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USE OF REAL-TIME CONDUCTIVITY DATA FROM AUTONOMOUS SENSORS TO DELINEATE EFFLUENT DISTRIBUTION ON A BOREAL LAKE DOWNSTREAM FROM A SASKATCHEWAN MILLING OPERATION

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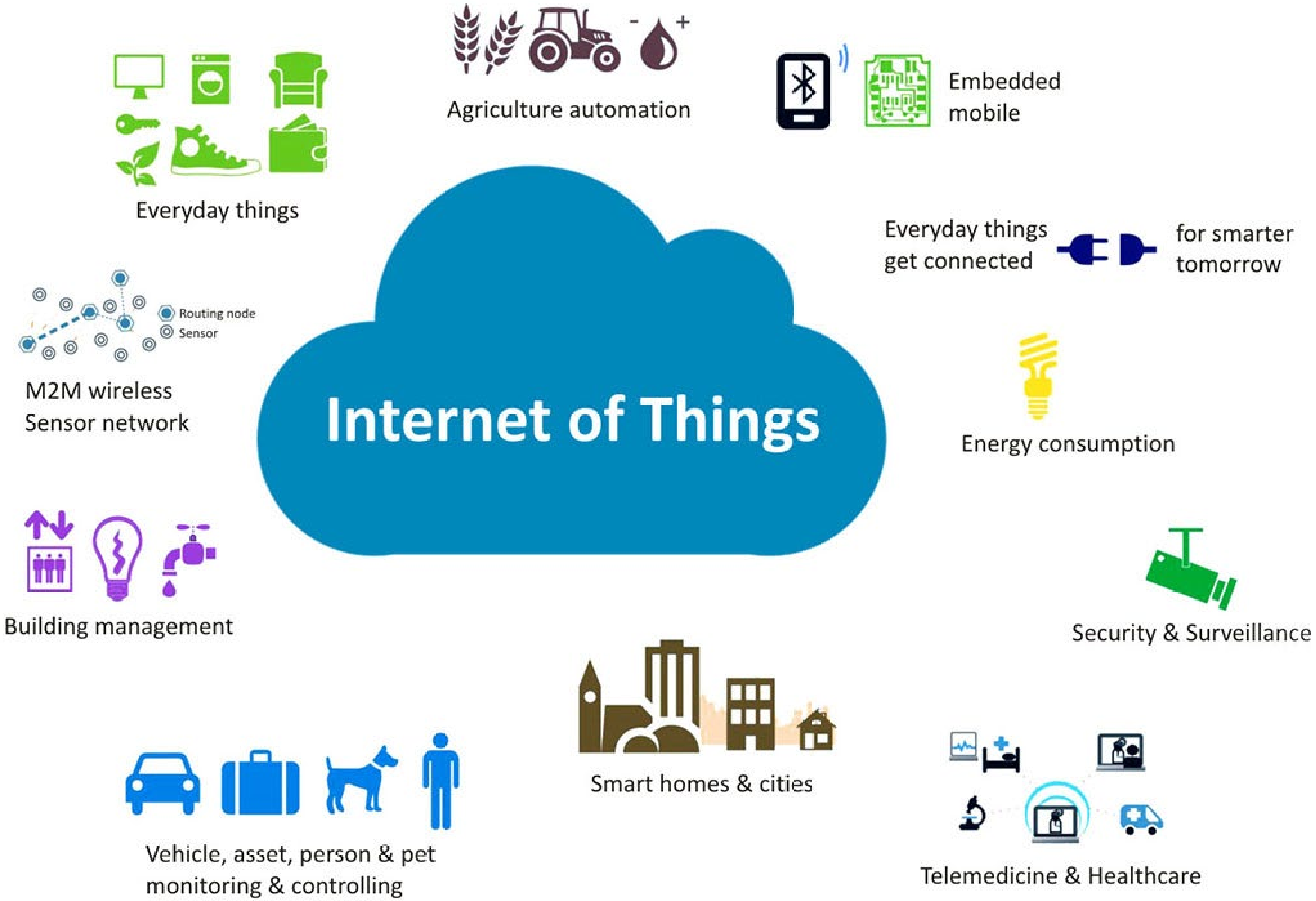
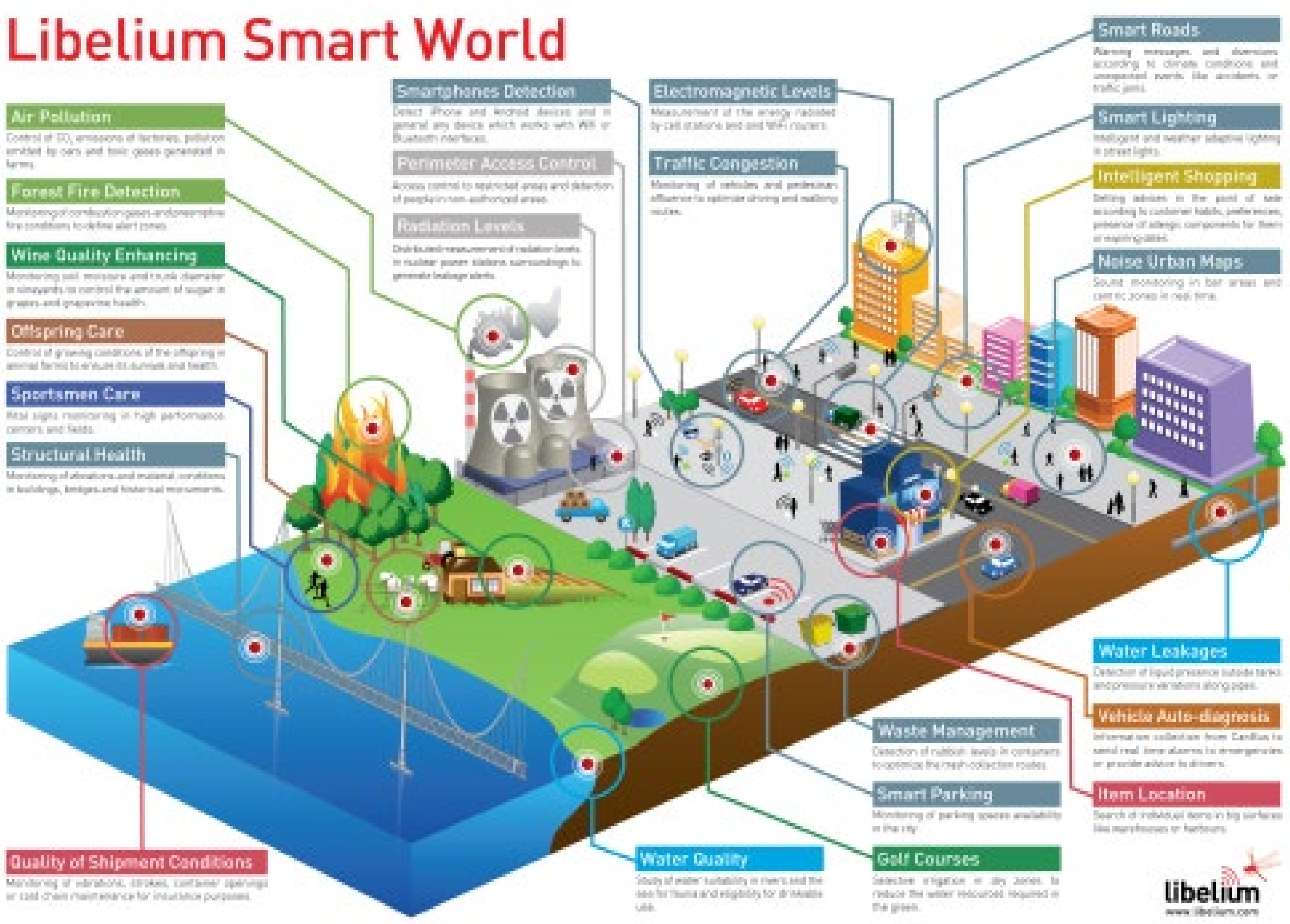
The Internet of Things (IoT)

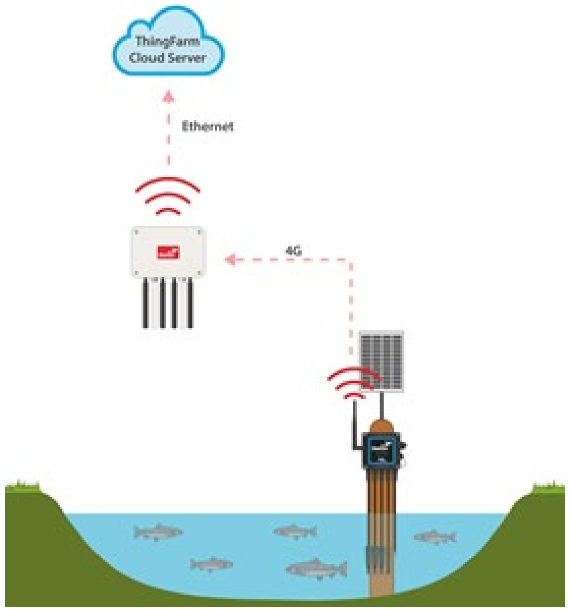


Libelium® Sensors



Source: Libelium ® website

Smart water



Source: Libelium ® website

Study Goal

- The aim of this study was to apply sensor technology (Libelium®) to delineate temporal changes in effluent distribution in a boreal lake with an unevenly mixed diluted uranium mill effluent.

Source: ECCC website

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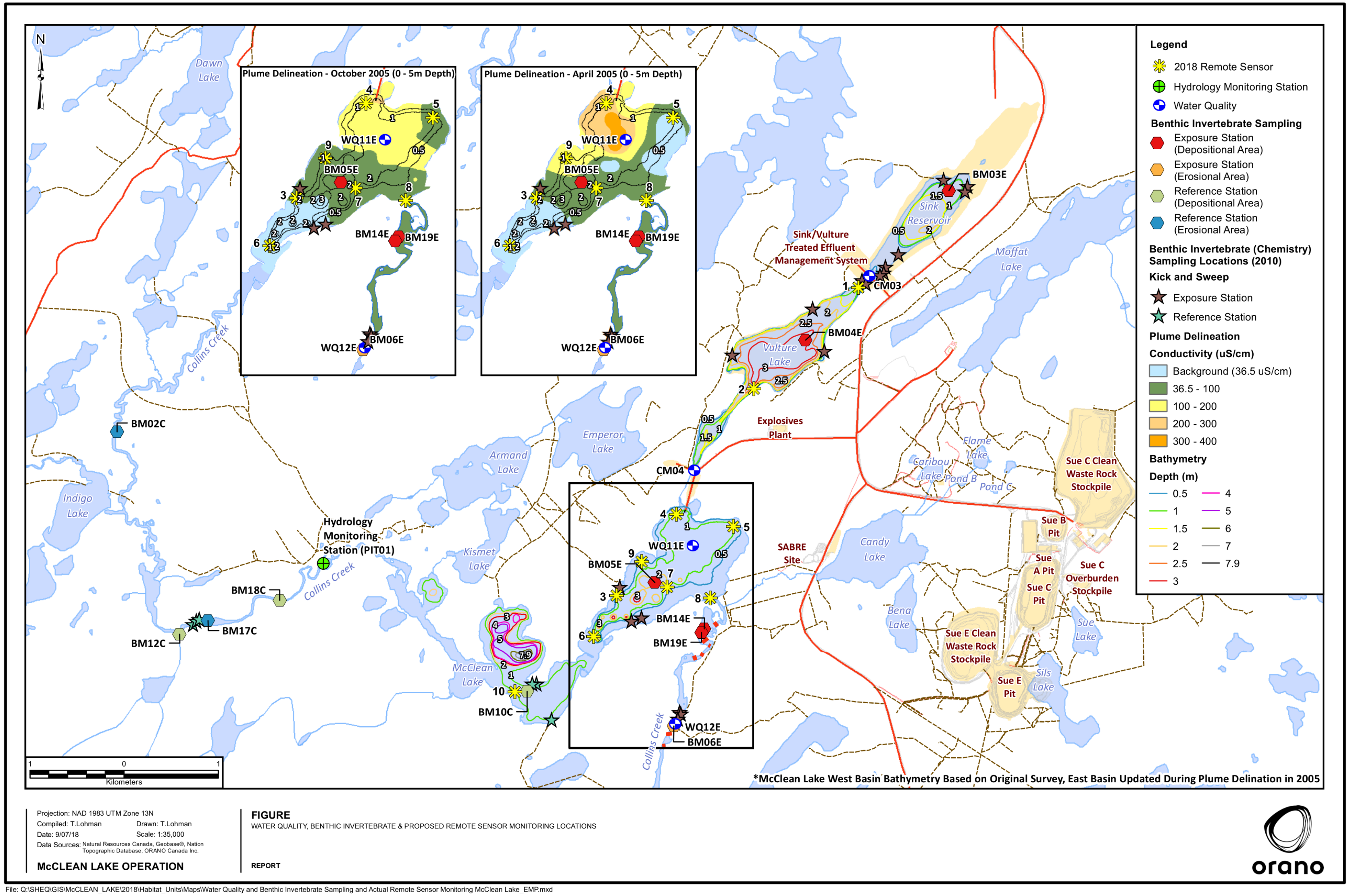
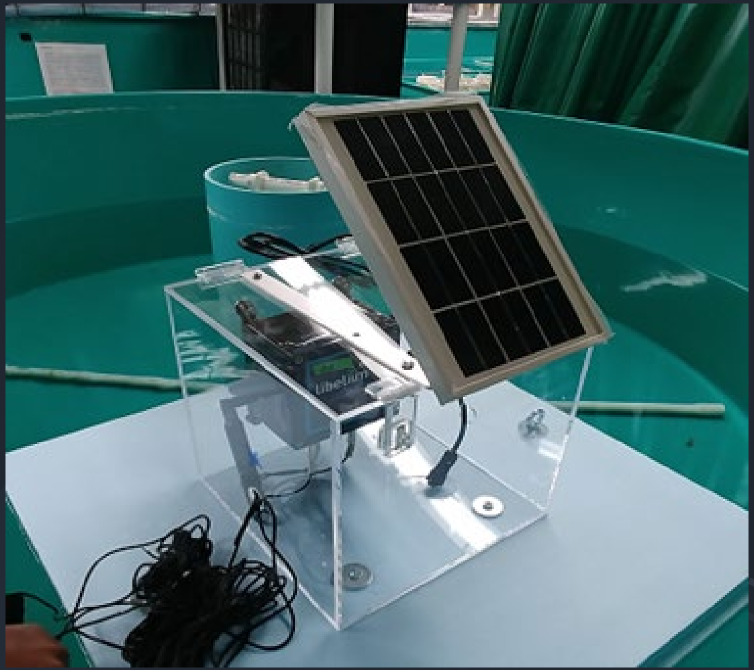
Study Site





Sensors Deployment

- Sensor holder design testing in the lab
- Deployment in 2018 for 5 weeks (trial) and 7 weeks in 2019
- EC and temperature readings every 4h in 2018 and every 12h in 2019
- Data stored in the Meshlium and ThingSpeak™.

EC- Temperature Conversion

- $c = 0.0191 / [1 + 0.0191(13 - 25)]$ (**Equation 1**)
- $EC_{13} = ECt / [1 - c\,(t - 13)]$ (**Equation 2**)

Alternatively,

- EC_{25} $ECt = EC_{25}\,[1 + a(t - 25)]$ (**Equation 3**)

a = 0.0191 (Clesceri et al.,1998)
Where a = conversion factor

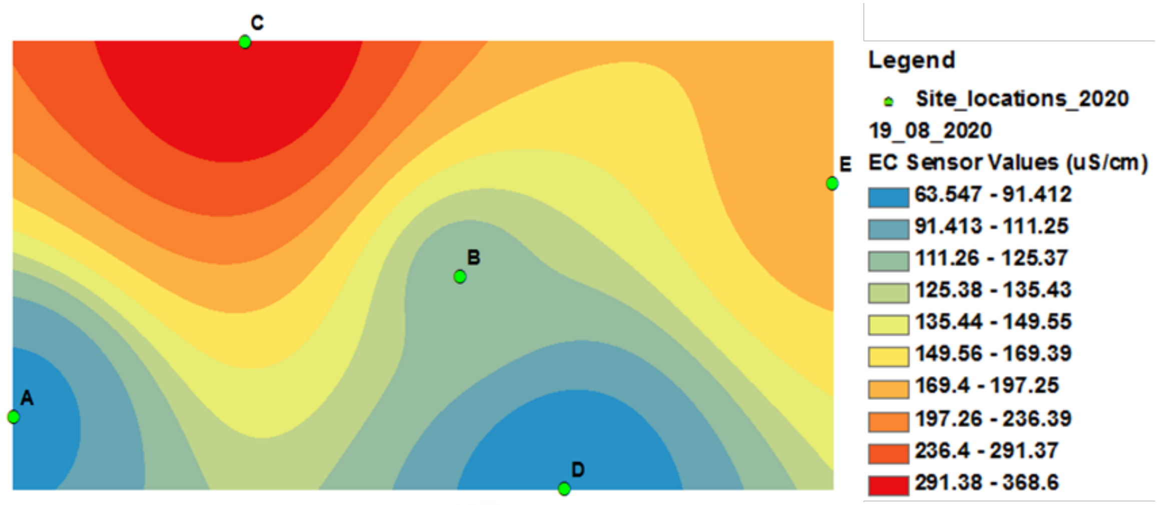
Graphic Representation

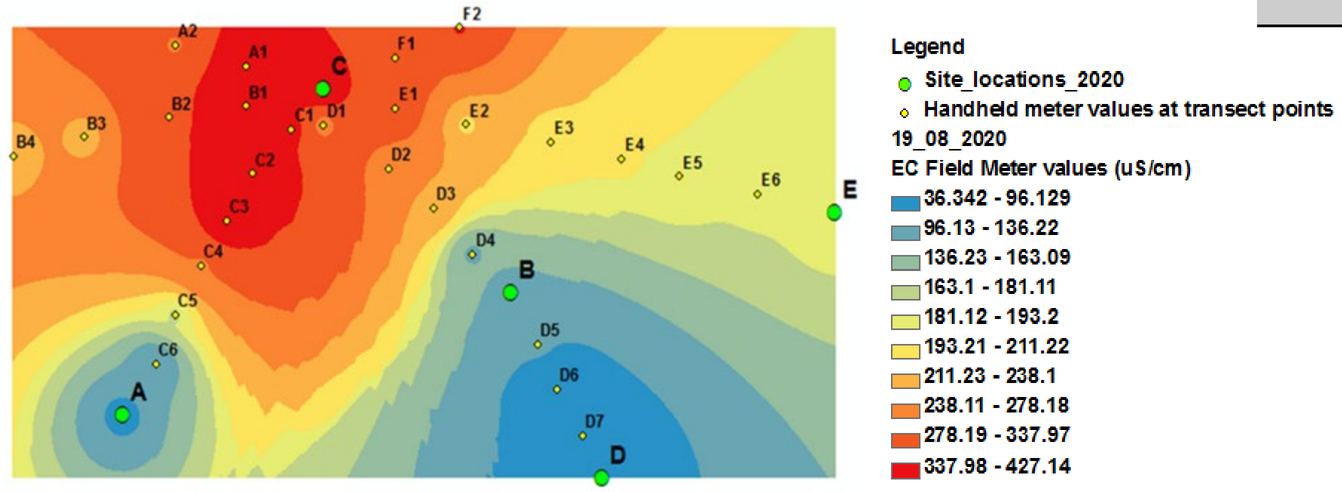
- Spatial effluent distribution maps were generated based on EC_{13} values by using the inverse-distance weighting (IDW) interpolation technique in ArcGIS version 10.6.

ArcGIS

Validation of EC readings

- In 2020, additional validation step included comparison of hand-held field meter *vs* sensors



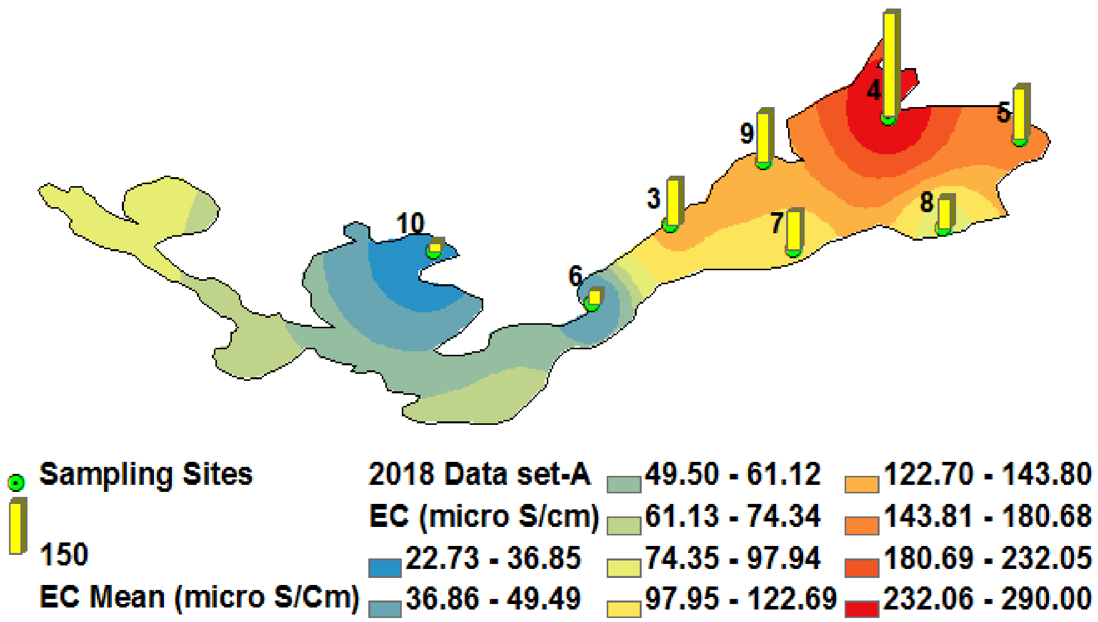


Site	EC (µS/cm) Autonomous sensors	EC (µS/cm) Handheld field meter
A	87.2 ± 9.4	85.9 ± 12.8
B	141 ± 33.0	155 ± 41.8
C*	408.3 ± 103.8	376.3 ± 56.9
D	109.6 ± 65.0	100.7 ± 61.3
E	186.5 ± 37.7	184.8 ± 27.4

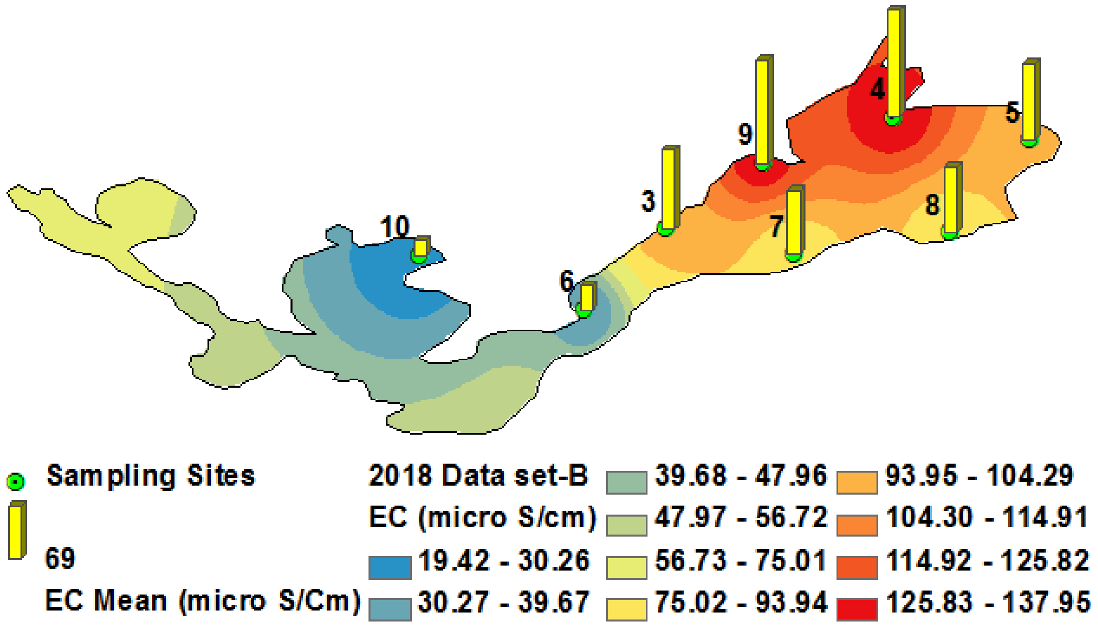
(*) Sensor placed right on top of the effluent diffuser

Results 2018

- Aug 19th – Sep 5th, 2018

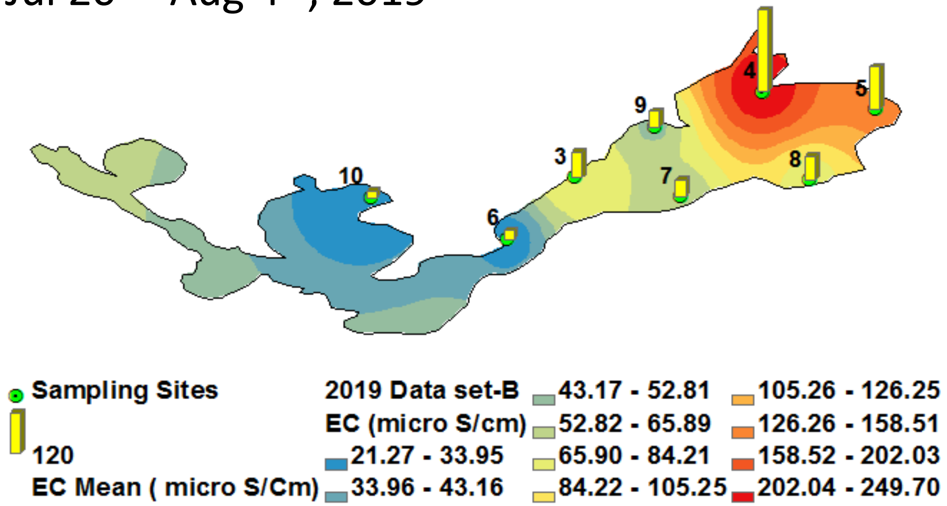


- Sept 6th – Sept 23rd, 2018

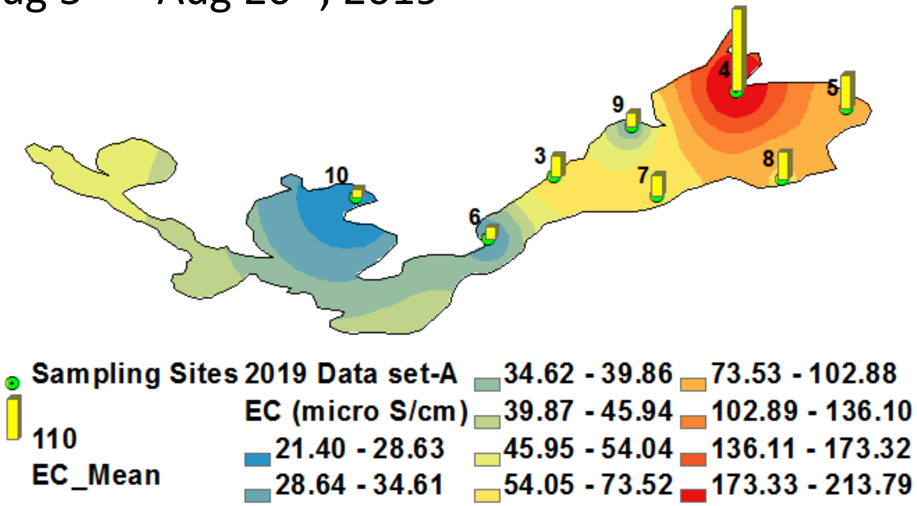


Results 2019

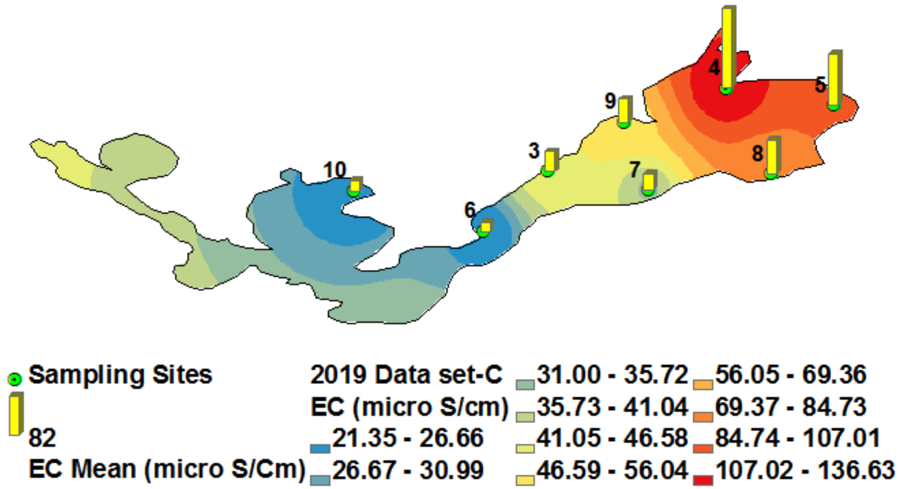
- Jul 20th- Aug 4th, 2019



- Aug 5th – Aug 20th, 2019



- Aug 21st- Sept 5th , 2019



Advantages

- Continuous collection of water quality data, allowing for better description of temporal trends
- Ability to remotely characterize dynamic hydrologic properties on a real-time scale
- Quick identification of abnormal events

Limitations

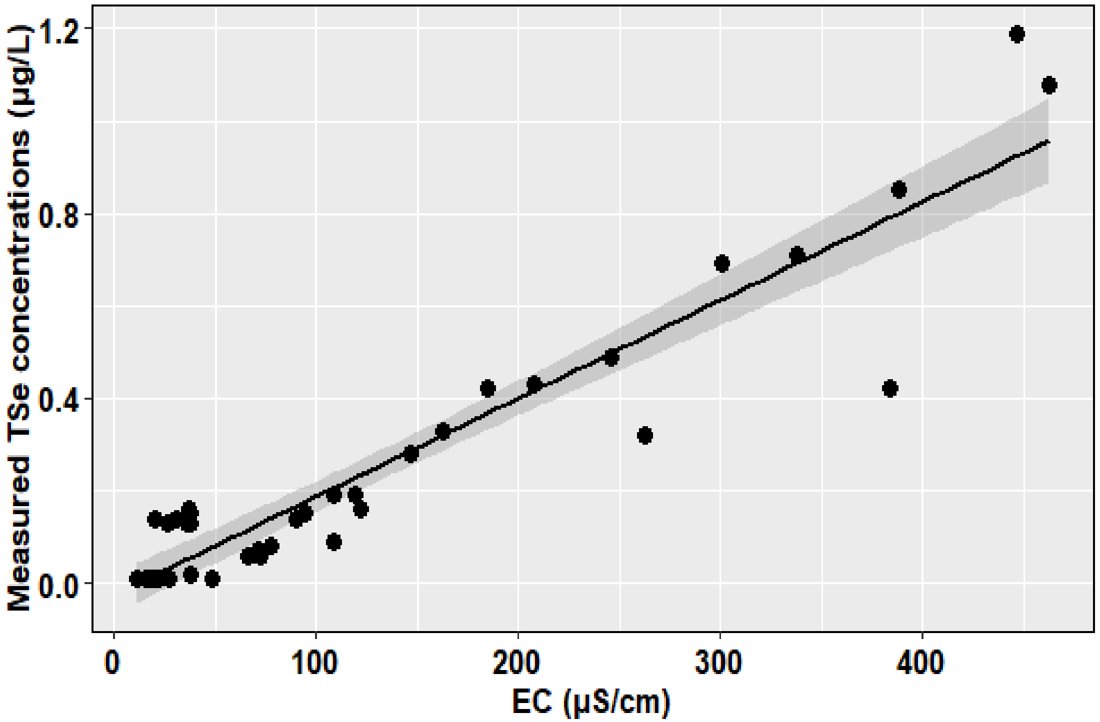
- Routine calibrations and cleaning of probes (biofouling) for accurate measurements
- Cellular signal strength
- Extreme cold environment
- Initial investment in sensor hardware

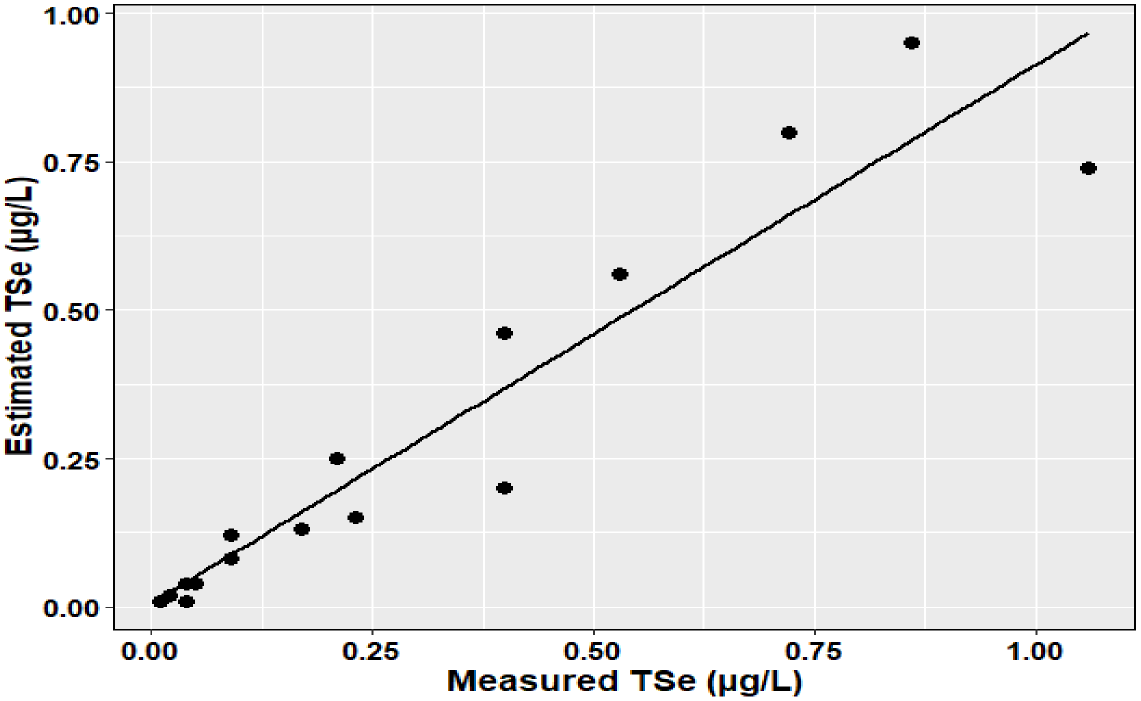
Case study: Selenium (Se)

- Correlation between measured Se concentrations in water and EC_{13}

$\log[TSe] = -3.2 + 1.2 \times \log(EC_{13}) \quad r^2 = 0.74$

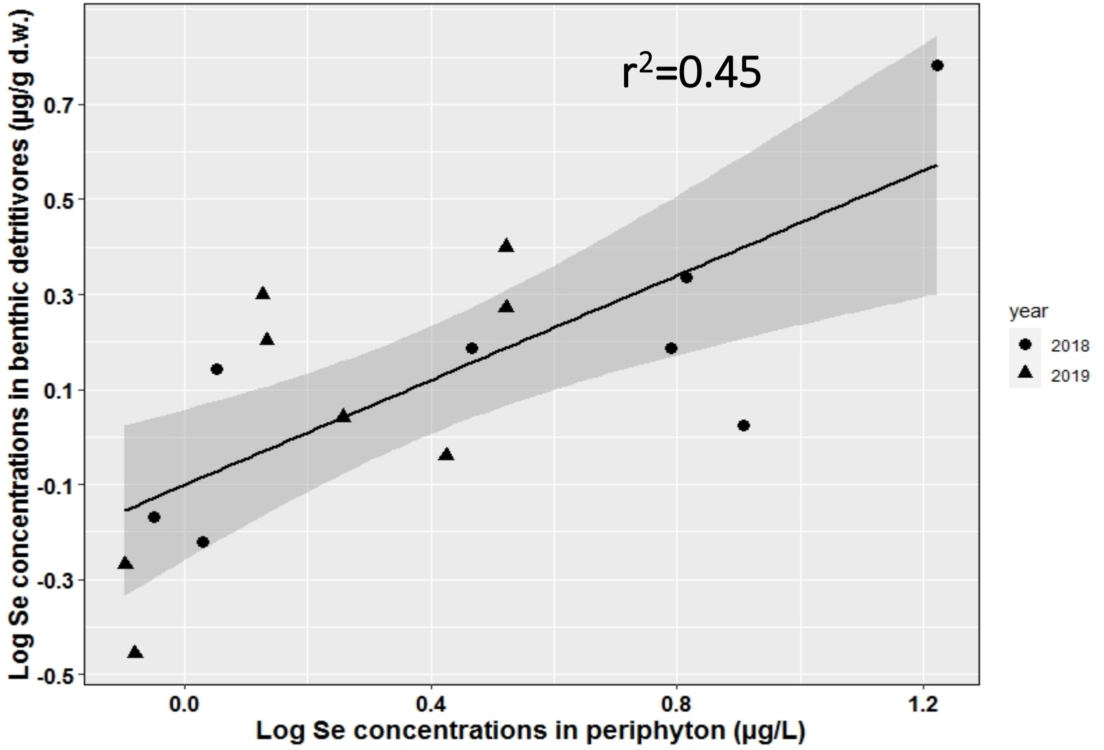
RMSE (0.09) and MAE (0.06)



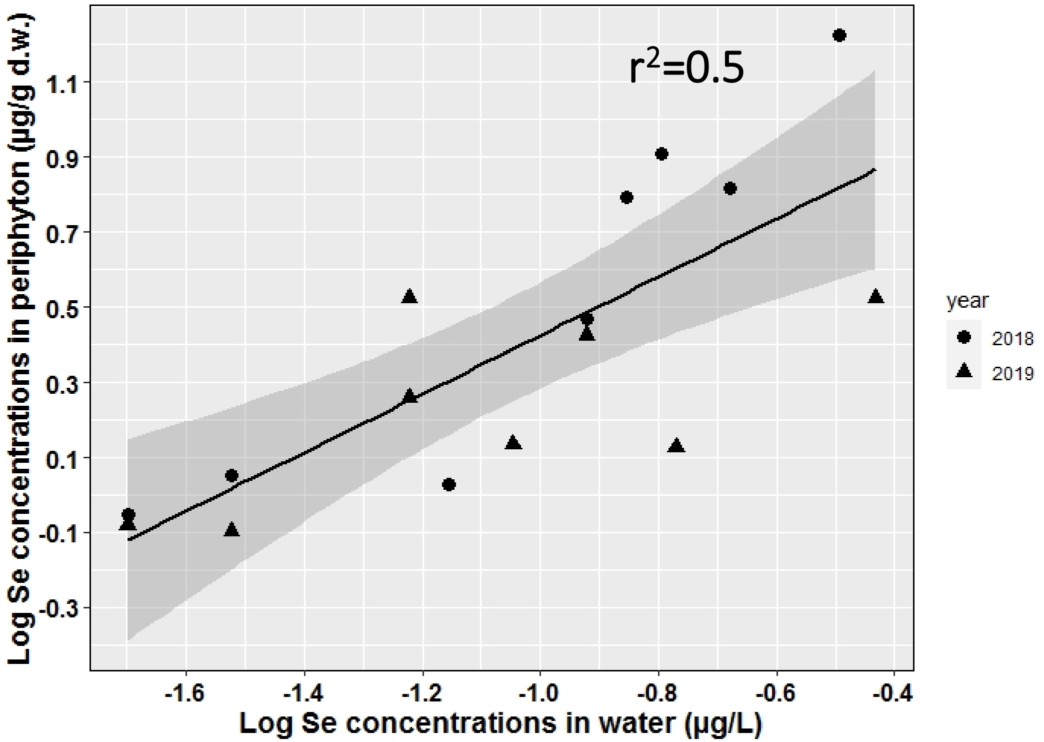


Case study: Selenium (Se)

log[Se_bmi] = -0.1 + 0.1×[Se_periphyton]



log[Se_periphyton] = 3.0 + 0.9×[logTSe]



Estimated safe threshold= 0.7 ± 0.2 µg/L

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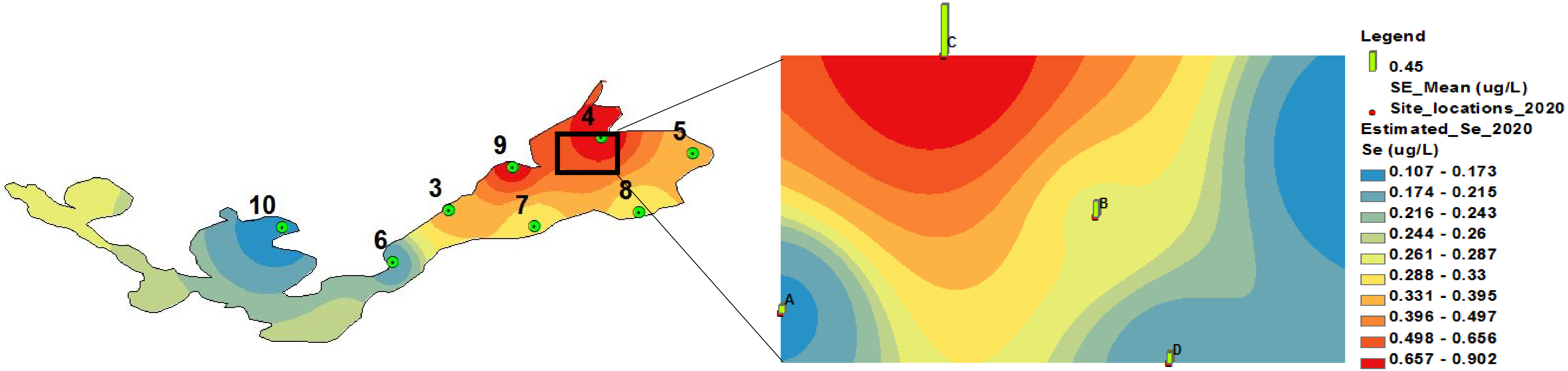
Case study: Selenium (Se)



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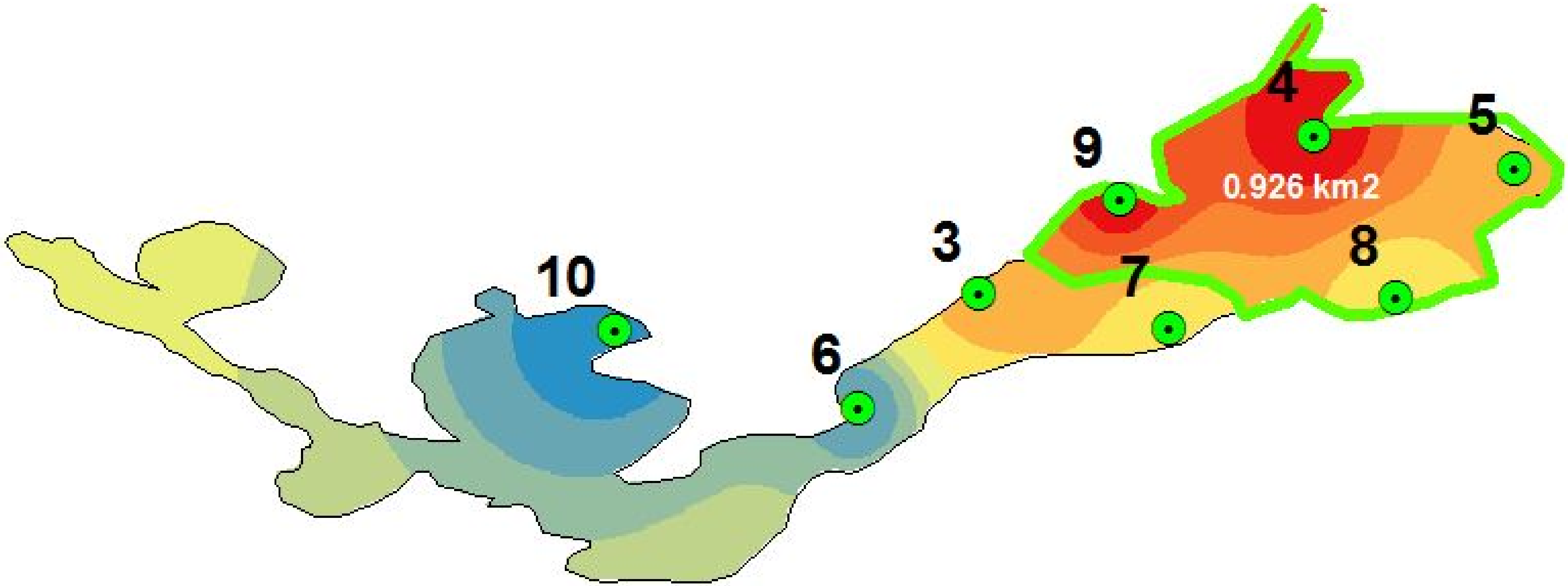
Proposed monitoring area for McClean Lake east basin



Conclusions

- Libelium® Smart Water sensors can accurately measure and report real-time EC under northern Saskatchewan conditions
- EC data can be used as a surrogate parameter to monitor some metals and trace elements such as Se
- Regular intervals of probes cleaning are necessary to account for biofouling and ensure accurate readings
- A minimum number of sensors per study area is required to ensure a more accurate geographic representation while using the IDW interpolation technique in ArcGIS.

Acknowledgements

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Xia Liu – ICPMS Technician

GWF

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Giving nuclear energy its full value