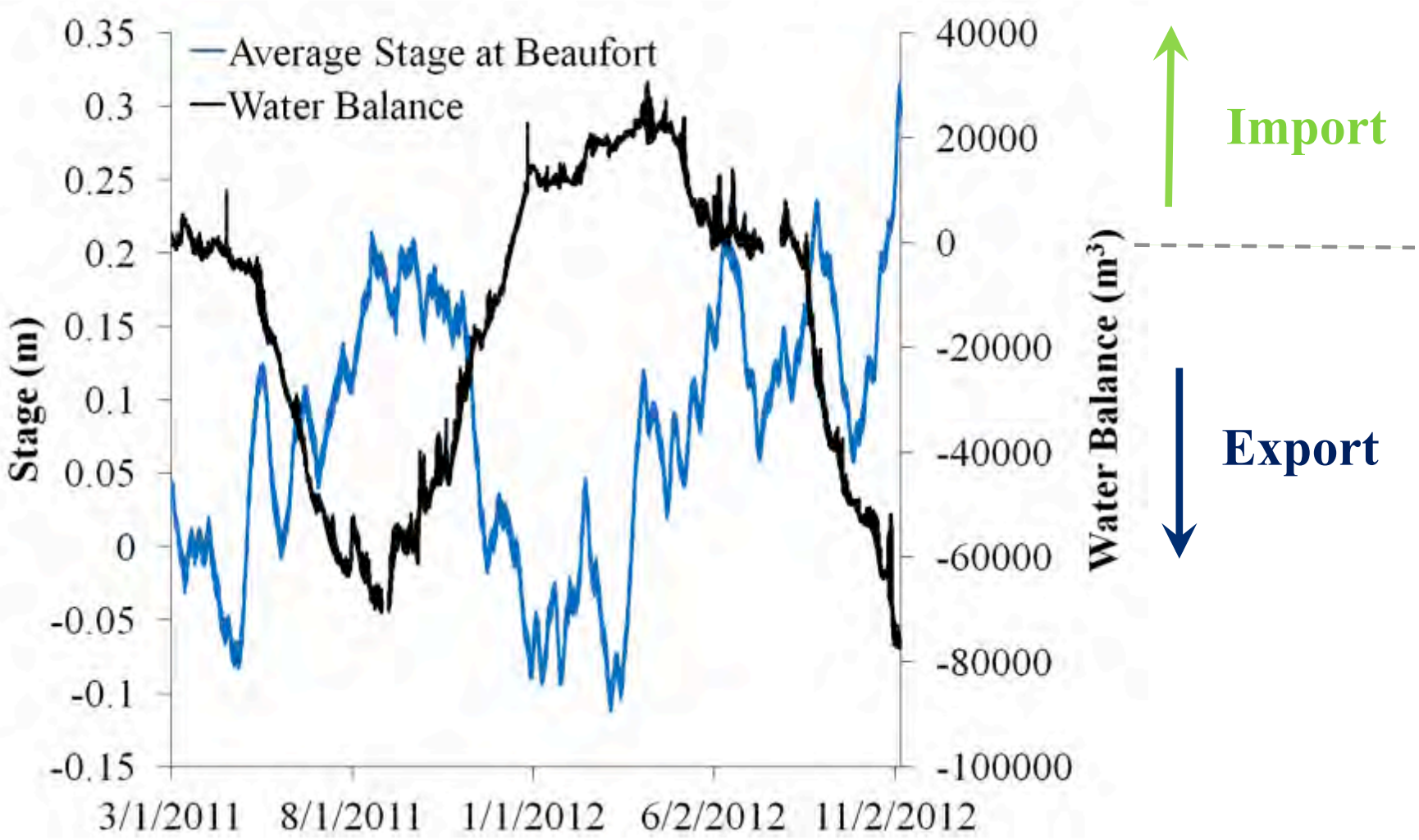
Water Balance



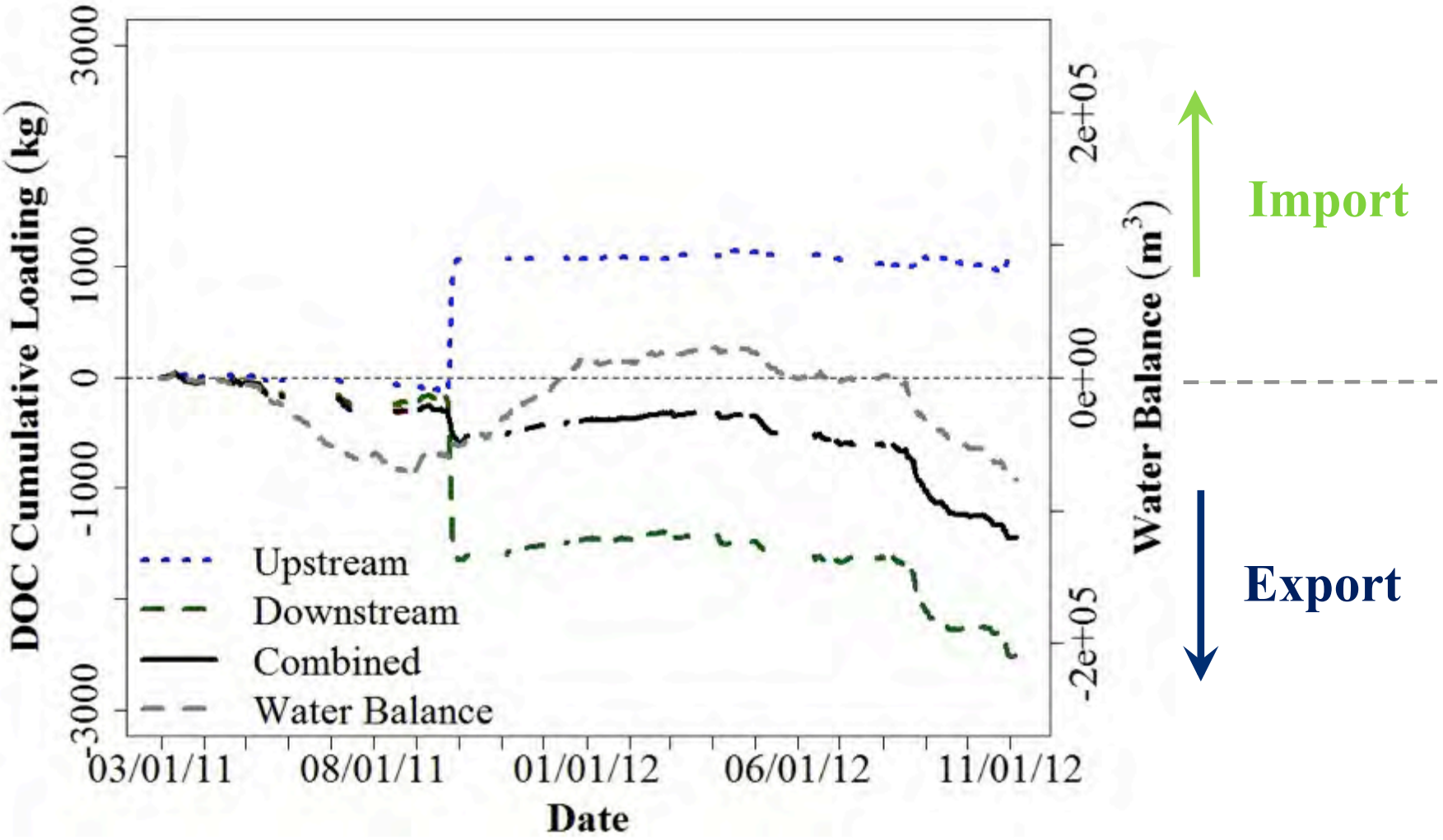
Water Balance



Water Balance



DOC


DOC Cumulative Loading (kg)
3000
1000
0
-1000
-3000
Upstream
Downstream
Combined
Water Balance
03/01/11
08/01/11
01/01/12
06/01/12
11/01/12
Date
2e+05
0e+00
-2e+05
Water Balance (m3)
Import
Export

Conclusions

- Marsh retained 9% of the nitrate that entered and exported all other monitored parameters
- Groundwater flow driving fluxes of DOC and other nutrients
- Low residence time reduces retention when compared to treatment wetlands
- Residence time is higher than upland stream with uni-directional flow potentially providing more retention