Investigating hydrological and biogeochemical controls within Irish alkaline fen habitat for protection and sustainable use

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Project: Ecometrics

- Ecometrics – Research on ecological support metrics in GWDTE's
- EU Habitats Directive requires action for protection/conservation of Alkaline and *Cladium* fens
- Aim of study:
  - define hydrological and hydro chemical metrics that to indicate fen ecological conditions
- Four fen research sites: varying intact to degraded ecological conditions

Fens in Ireland

- Fen habitat in Republic of Ireland: 20 000 ha
- Fen habitat conserved: 763 ha
- Loss of habitat: 79%

Distribution of Fens in Ireland 2017

Ballymore

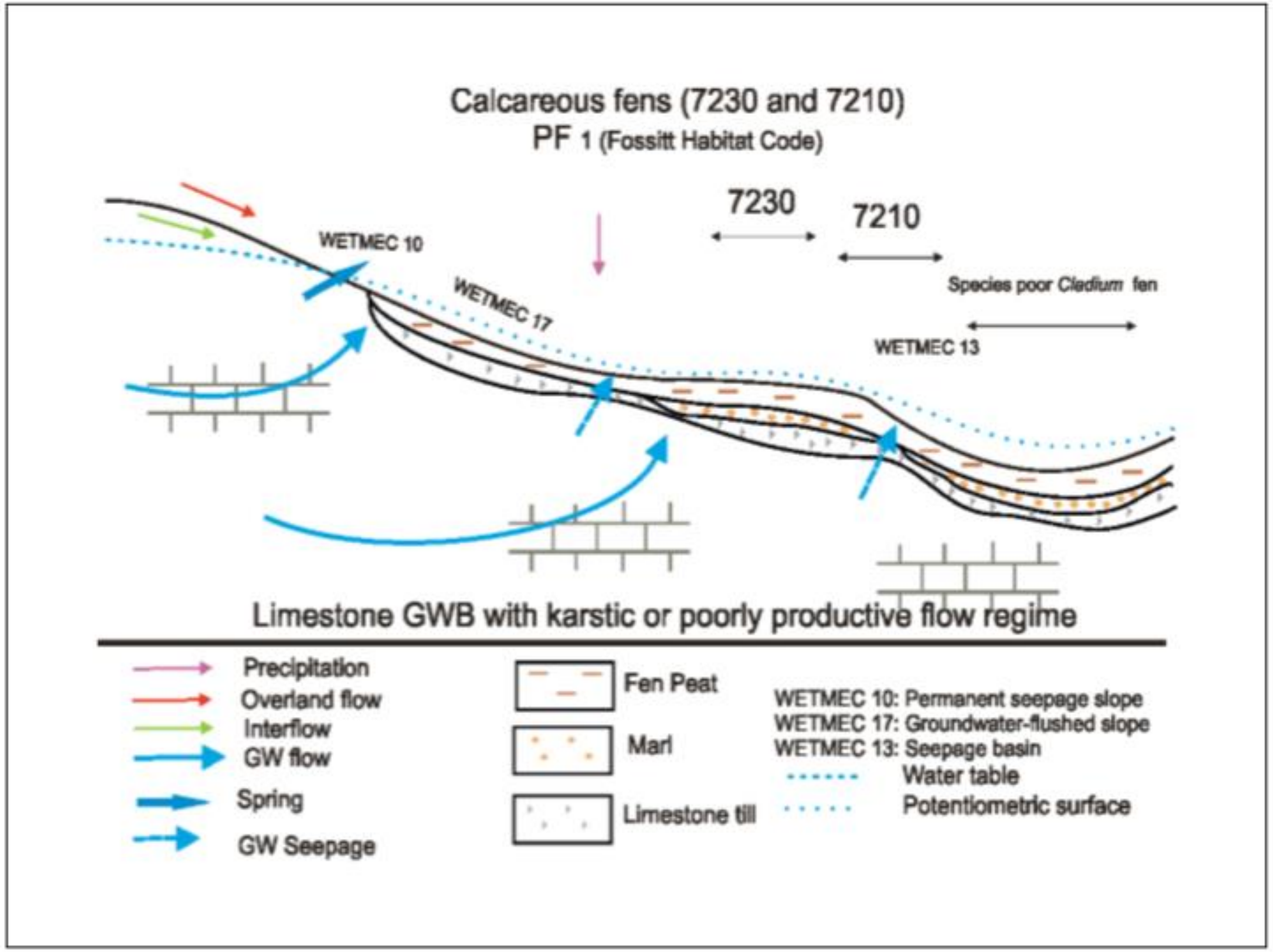
Scragh Bog (fen)

Pollardstown

Tory Hill

Preliminary conceptual model as described in:

Evaluating the Influence of Groundwater Pressures on Groundwater-Dependent Wetlands



S. Kimberley & C. Coxon (2011-W-DS-5)

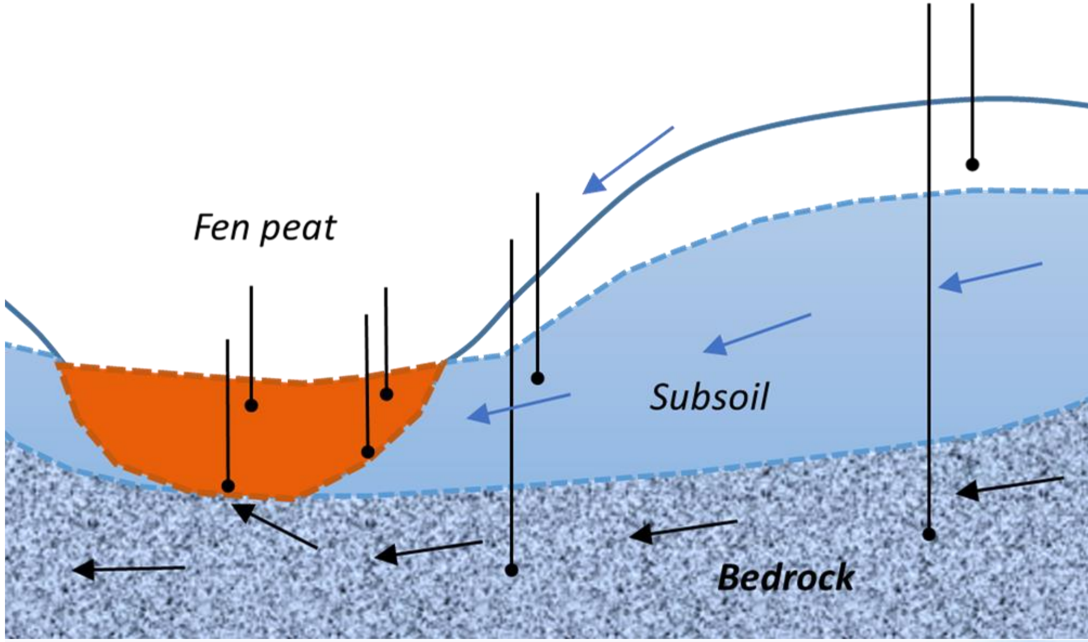
Site specifics*

Name	Pollardstown	Tory Hill	Scragh Bog (fen)	Ballymore
County	Kildare	Limerick	Westmeath	Westmeath
Area (ha)	266.1	76.9	23.9	43.1
Designation	SAC NHA	SAC, pNHA	SAC	SAC
Condition	Degraded	Degraded	Near intact	Intact
Damage, Threats and Pressures	Drainage Grazing Dumping Gravel quarry	Drainage Infilling Grazing	Fertilisation Roads Diffuse Pollution	Diffuse Pollution

*as reported in Natura 2000 – standard data form

Instrumentation

- Five research sites
  - Ballymore, Scragh, Pollardstown A+D, Tory Hill
- Nine piezometer transects in a range of different fen conditions
  - Groundwater level and chemical monitoring
  - Measurements taken from piezometers and phreatic tubes
- Well and borehole survey outside fen
  - Groundwater and chemical monitoring
- Rainwater sampling



Data Collection

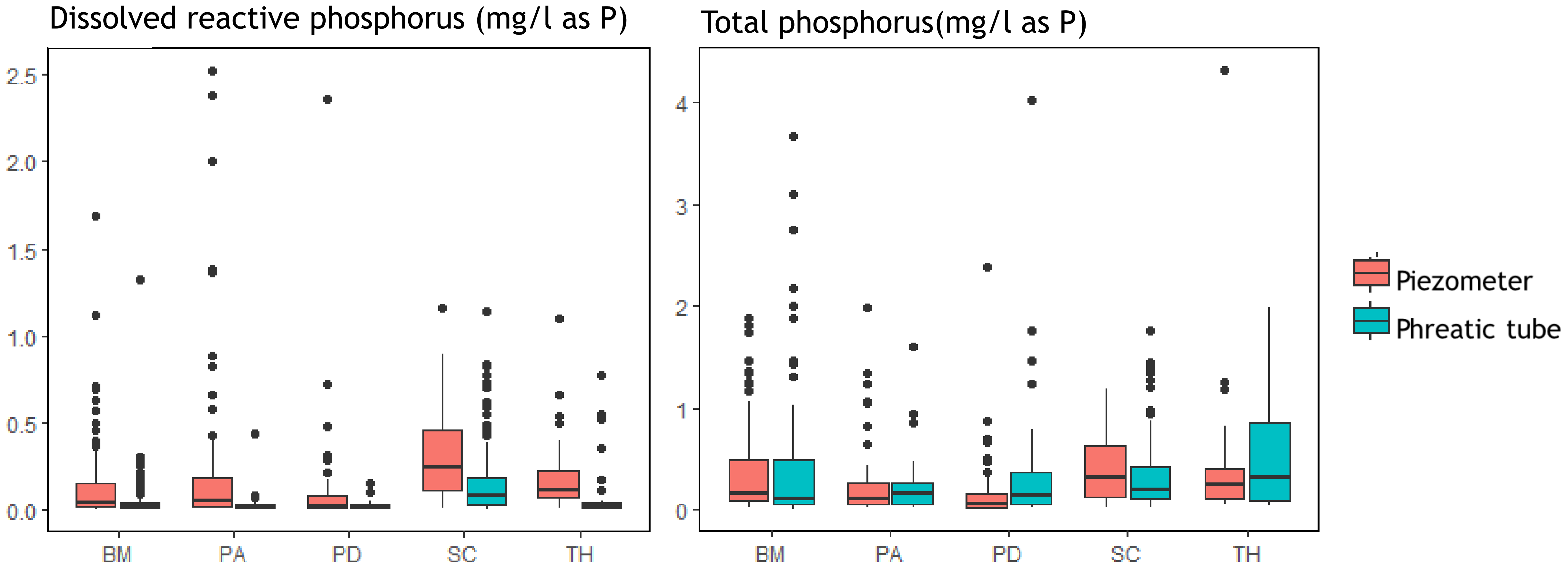
- 12 data collections between July 2018 and February 2020

- Measurements
  - Water levels: Manually + Loggers
  - Conductivity, oxygen, pH, temperature

- Water sampling
  - Nutrients: DRP, TP, NH_3, NO_2, TO_xN, TDN
  - major ions: Alkalinity (HCO_3), SO4, Cl, Ca, Na, Mg, K
  - Metals: Fe^{2+}, Total Fe, Mn

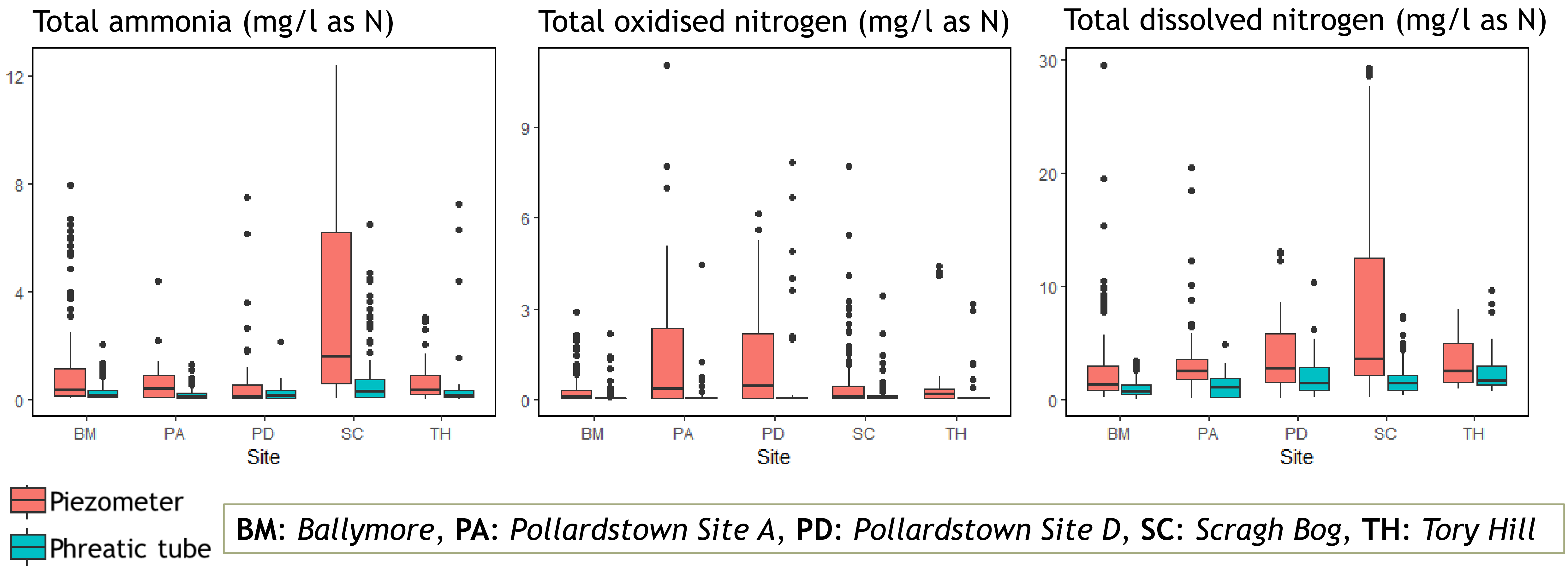
Summary of Hydrochemistry

Data collected between July 2018 and December 2019



BM: *Ballymore*, **PA**: *Pollardstown Site A*, **PD**: *Pollardstown Site D*, **SC**: *Scragh Bog*, **TH**: *Tory Hill*

Total phosphorus (TP) is present in both phreatic tubes and groundwater piezometers in concentrations with means of 0.37 and 0.33 mg/L as P respectively. Scragh Bog (fen) stands out most for having the highest concentration of DRP in groundwater piezometers (0.26 mg/L as P), second is Tory Hill with 0.19 mg/L as P.



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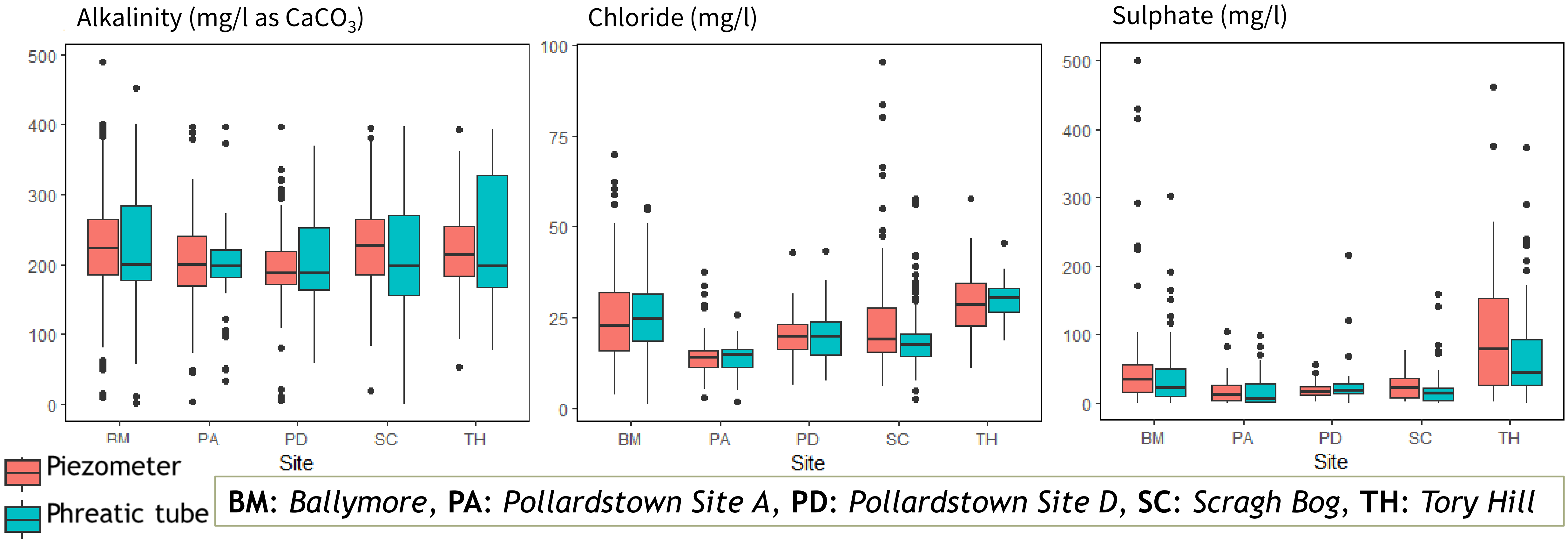
Both total dissolved nitrogen (TDN) and ammonia (NH_3) is found with higher concentrations in groundwater piezometers with means of 4.43 mg/L as N and 1.60 mg/L as N respectively. Again Scragh Bog (fen) stands out most displaying high concentration in samples taken from the groundwater piezometers for TDN and NH_3 with means of 6.88 mg/L as N and 2.98 mg/L as N respectively.



Alkalinity (mg/l as $CaCO_3$)

Chloride (mg/l)

Sulphate (mg/l)

BM: *Ballymore*, **PA**: *Pollardstown Site A*, **PD**: *Pollardstown Site D*, **SC**: *Scragh Bog*, **TH**: *Tory Hill*

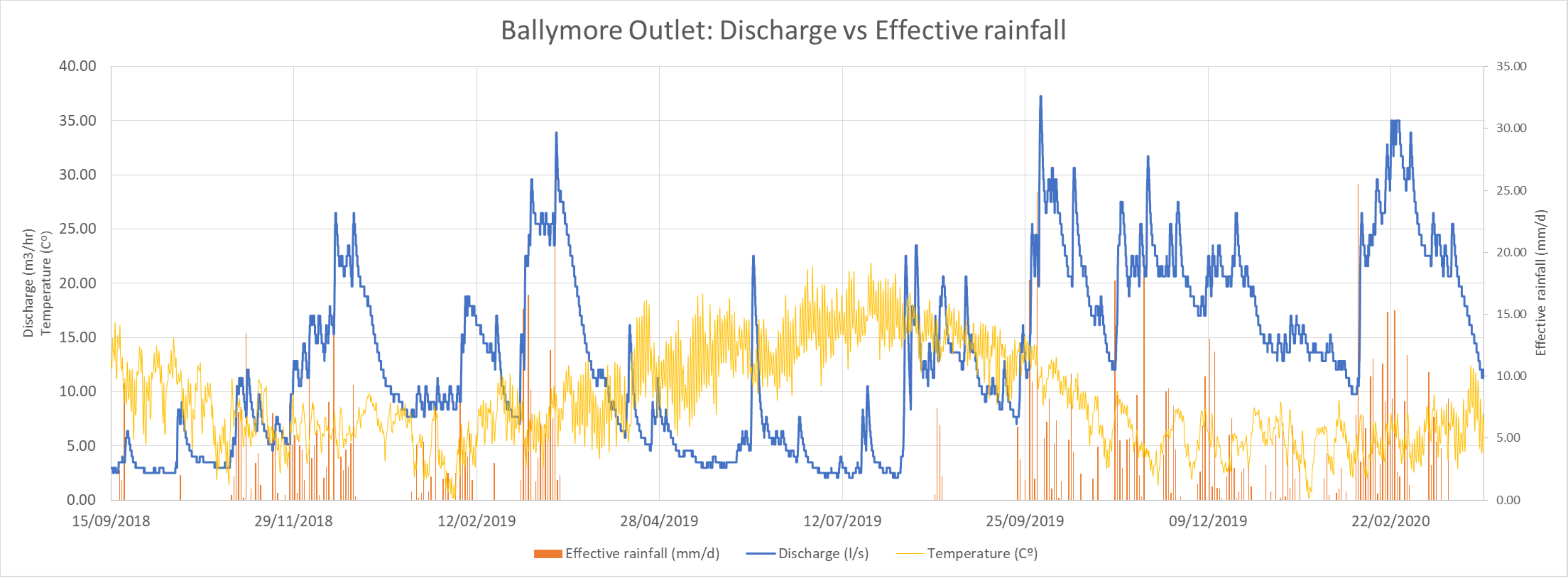
From the major ions, sulphate (SO_4) stood out most in samples collected from Tory Hill. Here concentrations with a mean of 89.0 mg/L SO_4 were found. This in in contrast with the overall mean for the other fen sites combined (17.5 mg/L SO_4). This might be due to the oxidised conditions in Tory Hill caused by a high degree of artificial drainage.

Preliminary Results Ballymore

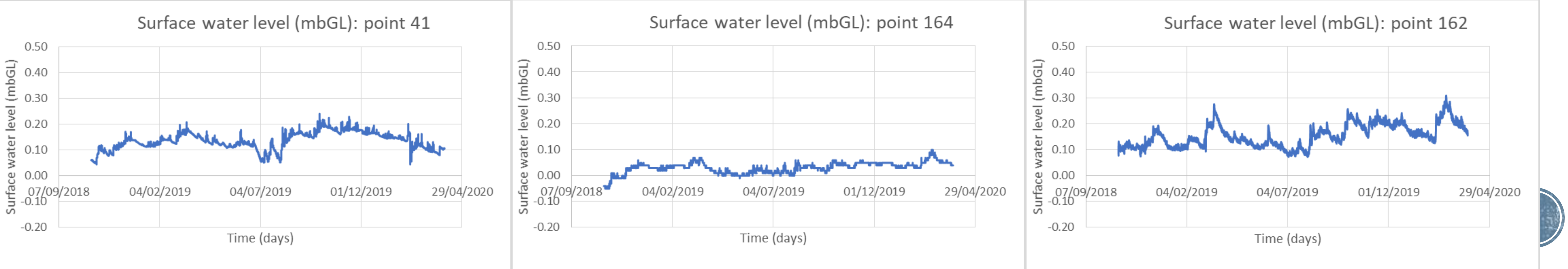
- Hydrology
  - Discharge and effective rainfall
  - Water balance
  - Hydraulic gradients

- Hydrochemistry
  - Linkages to fen habitat

Ballymore - Instrumentation



- No effective rainfall in summer; fen relies on groundwater recharge in winter to maintain stable surface water level. See surface water logs below:



Waterbalance

- Catchment area: 0.88 km^2
- Fen area: 0.23 km^2

Hydrological year

01-10-2018 to 30-09-2019

	Total (m3)	Flux (mm/d)	Lost from rainfall
Rainfall	916119	2.84	
Evapotranspiration	591348	1.70	64.5%
Runoff	319821	1.02	34.9%
Storage	4949	0.02	0.5%

Winter/Spring

01-10-2018 to 01-04-2019

	Total (m3)	Flux (mm/d)	Lost from rainfall
Rainfall	437856	2.73	
Evapotranspiration	129257	0.74	29.5%
Runoff	194225	1.21	44.4%
Storage	114374	0.71	26.1%

Summer/Autumn

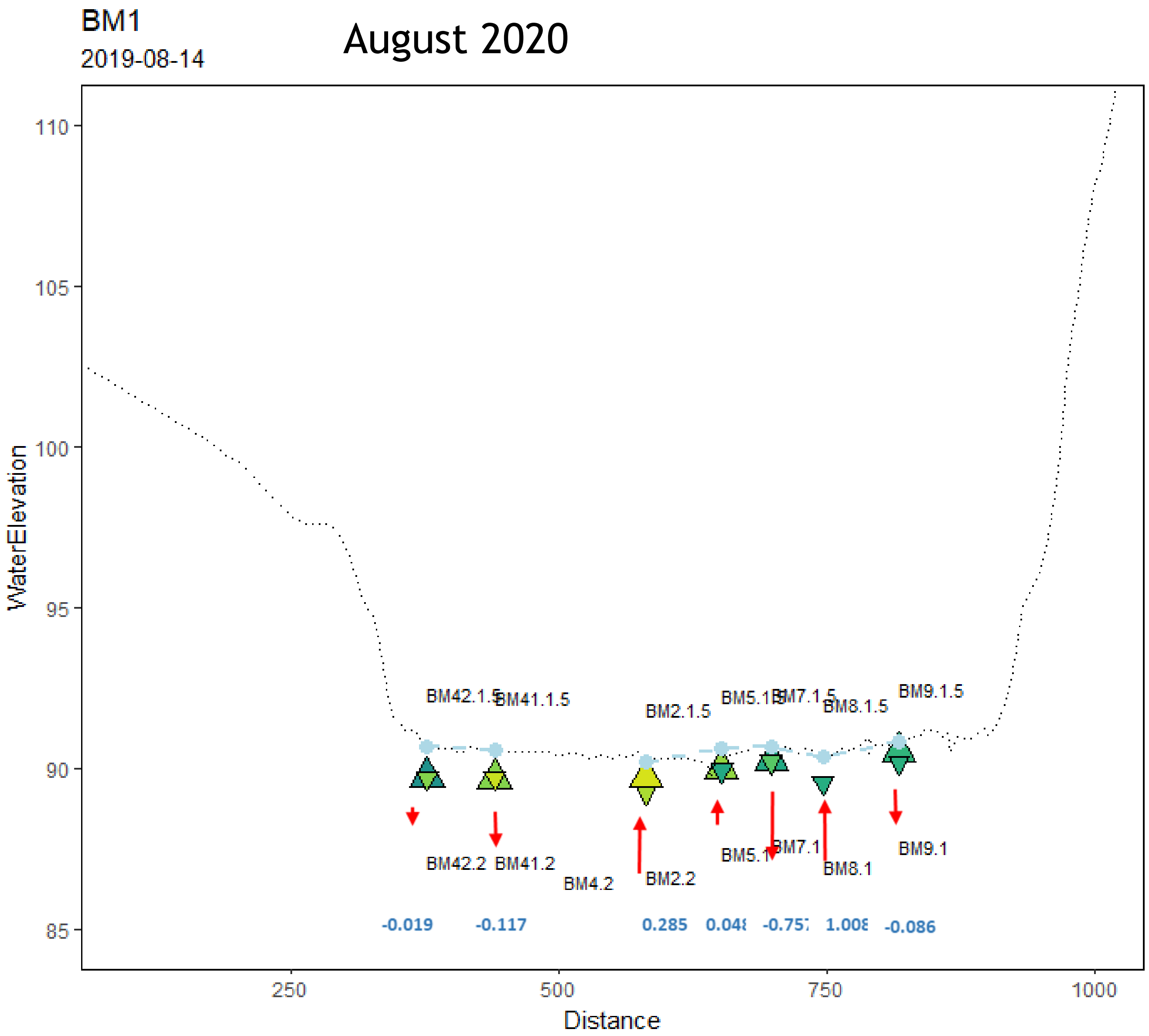
02-04-2019 to 30-09-2019

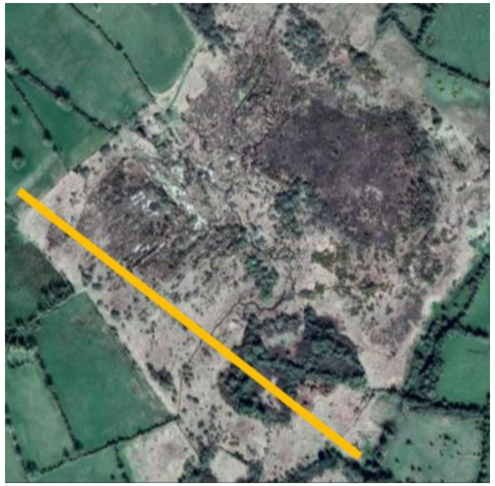
	Total (m3)	Flux (mm/d)	Lost from rainfall
Rainfall	478263	2.96	
Evapotranspiration	462091	0.75	96.6%
Runoff	125596	0.78	26.3%
Storage	-109425	-0.68	-22.9%

- Water balance prepared on the assumption of no significant change on storage in fen between beginning and end of hydrological year
- Positive water balance in winter spring (net groundwater inputs) cf negative water balance in summer/autumn (net loss to groundwater?)
- However, hydrological changes made to fen could result in either flooding or drying out of the fen

Summer/winter hydraulic gradient and DRP comparison in transects

August 2020





△ Phreatic tube

▽ Piezometer

Surface water level

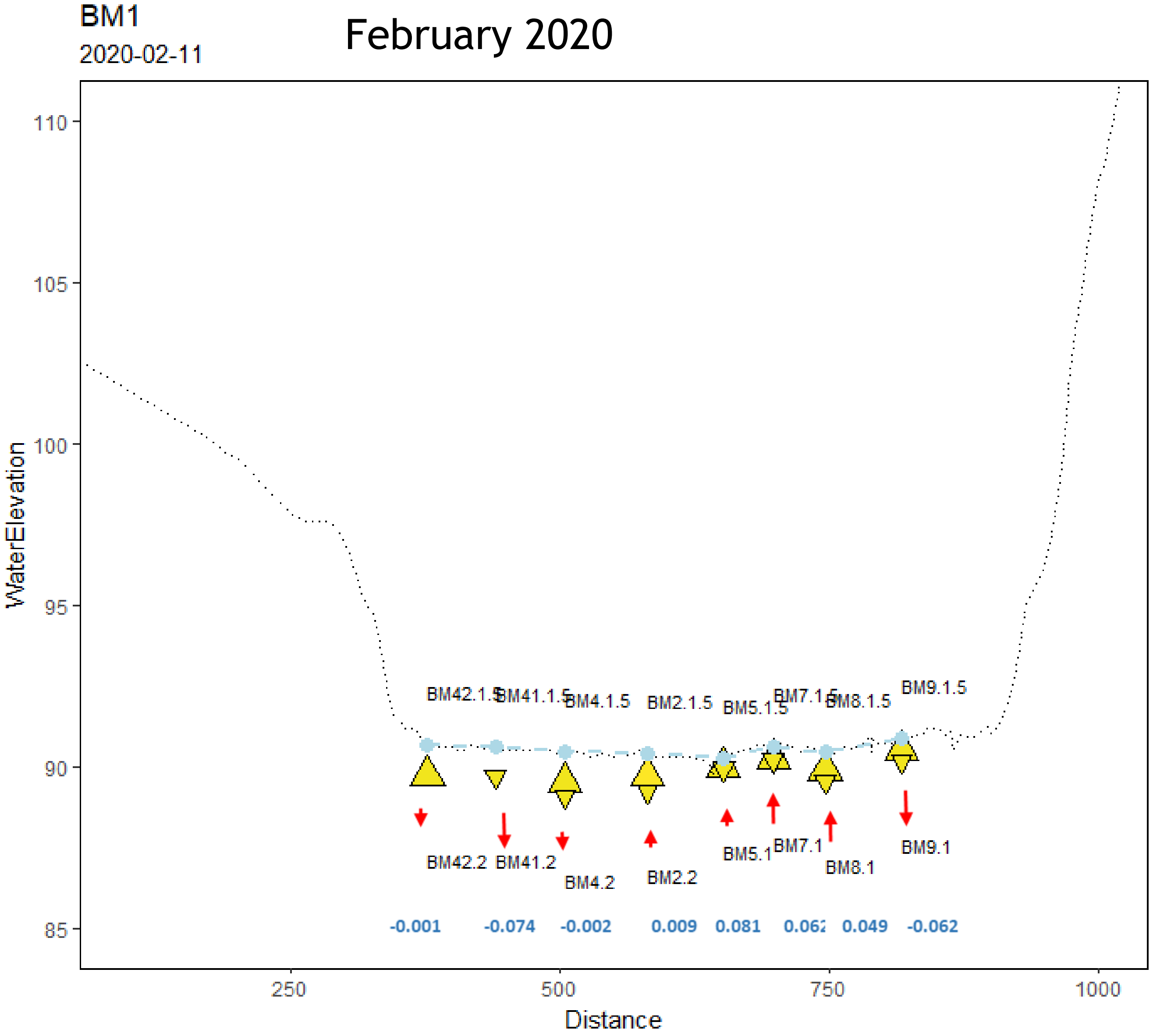
↓ ↑ Direction of flow

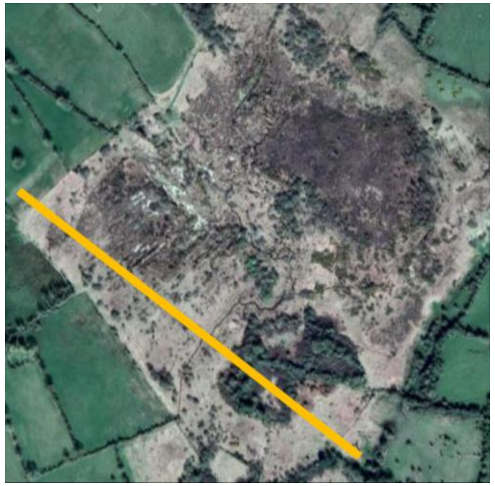
0.000 Hydraulic gradient

------------ Ground level

Summer/winter hydraulic gradient and DRP comparison

February 2020





Dissolved reactive phosphorus (mg/l as P)

0.5
0.4
0.3
0.2
0.1
0.0

△ Phreatic tube

▽ Piezometer

Surface water level

↓ ↑ Direction of flow

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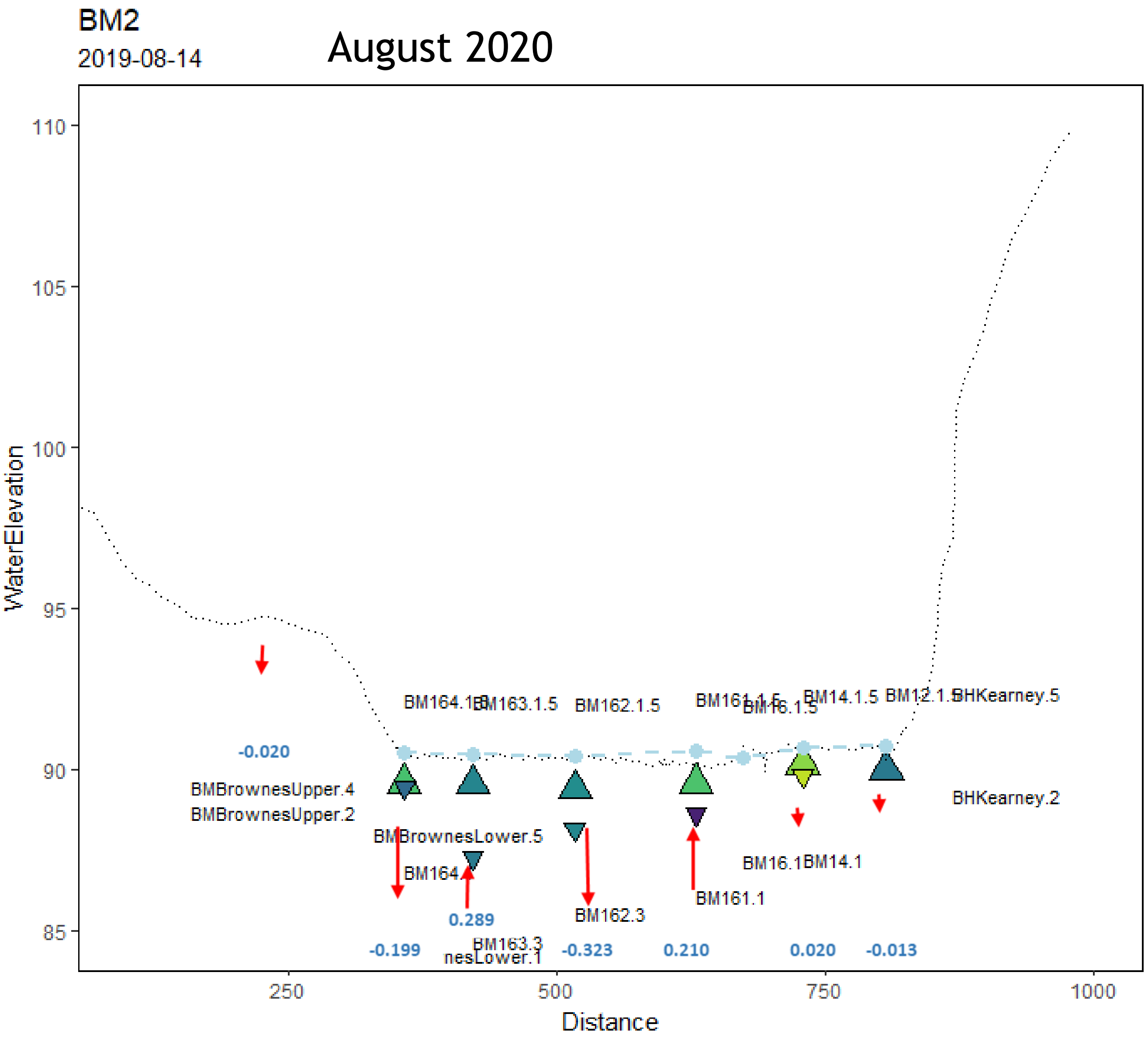

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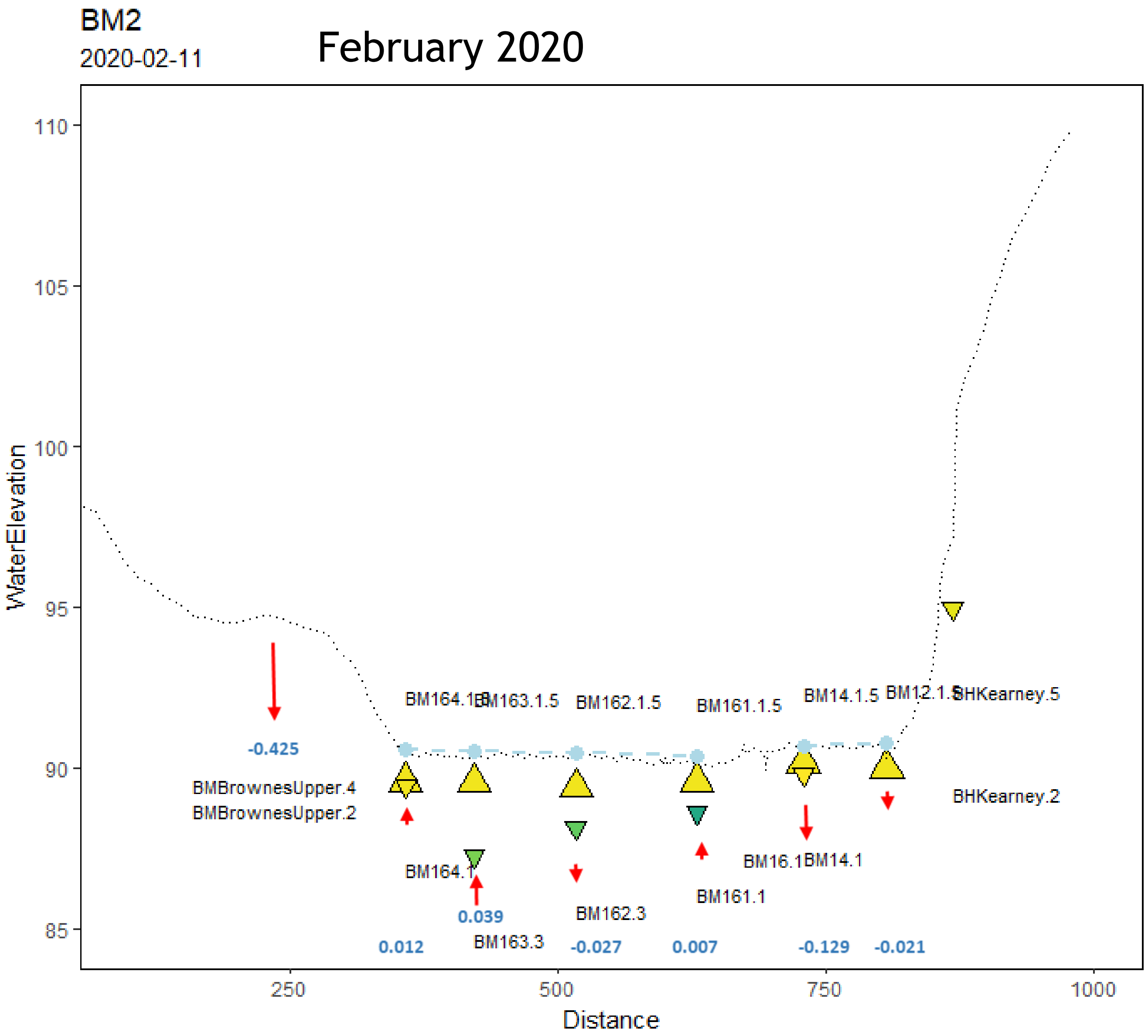

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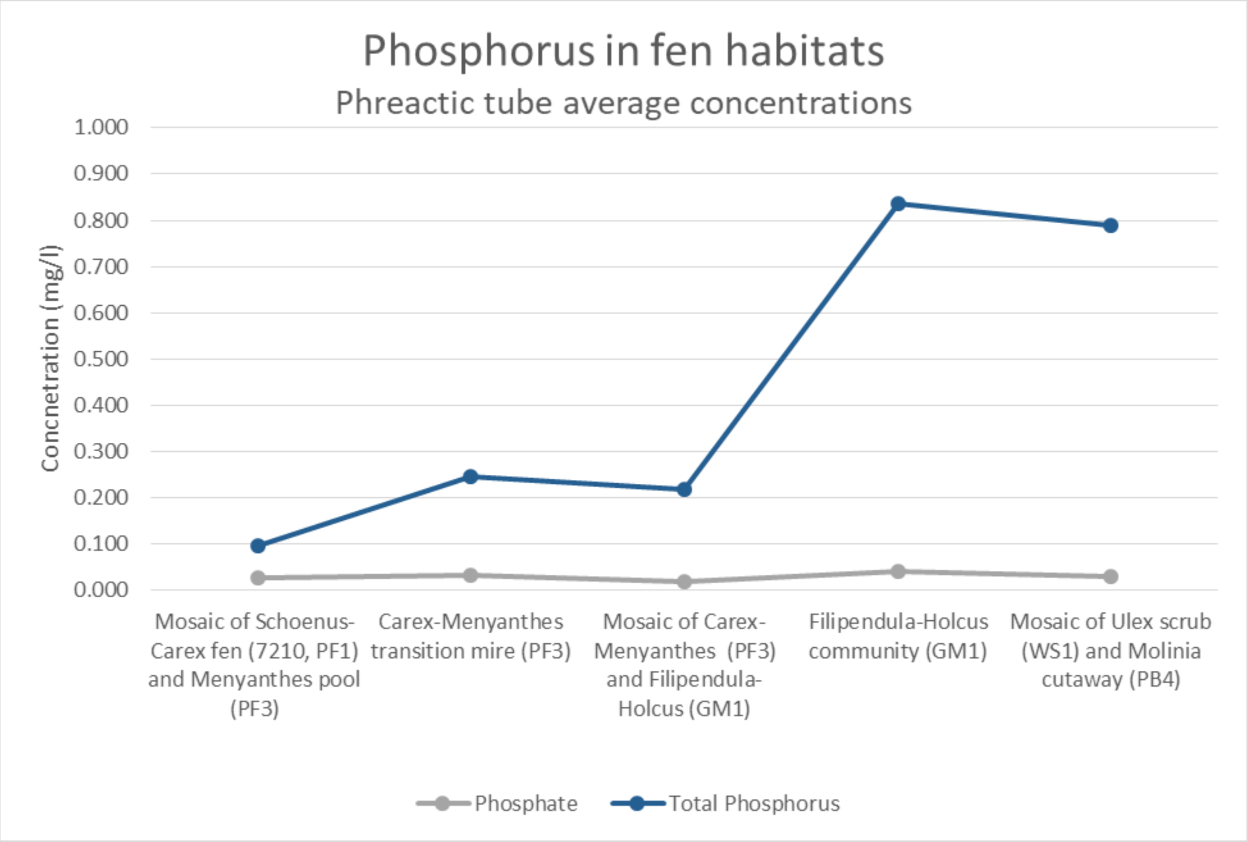
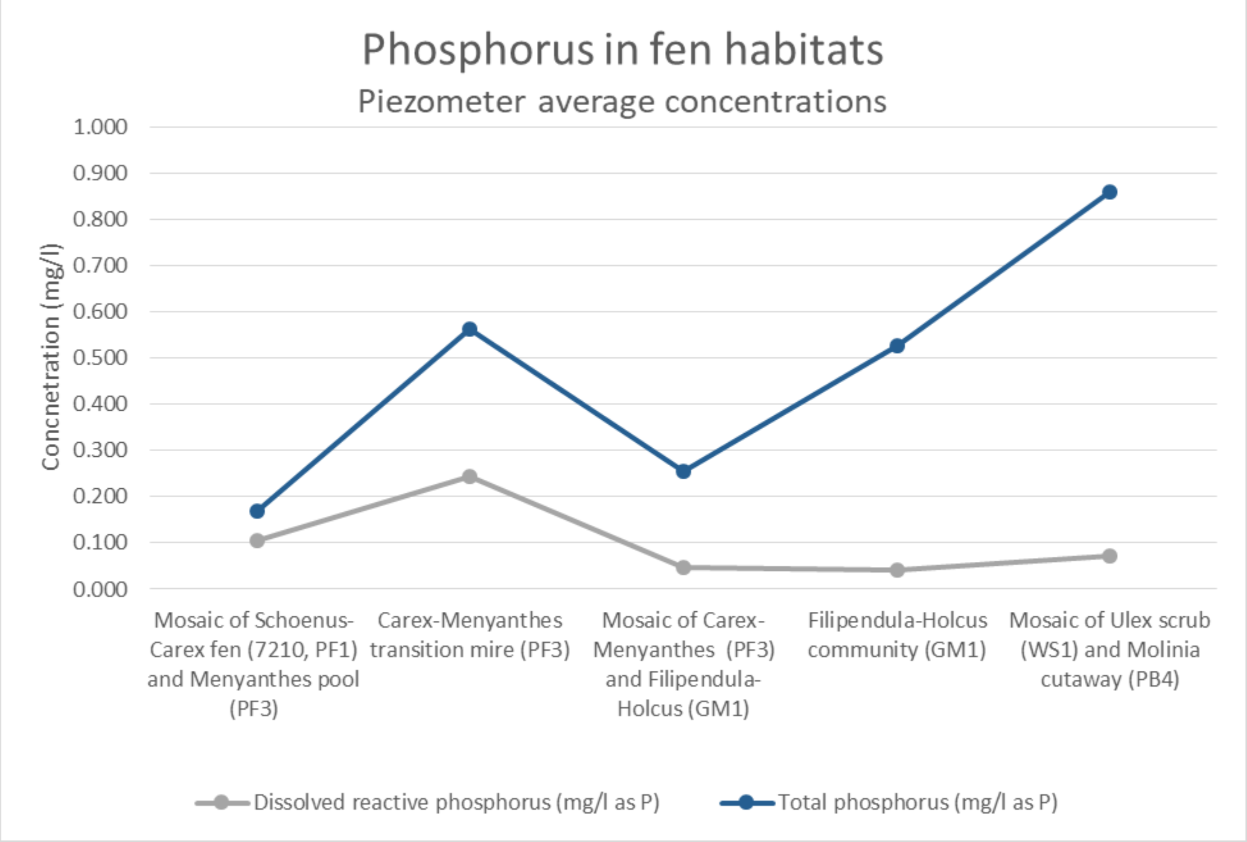
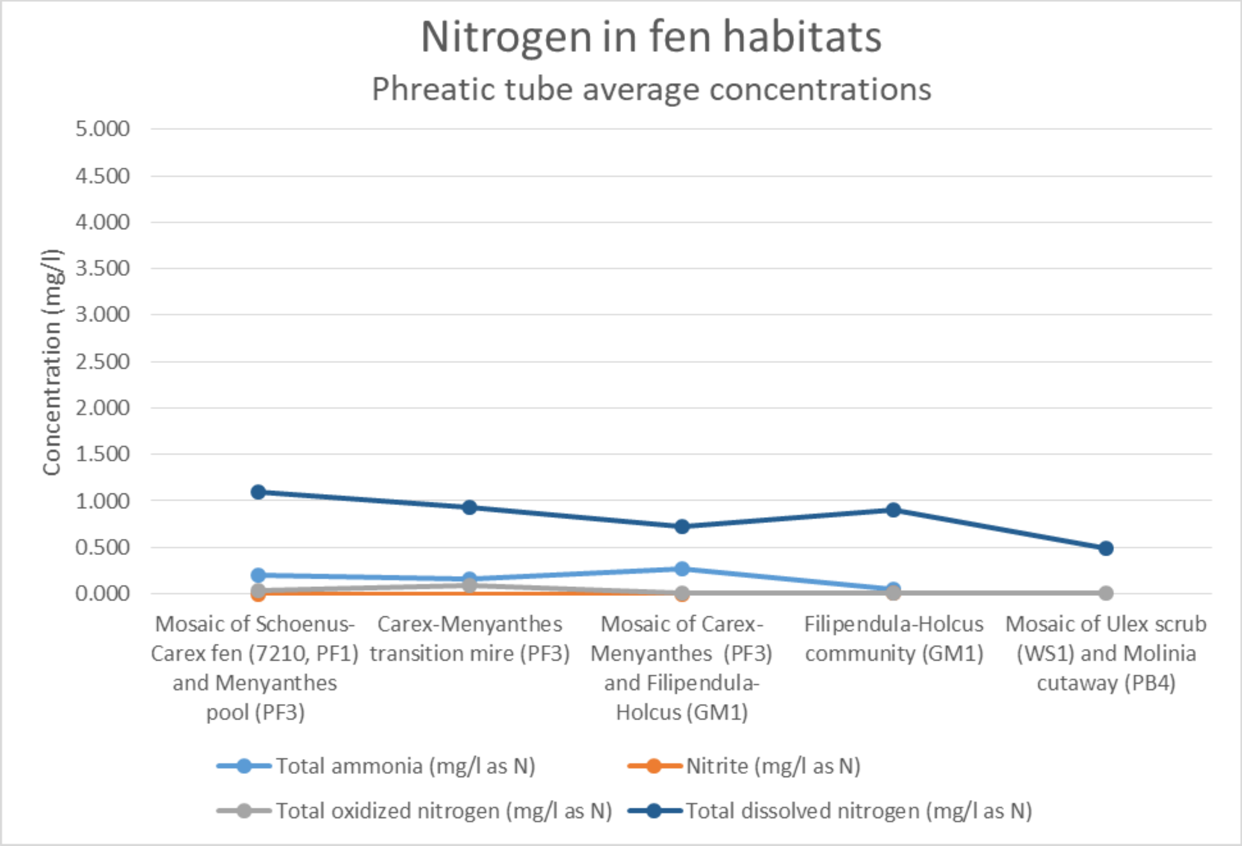
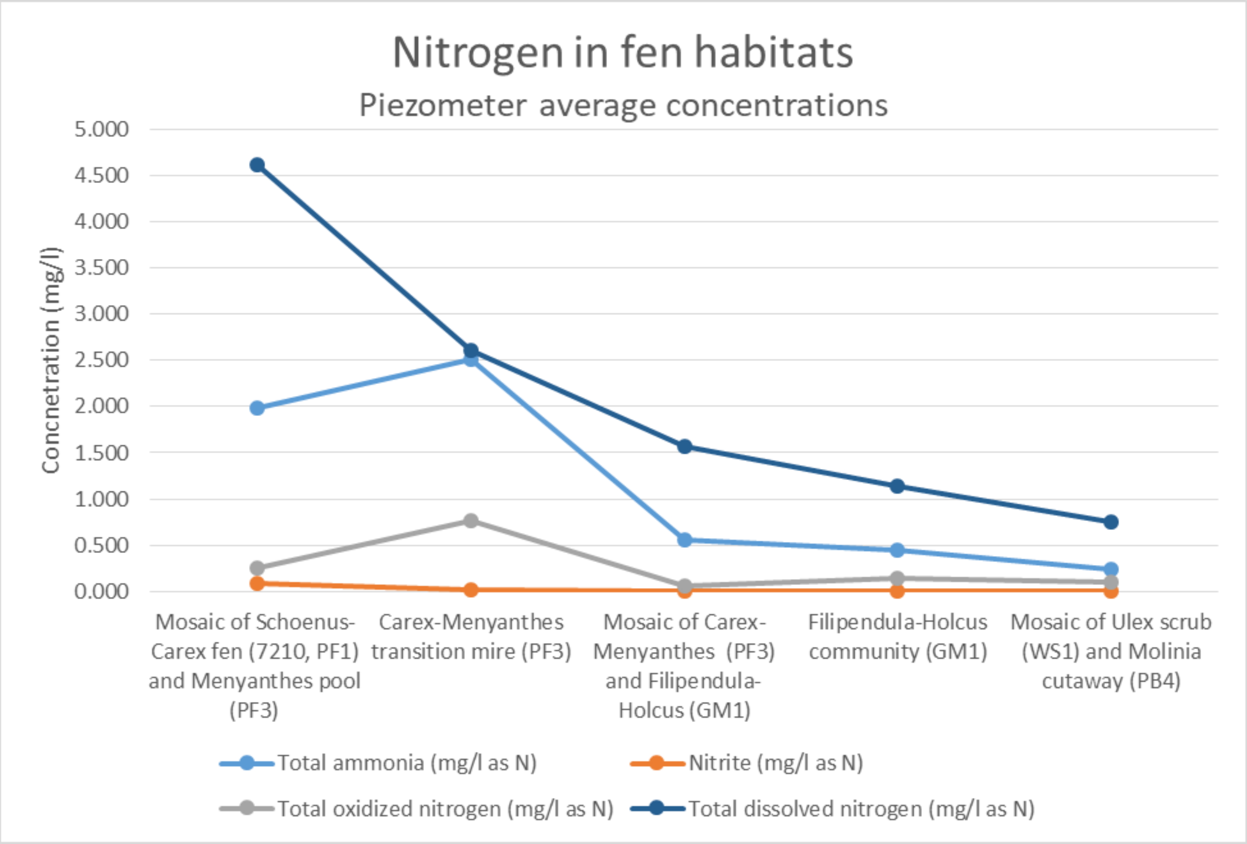
Hydrochemistry/ fen habitat linkages





Habitat	Natura 2000 (Annex 1)	Irish habitats (Fossitt)
Schoenus-Carex fen	7230 Alkaline fens	PF1 Rich fen and flush
Menyanthes pool	7140 Transition mires	PF3 Transition mire and quaking bog
Carex-Menyanthes transition mire	7140 Transition mires	PF3 Transition mire and quaking bog
Molinia cutaway	7120 Degraded raised bog	PB4 Cutover bog
Filipendula-Holcus		GM1 Marsh
Ulex scrub		WS1 Scrub





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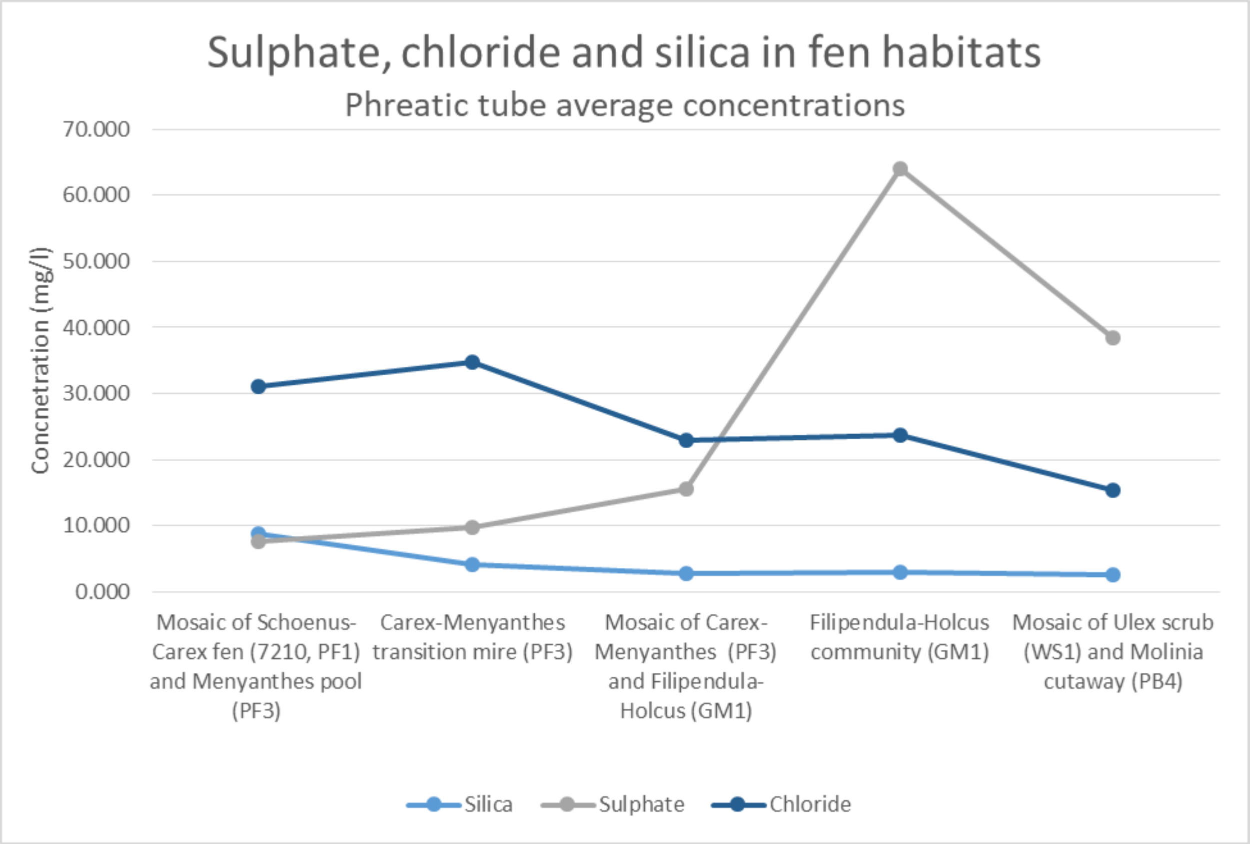
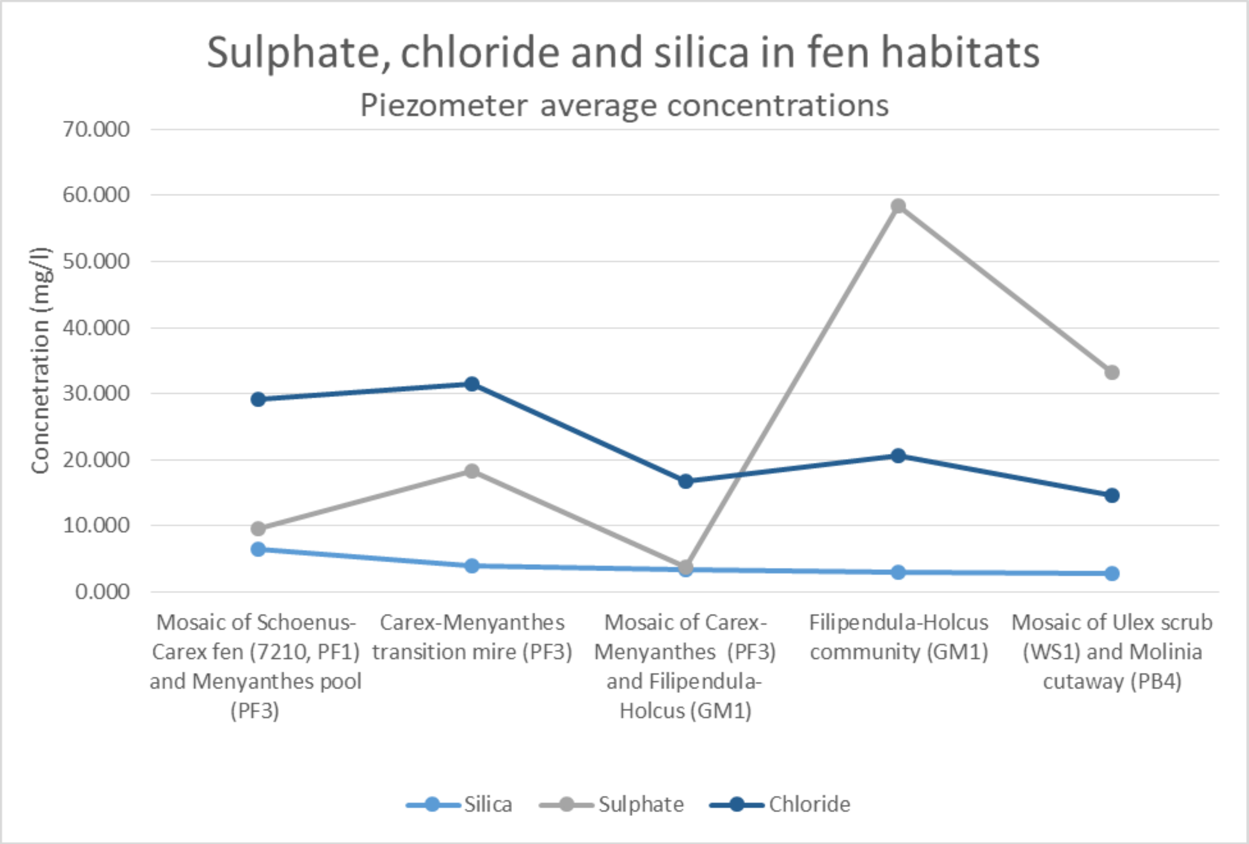
Results: Hydrochemistry





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Results: Hydrochemistry

Conclusions

- Main input of nutrients supplied to fen are largely driven by groundwater in Ballymore
- Rainfall significant input to maintain surface water level in fen. Also acts as diluting agent in fen water.
- Fen surface water level is controlled by seasonal inputs.
- Fen vegetation appear to be resilient to climate fluctuations.

- Water balance and nutrient inputs are important to take into account with fen management

Remote sensing

Overview

- Objective
  - Indicate the relation between vegetation and water levels using satellite data
  - Use water level data to aid unsupervised habitat classification

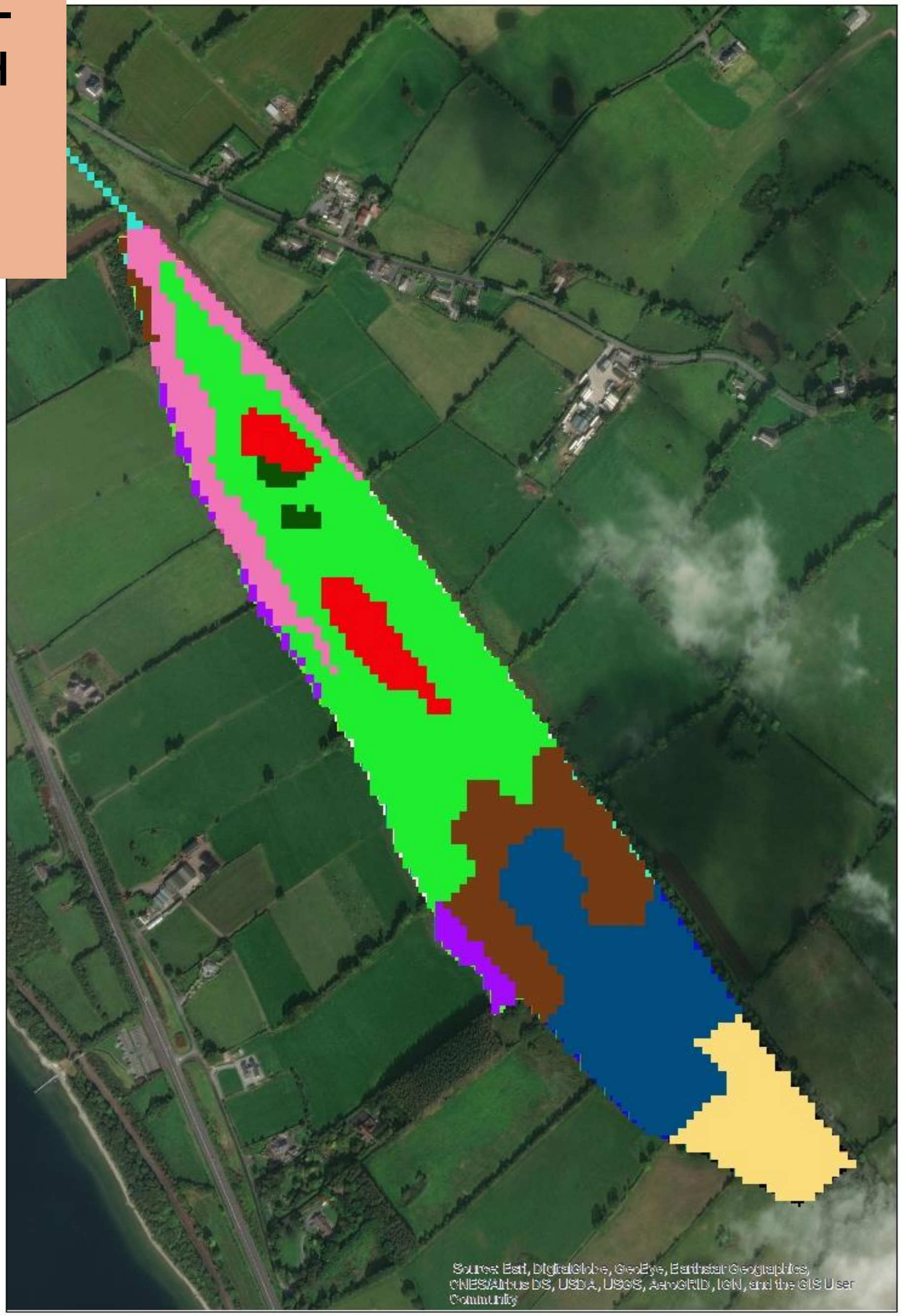
- Classification of Scragh bog (fen) using habitat map produced in October 2019.
- Supervised classification --> Giving input from habitat map, defining training data; testing on the whole wetland.
- Unsupervised classification --> No input from habitat map; the clusters are formed on the basis of similar spectral patterns on the ground.

Methodology

- Satellite data used
  - Sentinel- 2 Multispectral Instrument – Level -2 – Ready to use data
  - 10 spectral bands
  - NDVI (normalised difference vegetation index)
  - NDWI (normalised difference water index)

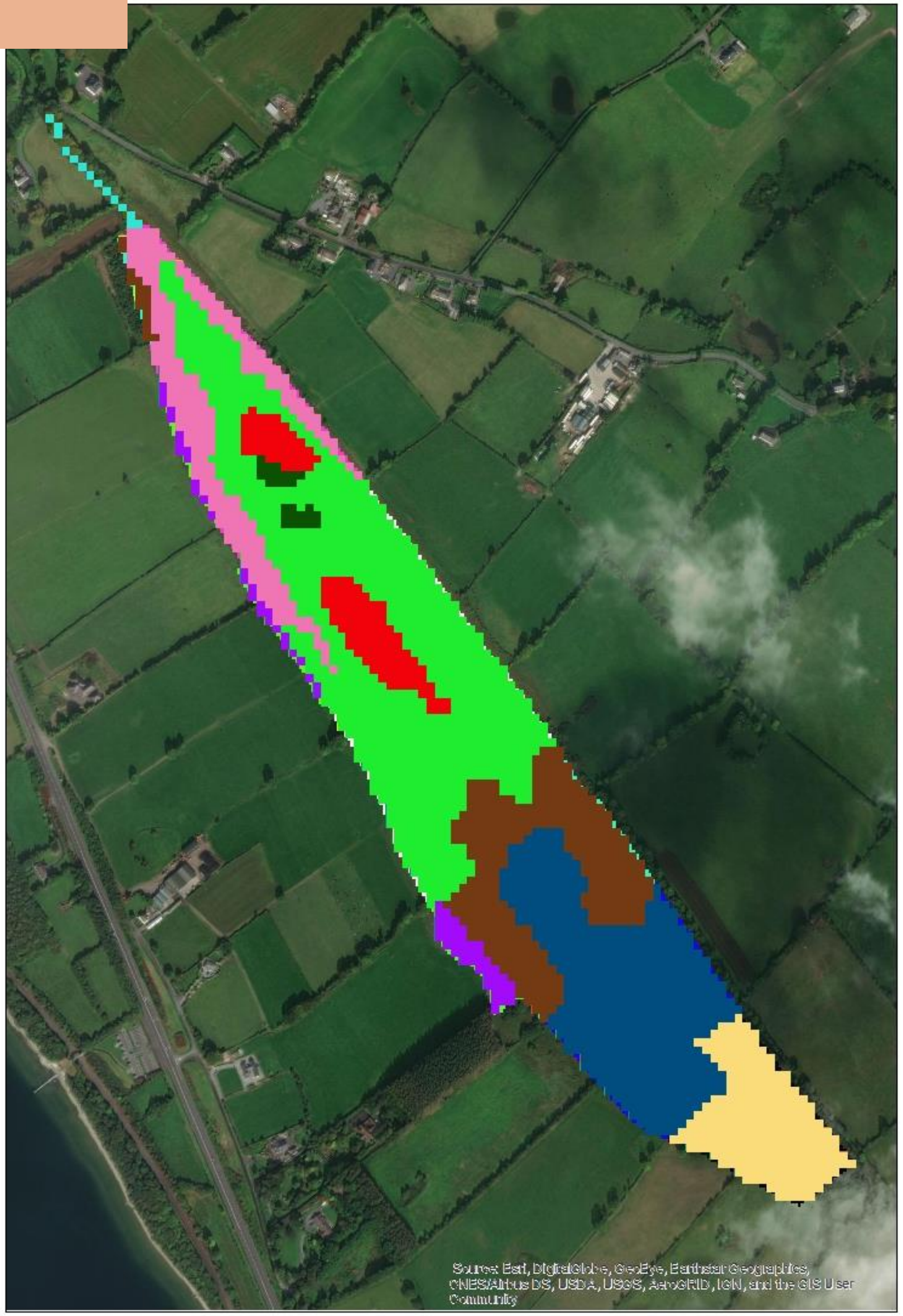
FIELD DERIVED - GROUND TRUTH

Habitat map - October 2019


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

1. WD4 – Conifer plantation
2. GS4 – Wet grassland
3. WN7 – Bog woodland
4. PF1 – Rich fen and flush
5. PF3 – Transition mire
6. FS2 – Tall herb swamp
7. FW2/WL2 - River/ tree line
8. FS1 – Reed and large sedge swamps
9. WN6 – Wet willows alder ash woodland

Ground Truth



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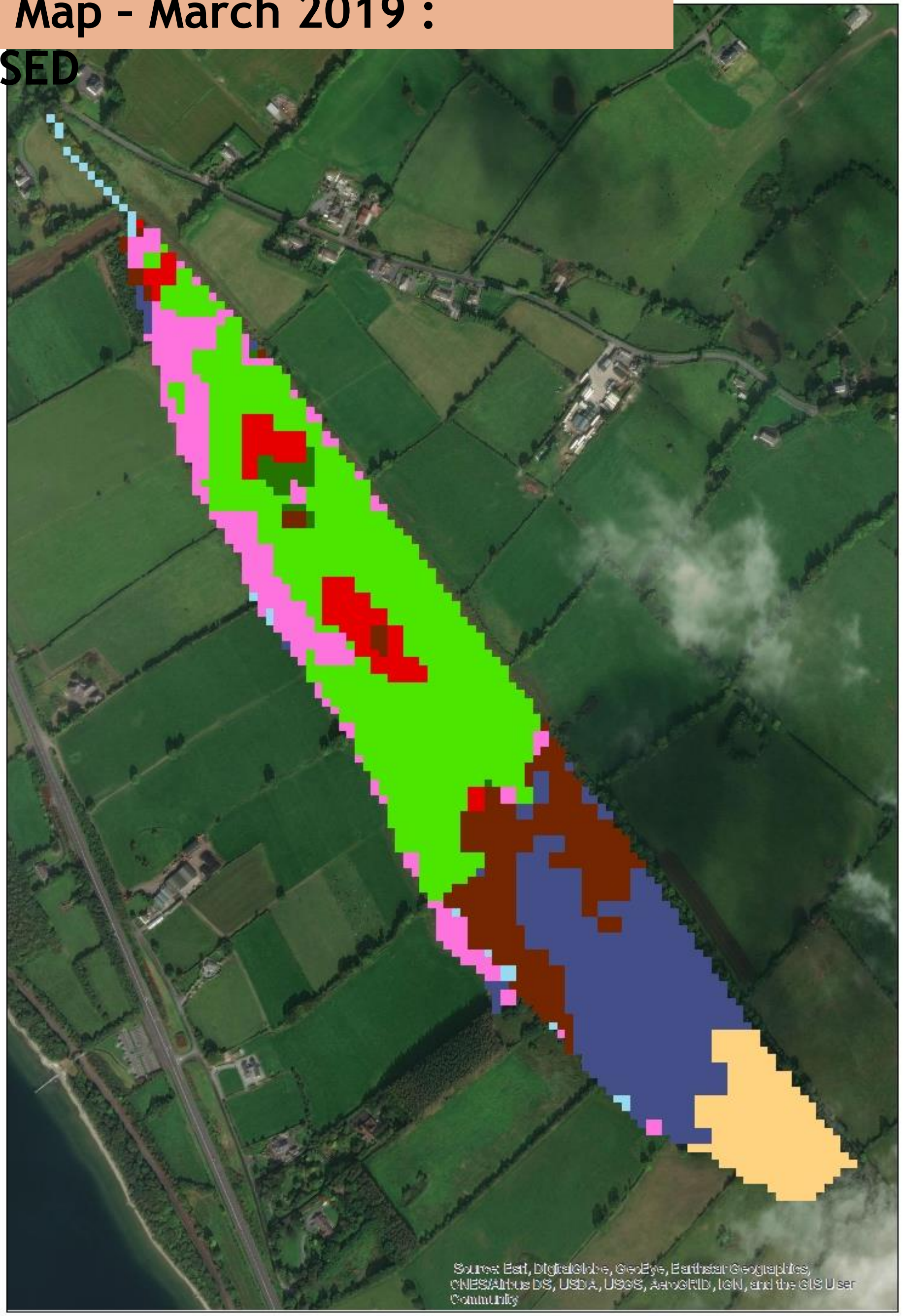
Satellite Map – March 2019 : SUPERVISED



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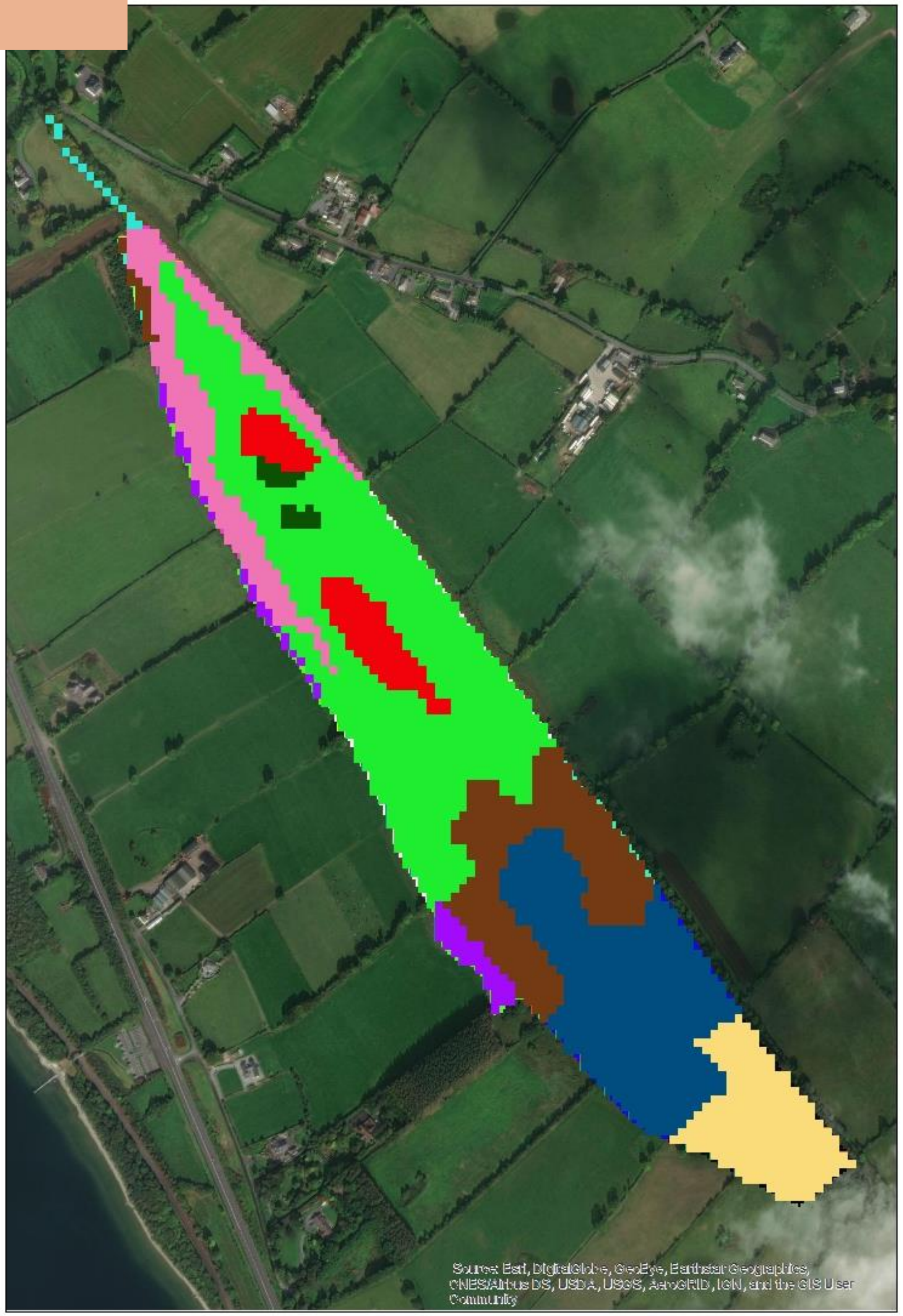
FOS_MAPPED

- 🟨 WD4
- 🟪 GS4
- 🟦 WN7
- 🟥 PF1
- 🟩 PF3
- ■ FS2
- ■ FW2/WL2
- ■ FS1
- 🟫 WN6

Ground Truth



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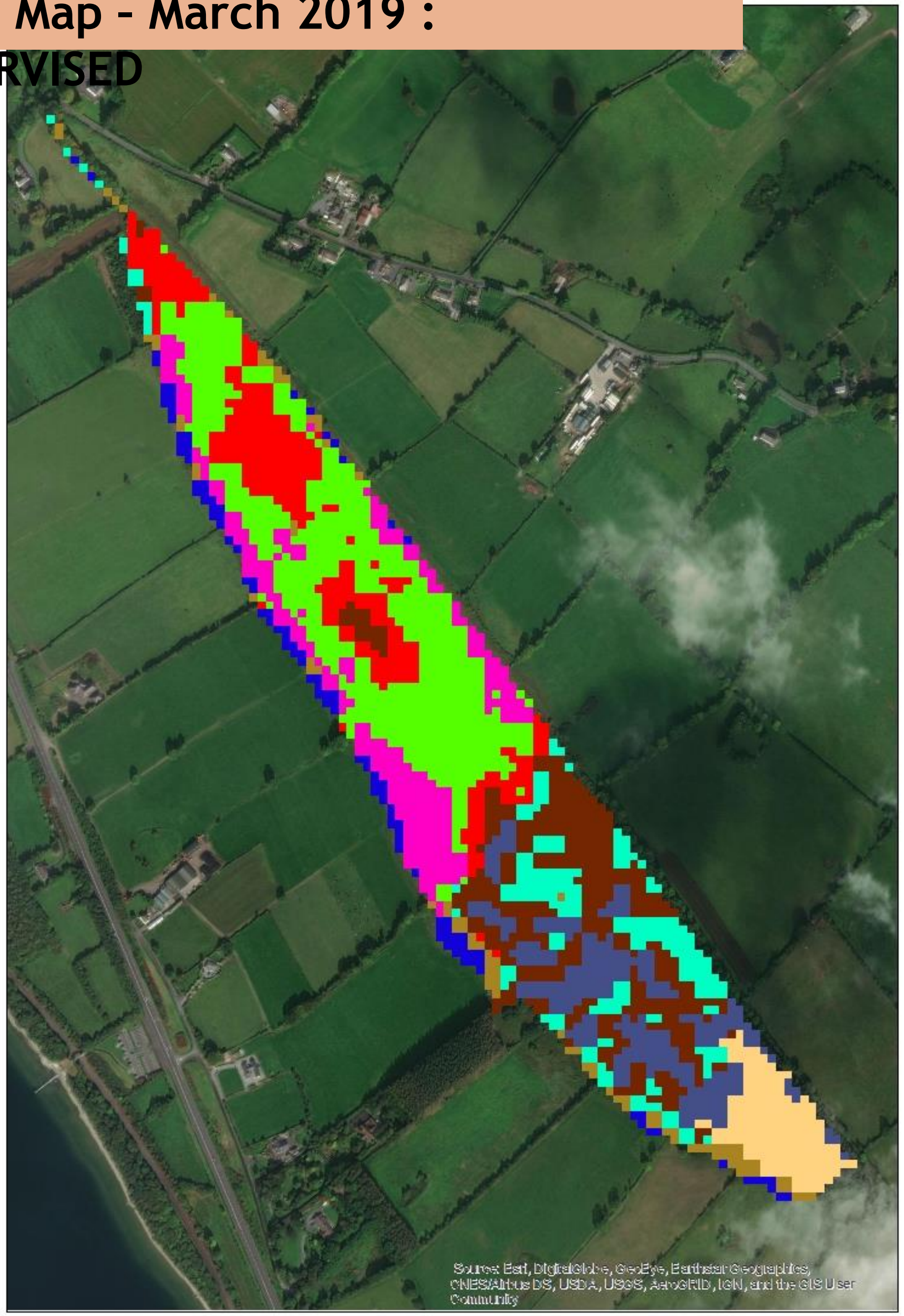
- 🟫 WN6

UNKNOWN

Satellite Map – March 2019 : UNSUPERVISED



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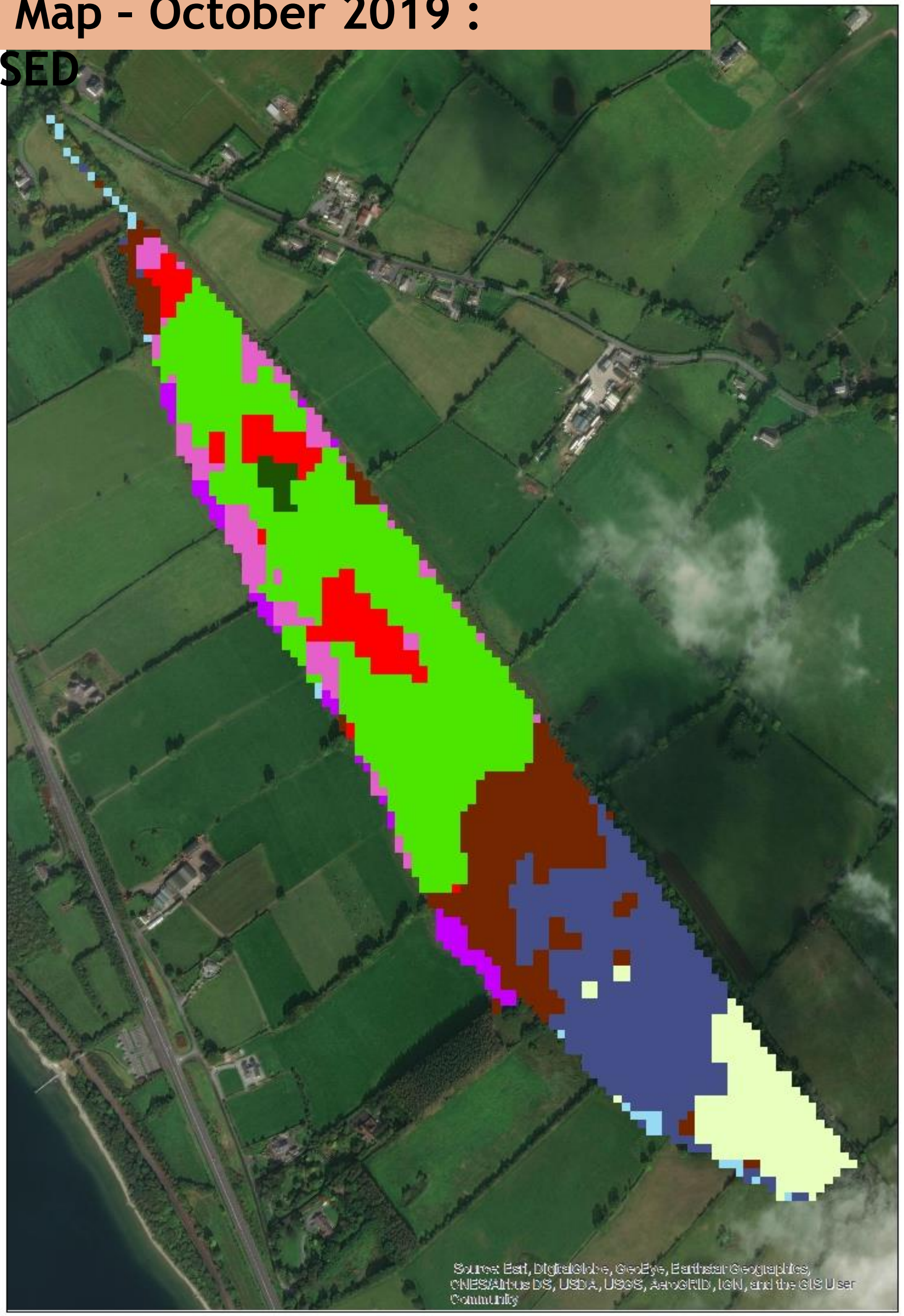

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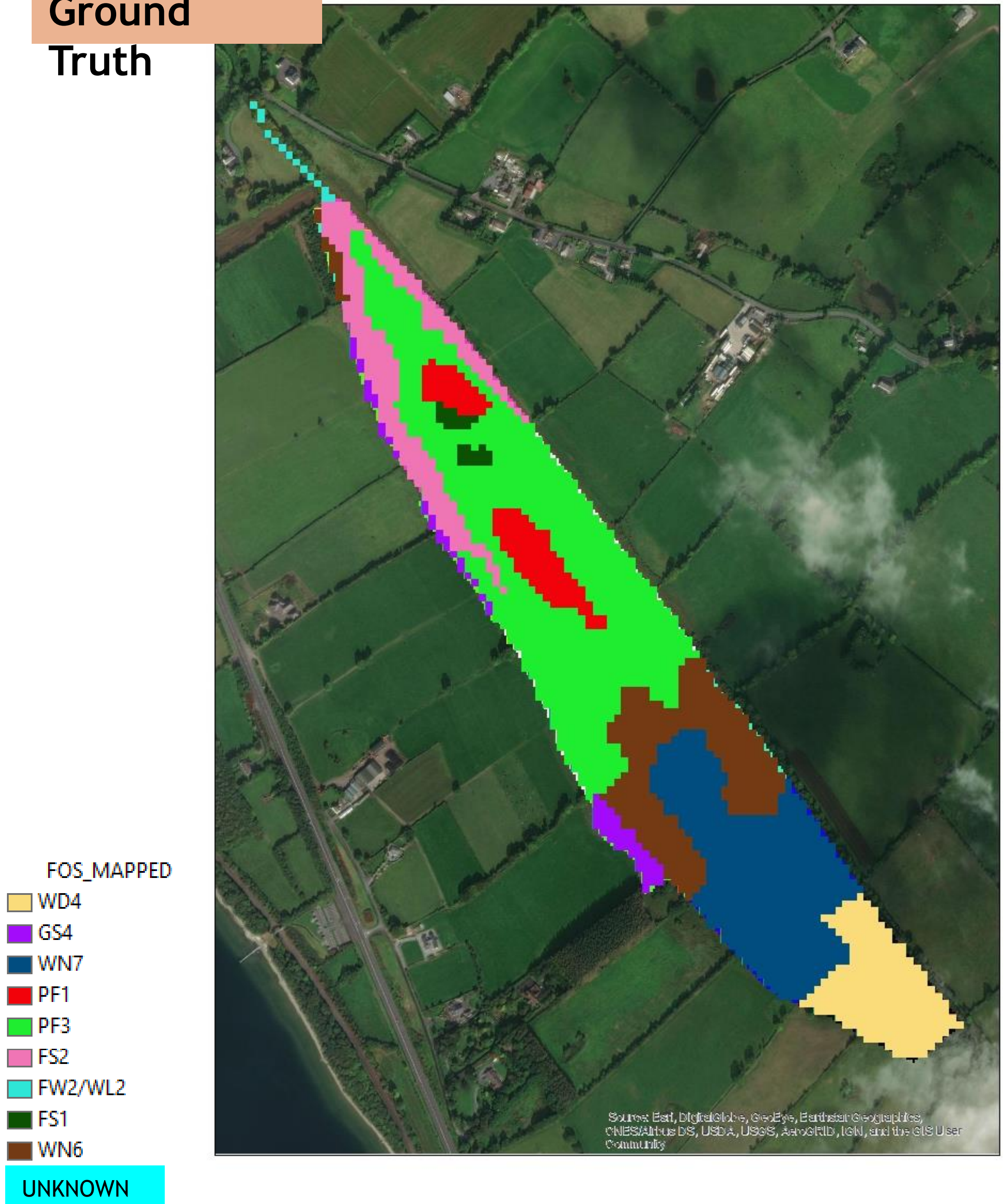
Ground Truth



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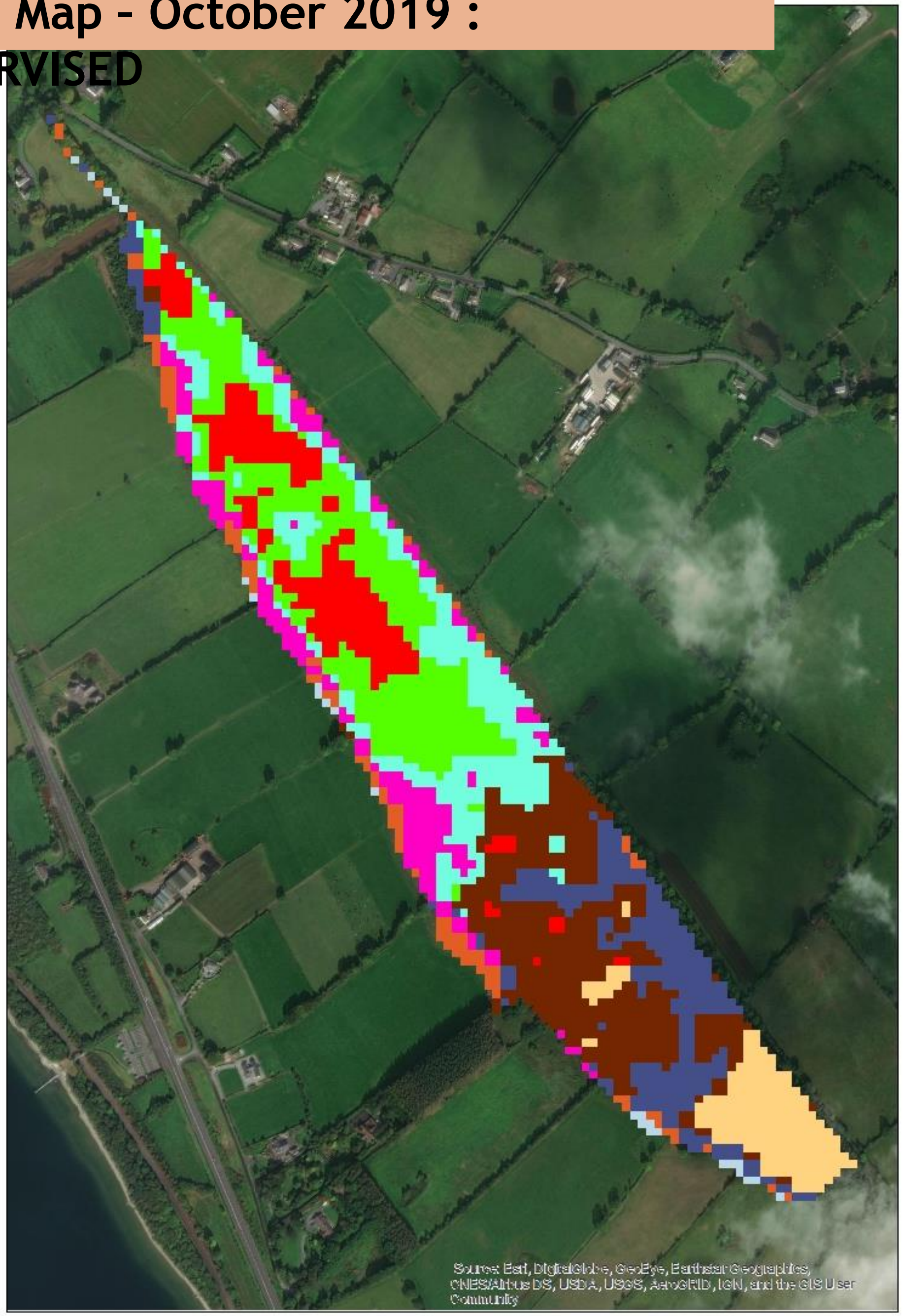

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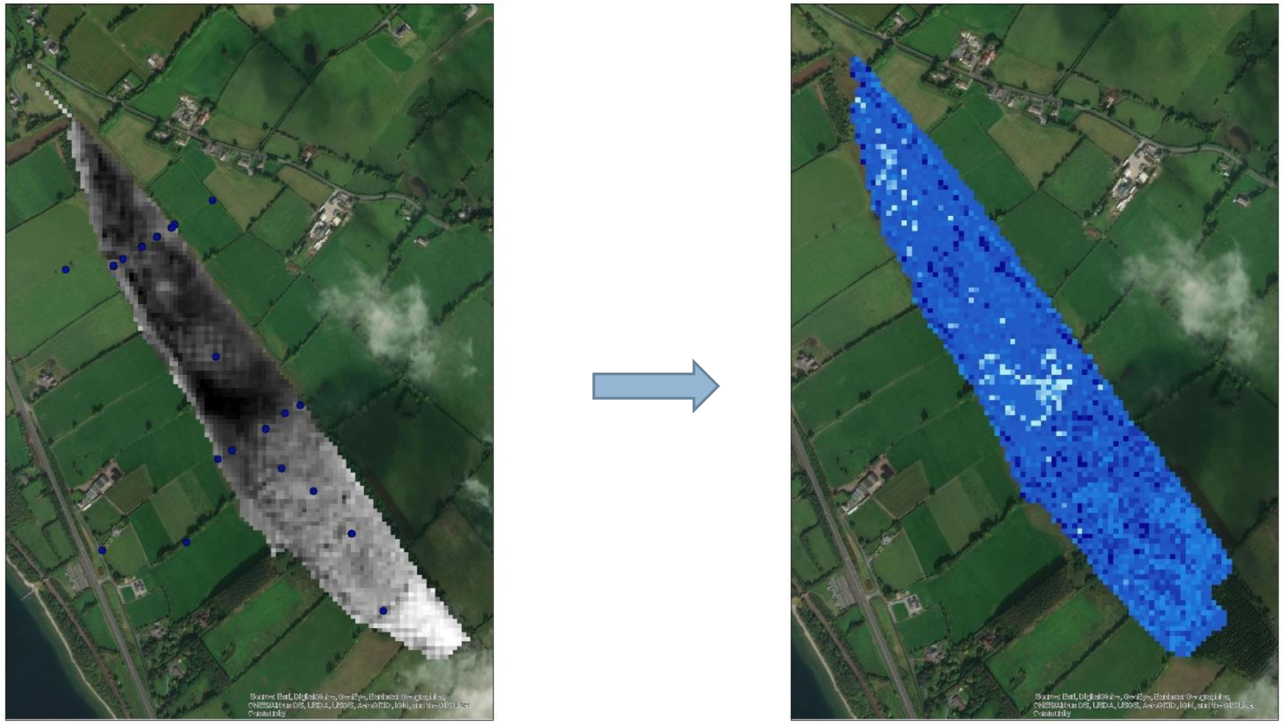
Addition of hydrometer data

- Using the moisture information as obtained using NDWI (normalised difference water index) for the wetland, and using surface water level data of the sampling points on ground – predicting an approximate surface water level for the entire wetland.



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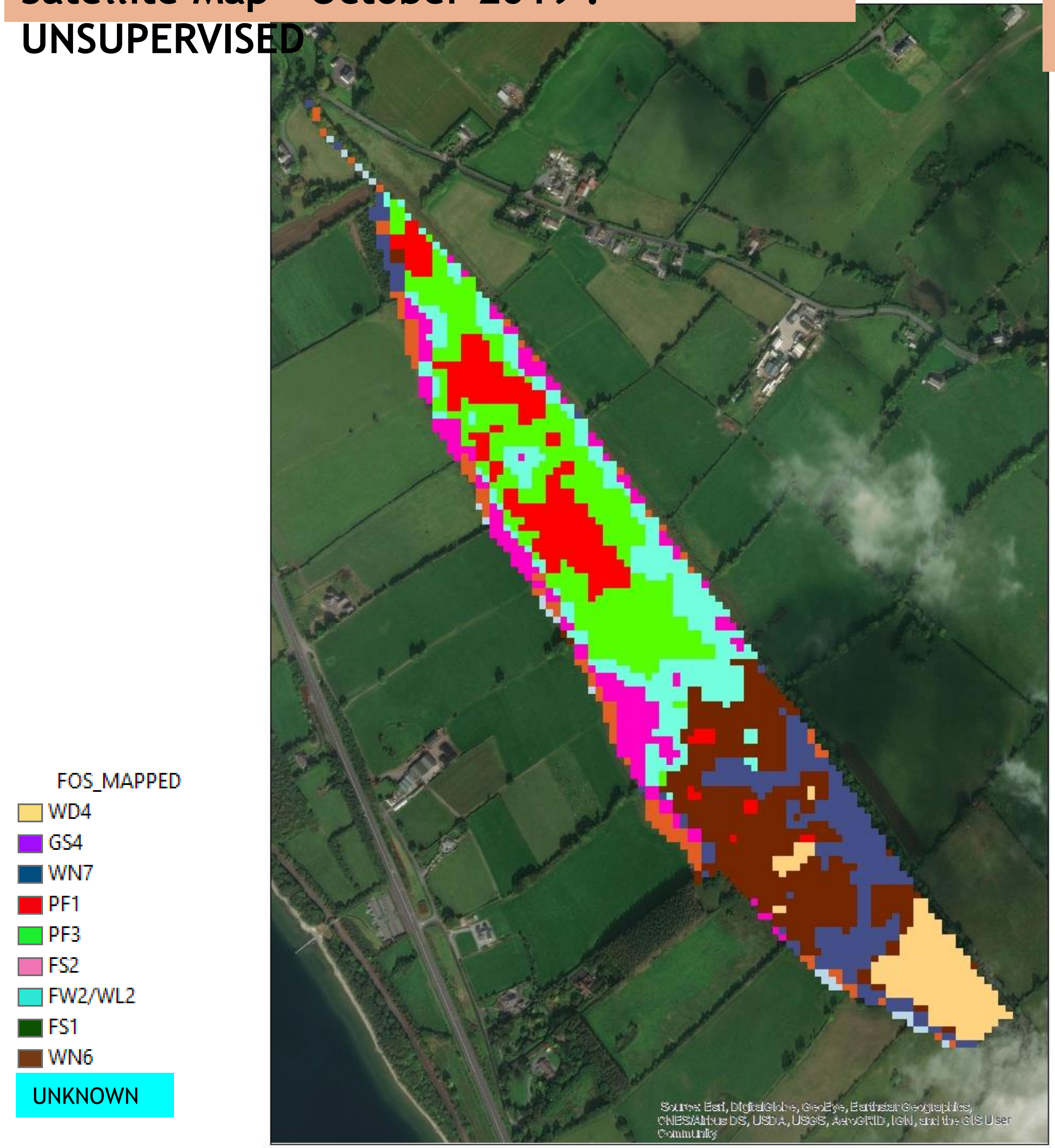

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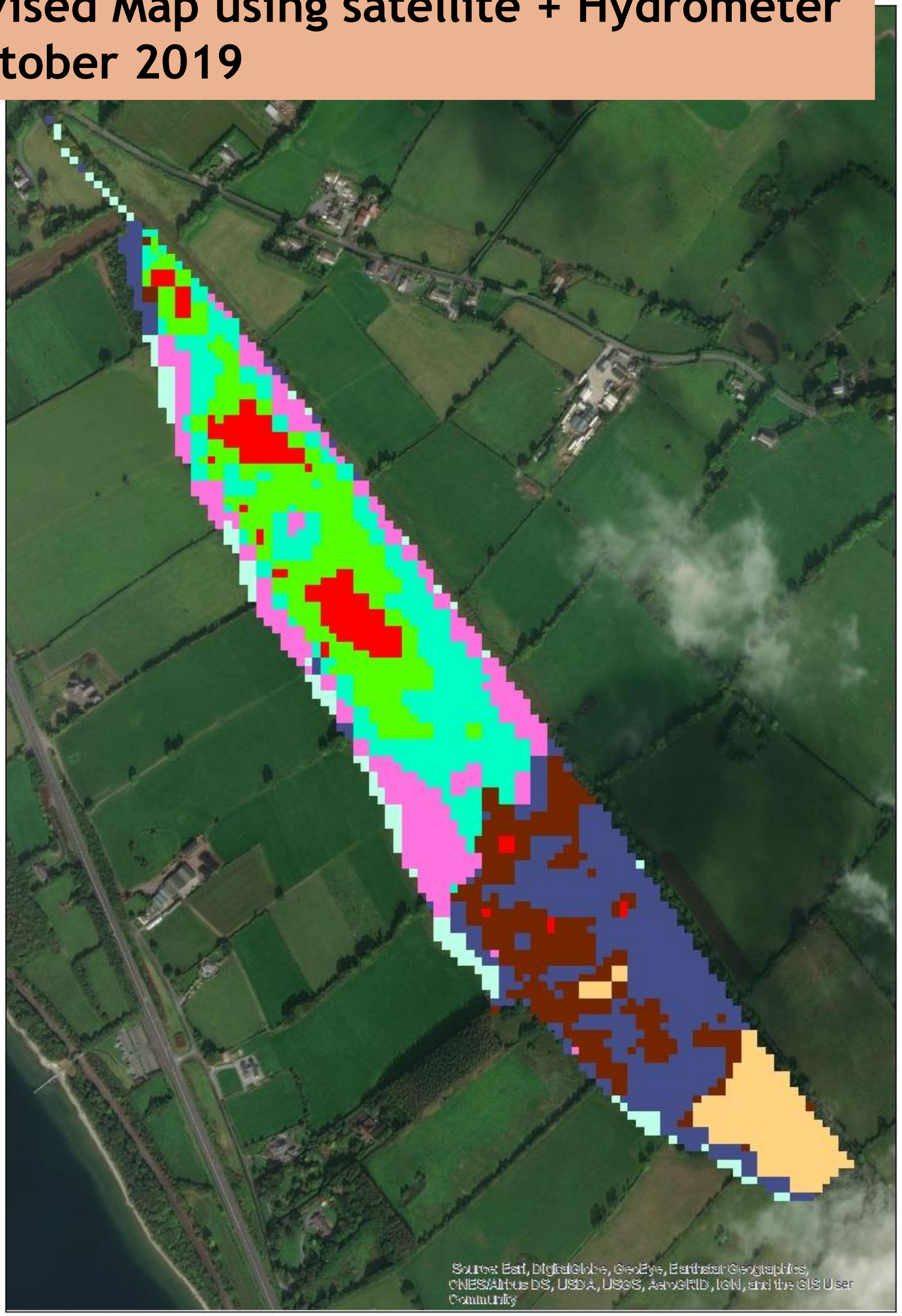
Unsupervised Map using satellite + Hydrometer data - October 2019



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Conclusions

- If the method is supervised, good mapping accuracy to up to 83%.
- The unsupervised classification (clustering) brings out new/unknown patterns.
    - Something important while making the actual maps; maybe the field could be visited at those points to confirm.

- Addition of hydrometer information leads to formation of better boundaries of the vegetation communities such as Alkaline fen.
    - Need more surface water level collection points in order to make a more robust model.

Thank you for reading