# In-ground and above-ground aquatic mesocosms as tools to understand short-term and multi-year to biological, ecological and chemical effects of reclamation technologies

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# What is a mesocosm?

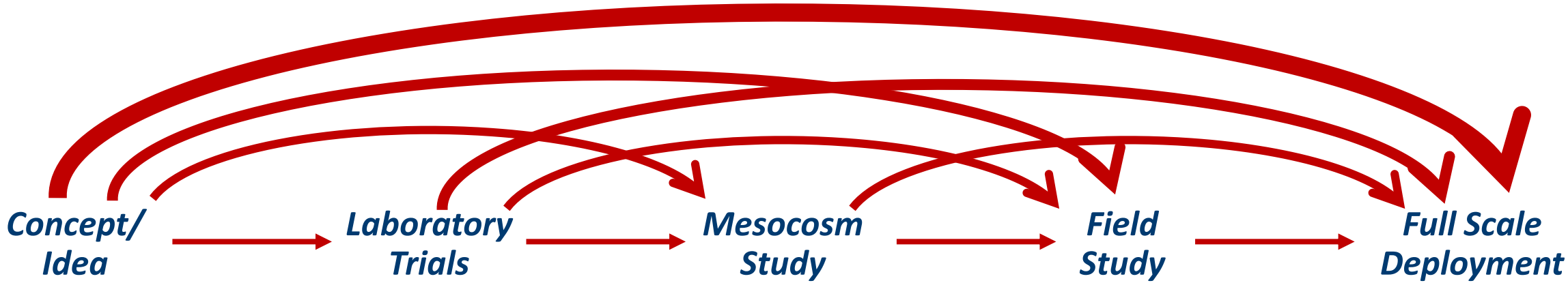
Mesocosms represent a balance between the replication and control of laboratory investigations and the realism and complexity of field studies

**Laboratory scale**
- High replication
- High variable control
- Low realism
- Low complexity

**Mesocosm scale**
- Moderate replication
- Moderate variable control
- Qualitative realism
- Moderate complexity

**Field scale**
- Low replication
- Low/no variable control
- High realism
- High complexity

# Why use mesocosms?




- Arrow weight signifies risk/uncertainty
- In progression of an idea or concept, the stepwise iterations can be used to manage risk
- Skipping a step can increase risk
- At InnoTech, *mesocosms are used to compare treatments that have been tested initially in a highly controlled laboratory setting*

# Above-Ground Mesocosms

- Facility housed in Vegreville and constructed in 2015
- Cost split between Helmholtz – Alberta Initiative (through U of A) and InnoTech Alberta
- Initially conceived as terrestrial venue, but very adaptable
- Ultimate goal: provide unique infrastructure for novel research to address environmental challenges

# Above-Ground Mesocosms

- Mesocosms: 5000 L volume, 1.3 m high, 2.2 m diameter
- 16 mesocosms on site, more could be added
- Can be used as terrestrial or aquatic systems

- Mesocosms are housed on a lined and bermed containment pad, providing a safe venue for testing potentially harmful materials

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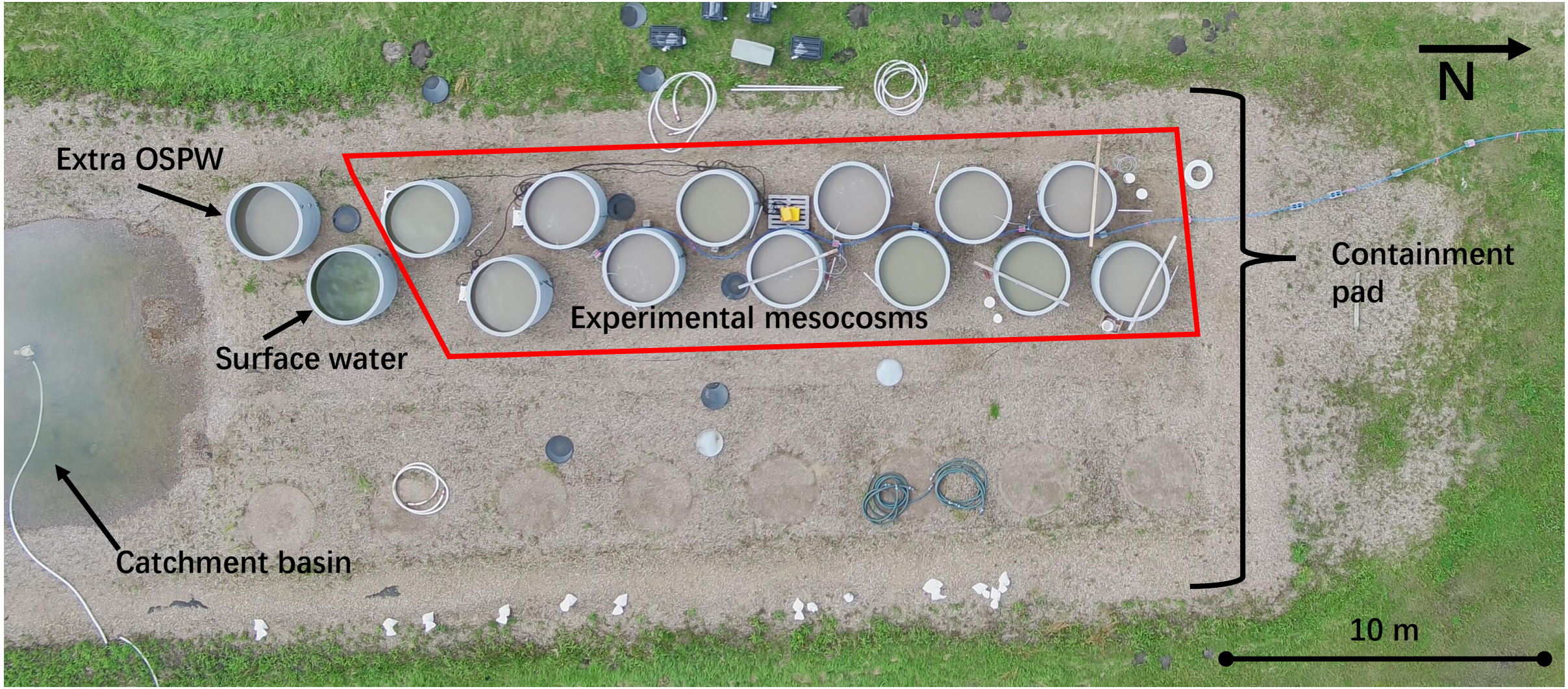
# Above-Ground Mesocosms

## *A multitude of sampling options*

- As aquatic systems: water chemistry, naphthenic acids, toxicity, $CO_2$ production (automated), DO and temperature, microbial communities (CFU and DNA/RNA)
- As terrestrial systems: time lapse and plant root cameras, piezometers, lysimeters, $CO_2$ flux (automated), temperature, conductivity, moisture

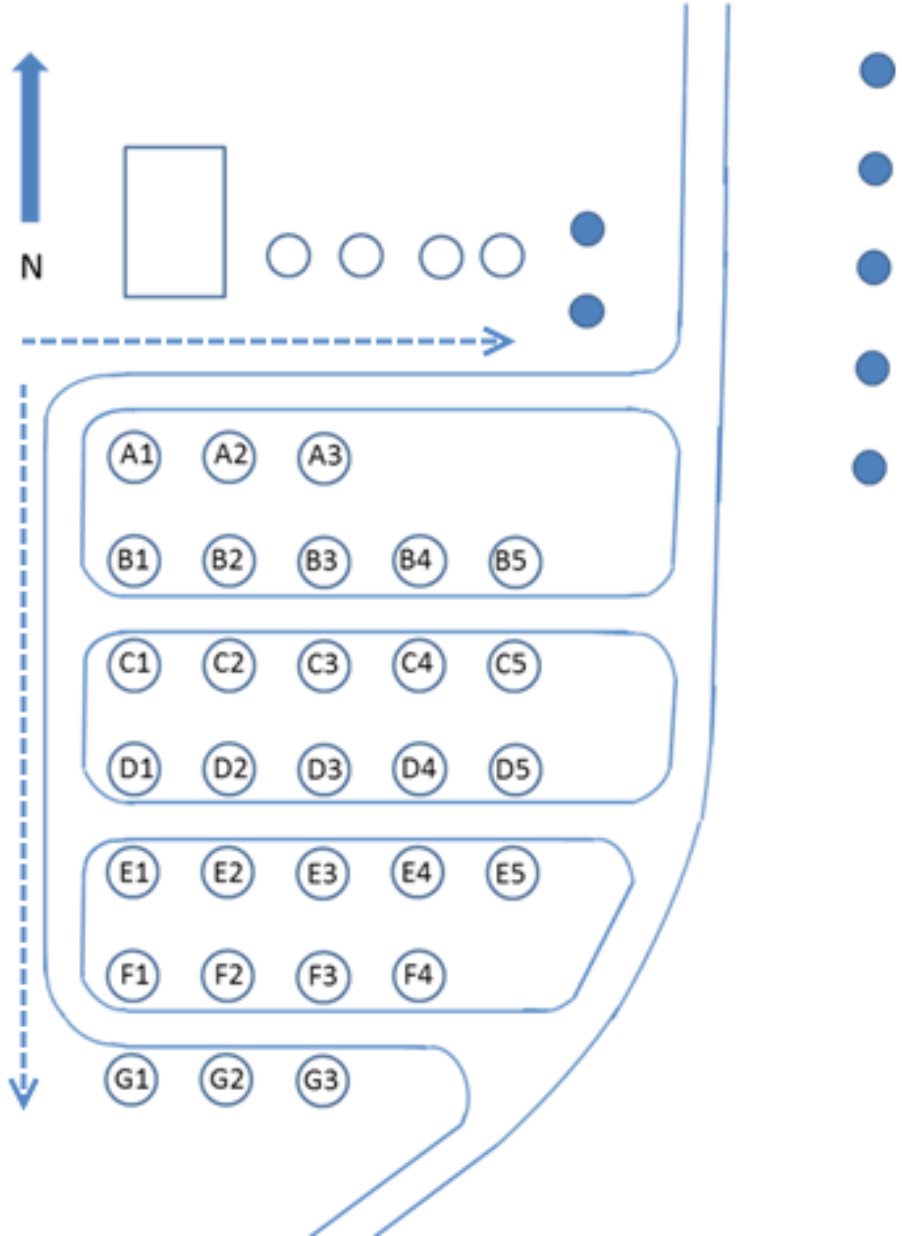
# Above-Ground Mesocosms

## Example of an experiment using Oil Sand Process-affected Water (OSPW)



# The Aquatic Mesocosm Facility at InnoTech

- 30 in-ground aquatic mesocosms with an outer tank to allow for thermal conductance and overflow containment
- Working volume of ~14,000 L each with a working depth of <157.5 cm and width of 3-3.6 m
- Arranged in grid to allow for randomization
- Facility includes potable water tanks, 5 waste water tanks, 4 deep supply ponds and a shallow supply pond



# The Aquatic Mesocosm Facility at InnoTech

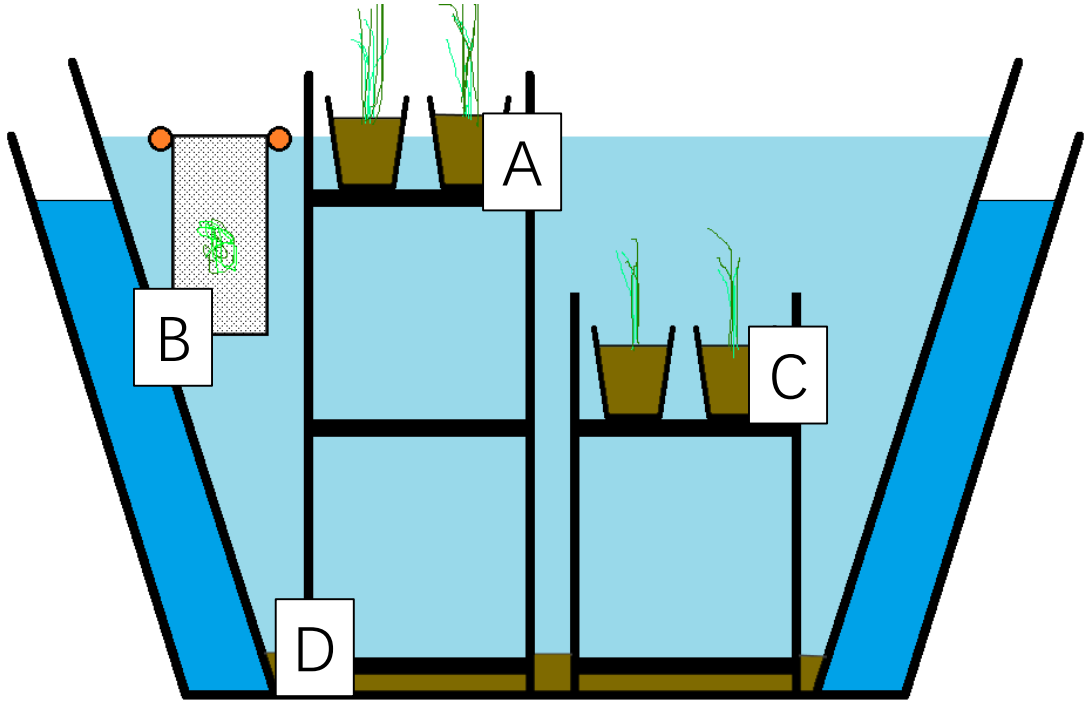
# The Aquatic Mesocosm Facility at InnoTech

## Aquatic Mesocosms at InnoTech can overwinter

- Unique characteristic
- Freeze without damage to infrastructure
- **Do not** freeze to the bottom
- **Organisms such as macroinvertebrates can overwinter in these systems**
- *All plants remained in mesocosms over 2019/20/21 (with harvest of aboveground biomass only), allowing for multi-year analysis of same individuals*

# Example mesocosm configurations 2017/18 and 2019/20/21

## 2017/18



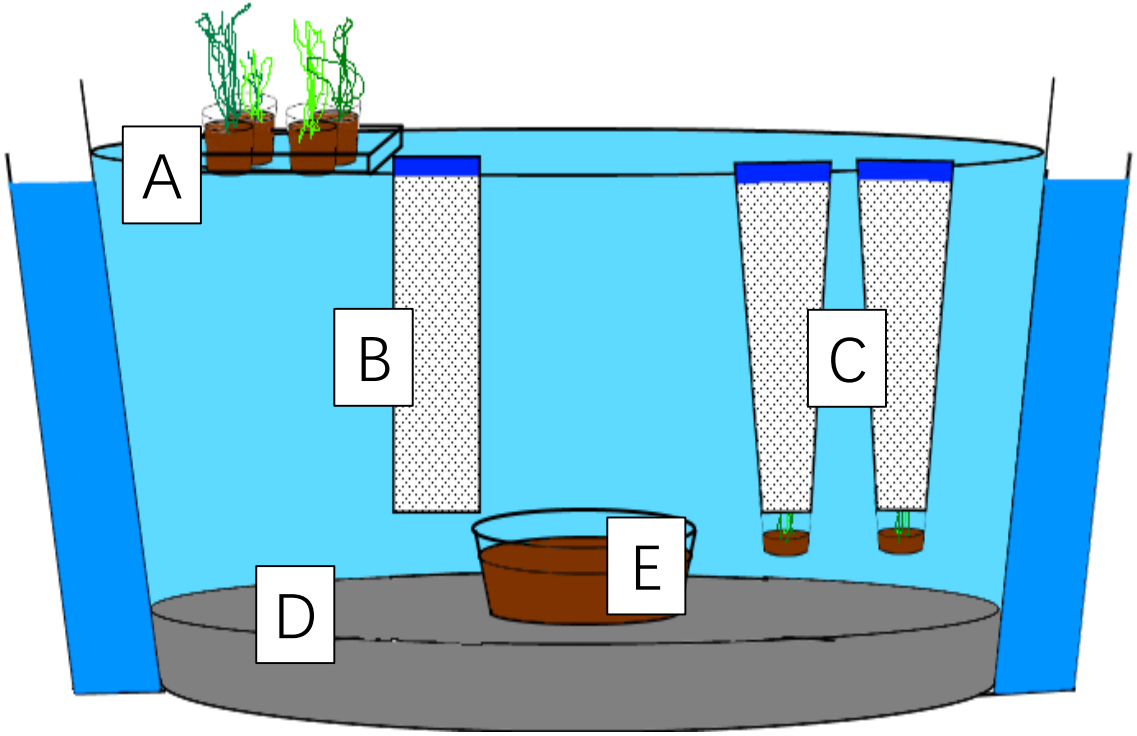

A: Standing shelves with plants

B:Floating plants in mesh sock

C:Submerged plants on half shelf

D:Tailings or soil or bare

## 2019/20/21




A:Floating plant supports

B:Floating plants in mesh sock

C:Submerged plants in mesh sock

D:Tailings or washed filter sand

E: Container with soil

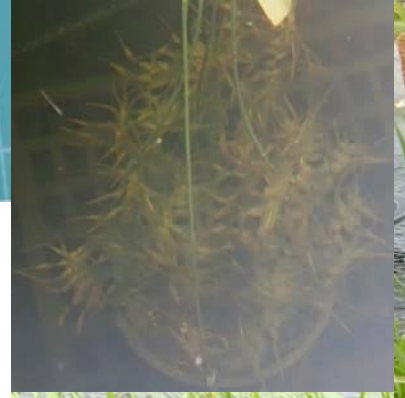
# Installed vegetation

## Emergent:

- Cattail (*Typha latifolia*)
- Water sedge (*Carex aquatilis*)
- Awned sedge (*Carex atherodes*)
- (Musk)Rat root (*Acorus americanus*)

## Submerged/floating:

- Hornwort (*Ceratophyllum demersum*)
- Richardson's pondweed (*Potamogeton richardsonii*)
- Northern milfoil (*Myriophyllum sibiricum*)



# The 2019/20/21 Aquatic Mesocosm Study: Design

Purpose:

To determine how different tailings streams and OSPW affect the aquatic system in terms of physical, chemical, biological and toxicological properties.

| Experimental Group | Fluid content | Sediment | # of Mesocosms |
|---|---|---|---|
| Control | Athabasca River Water | Filter sand | 5 |
| Treatment 1 | Athabasca River Water | Coarse Sand Tailings (CST) | 4 |
| Treatment 2 | Athabasca River Water | Thickened Fluid Fine Tailings (TT) | 4 |
| Treatment 3 | Athabasca River Water | Froth Treated Tailings [a] (FTT[a]) | 4 |
| Treatment 4 | Athabasca River Water | Fluid Fine Tailings (FFT) | 4 |
| Treatment 5 | 100% OSPW [a] | Fluid Fine Tailings (FFT) | 4 |
| Treatment 6 | 50% OSPW [b] | Thickened froth treated tailings [b] (TFTT[b]) | 5 |

# The 2019/20/21 aquatic mesocosm study: Set-up

## Commissioning

- Before experiment:
- Fill with 15,000 L Athabasca River Water (ARW)
- Add 4 L of wetland sediment
- Homogenize
  - Across rows and columns
  - Twice, 2 weeks apart
- Install plants
  - Acclimate to ARW
- Ensures initial water chemistry and biota are as similar as possible across mesocosms

## Installation of treatment materials

- Plant rafts/socks were removed and set aside
- ARW was evacuated to clean holding tanks
- Tailings or filter sand was poured into mesocosm
- ARW and/or OSPW was added back to mesocosm
- Plant rafts/sock were reinstalled

# Control Mesocosm early 2019

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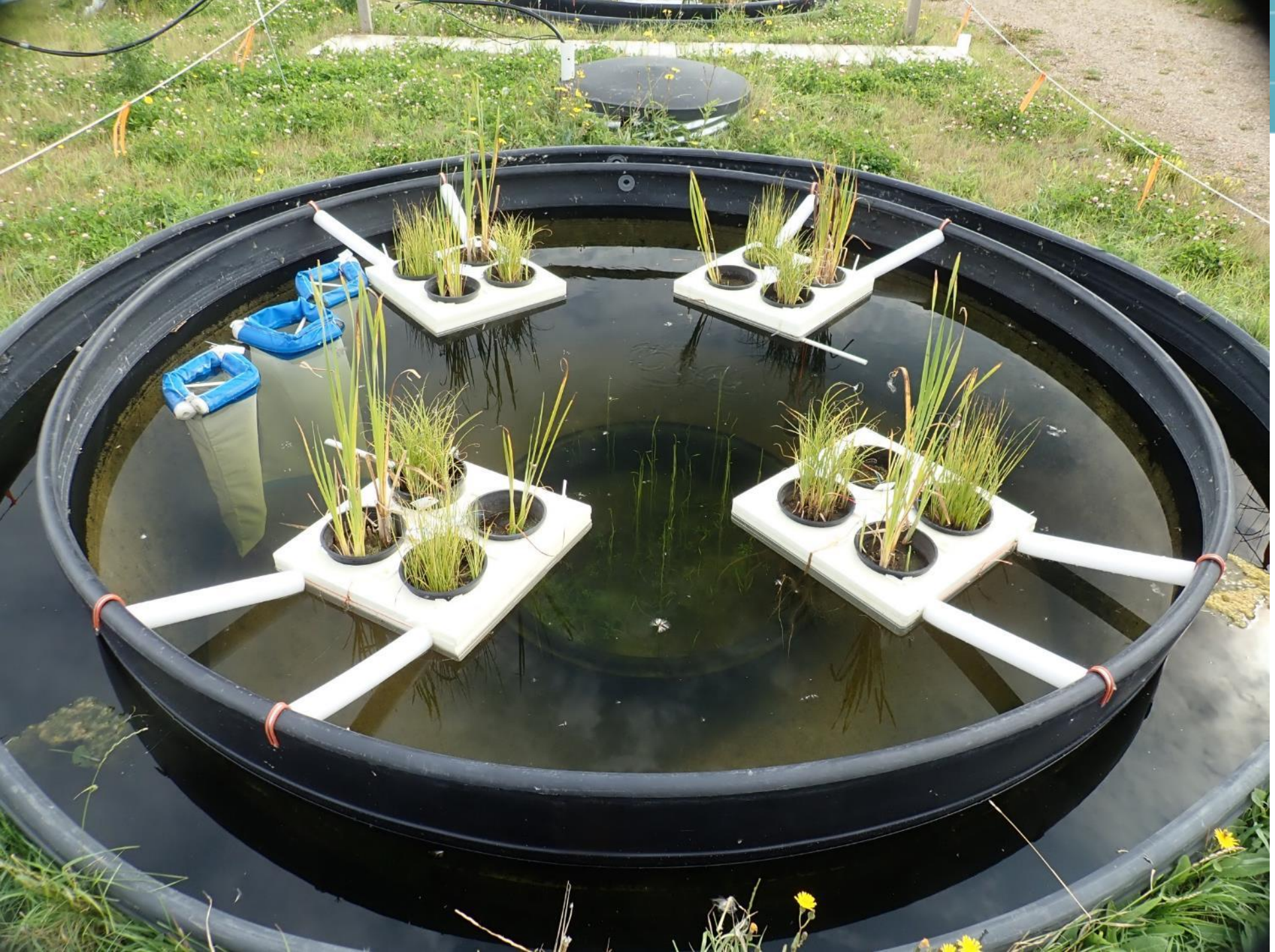

# Control Mesocosm late 2019

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# Mesocosm with Study Materials early 2019

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# Mesocosm with Study Materials late 2019

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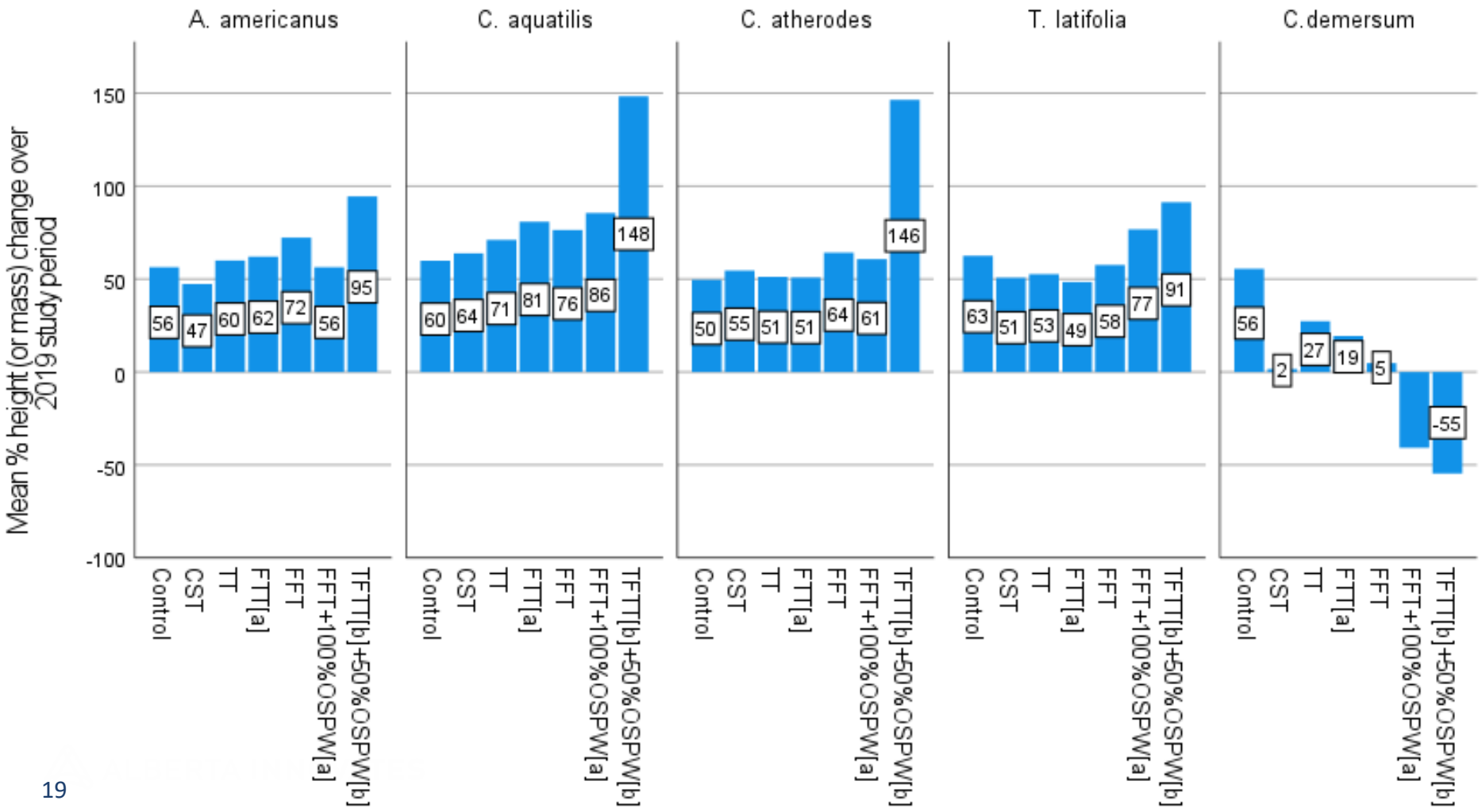
# 2019/20/21 Aquatic Mesocosm Study-Plant response




Take-away: not all tailings/OSPW are the same and not all plants respond to tailings or OSPW in the same manner.



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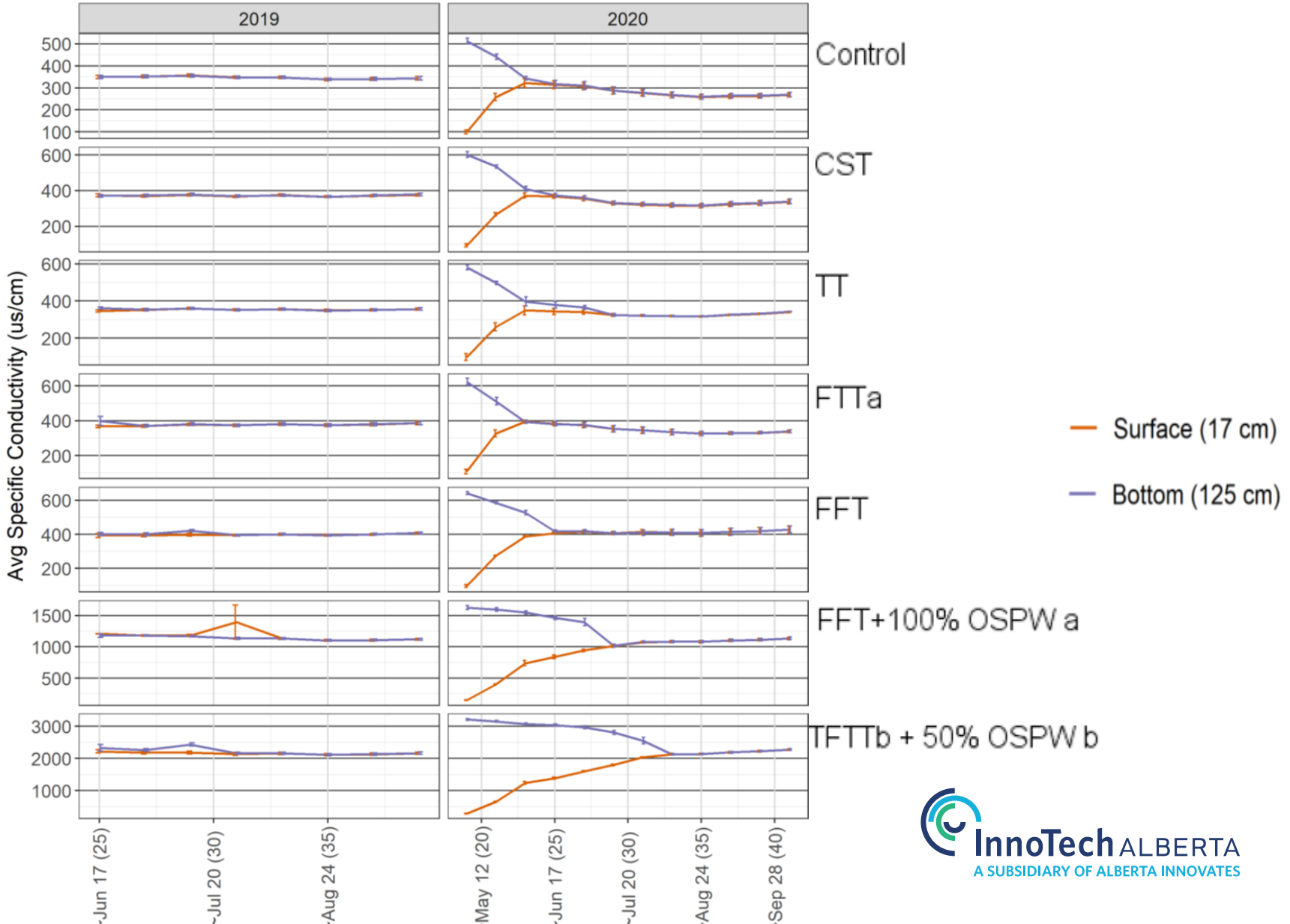
# 2019/20/21 Aquatic Mesocosm Study–Field Water chemistry

## *Importance of sample collection methods*

- Field water chemistry data was collected to accompany lab chemistry samples
- Chemocline formed over winter, which attenuates through the open-water season



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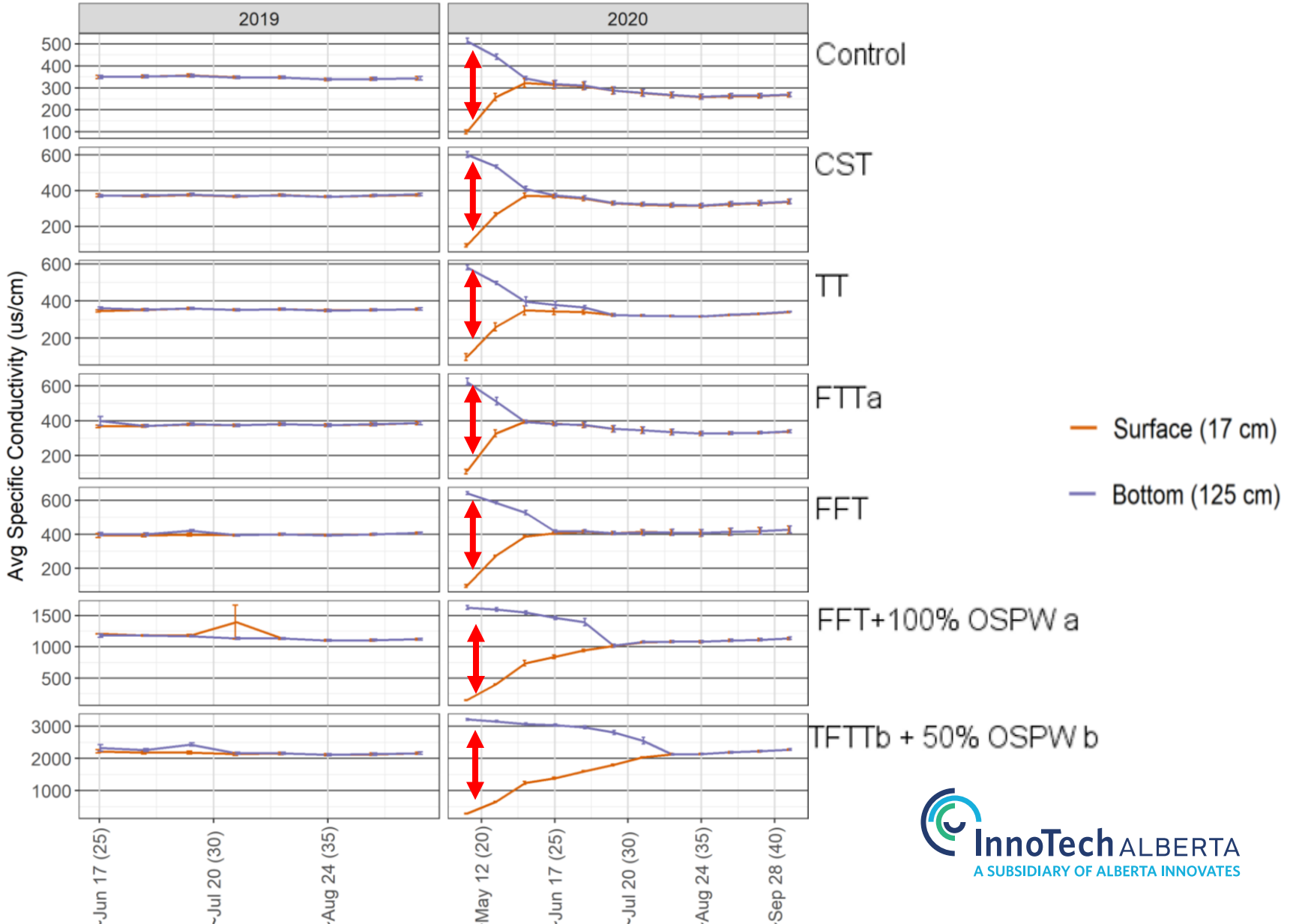




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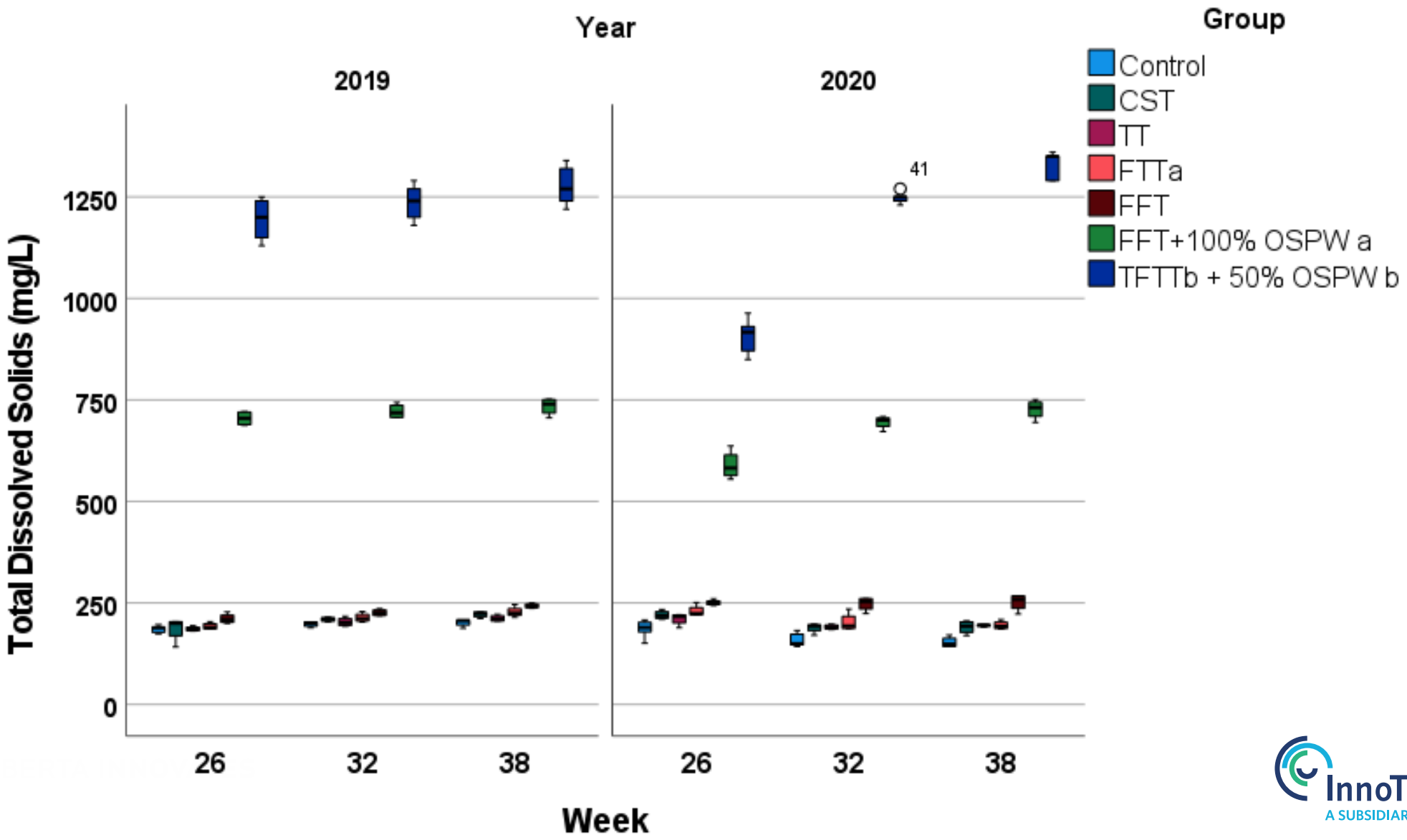




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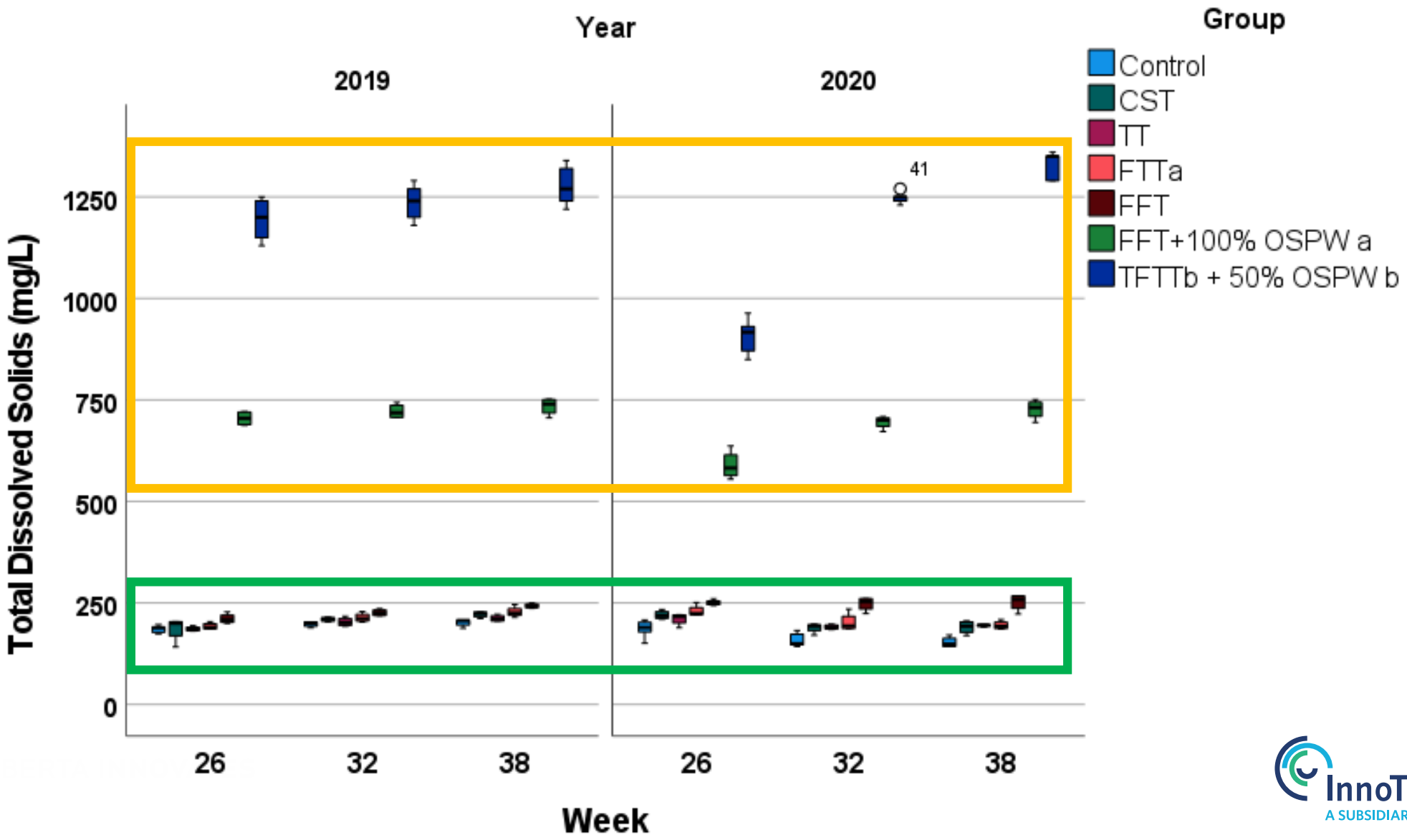




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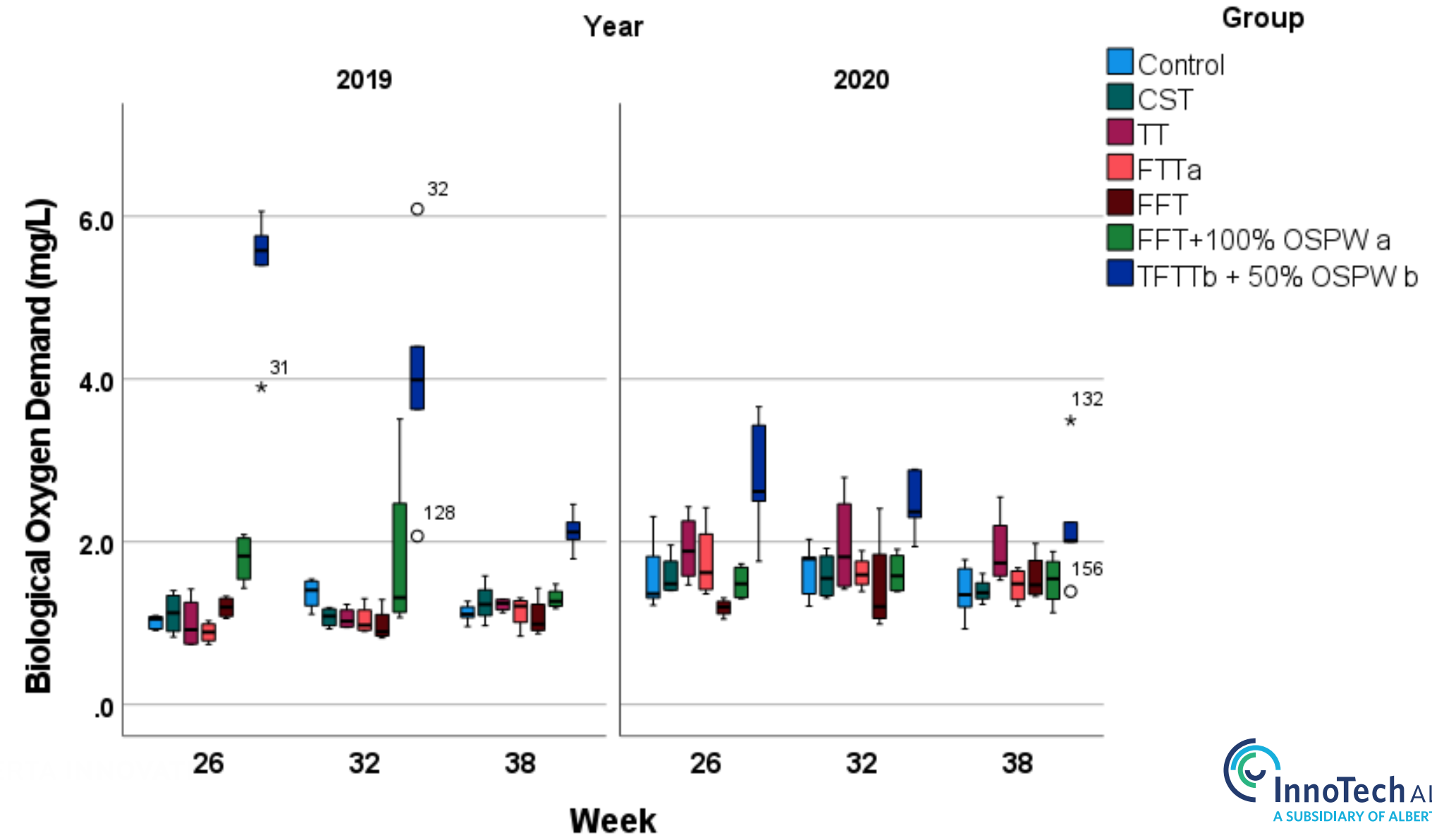




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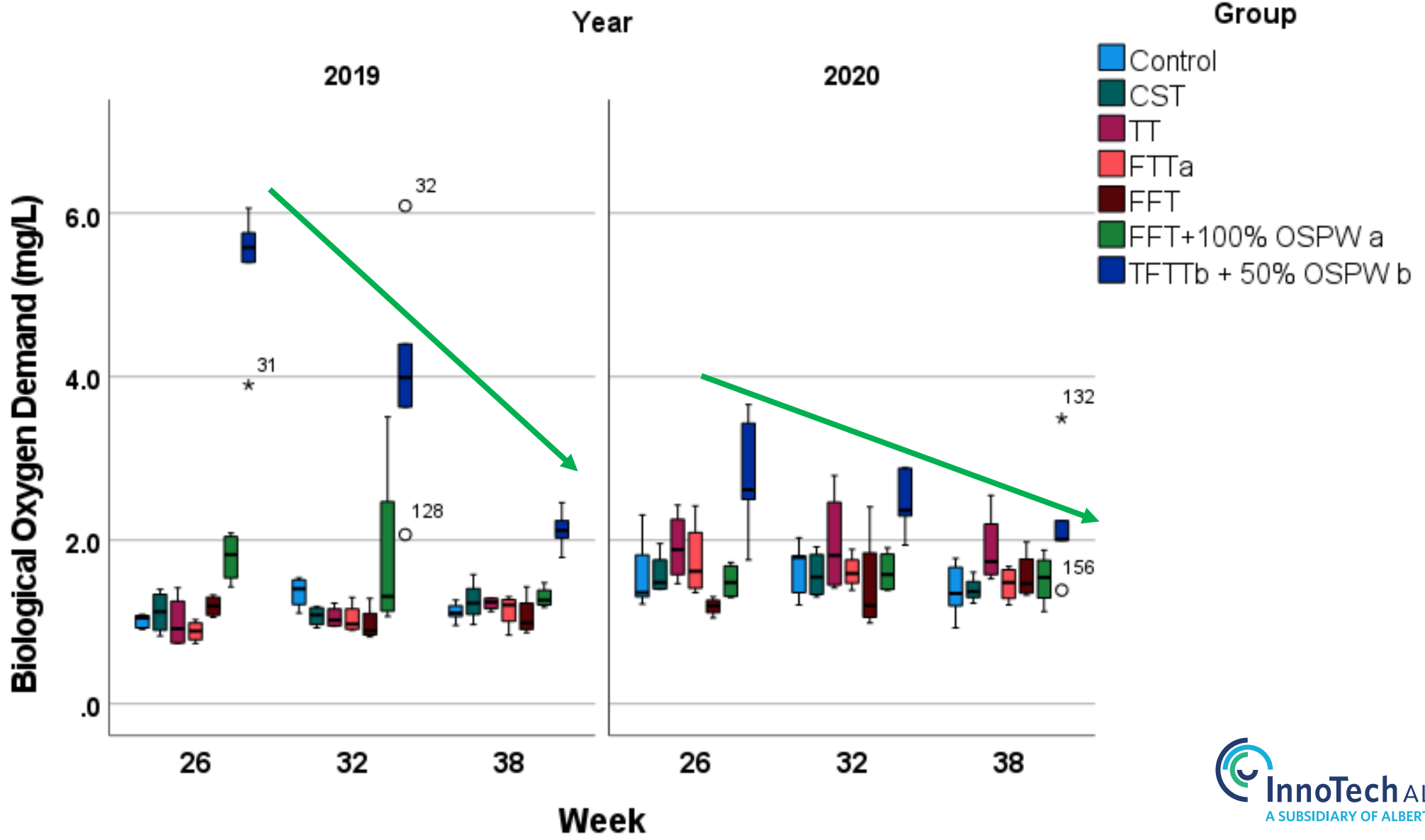




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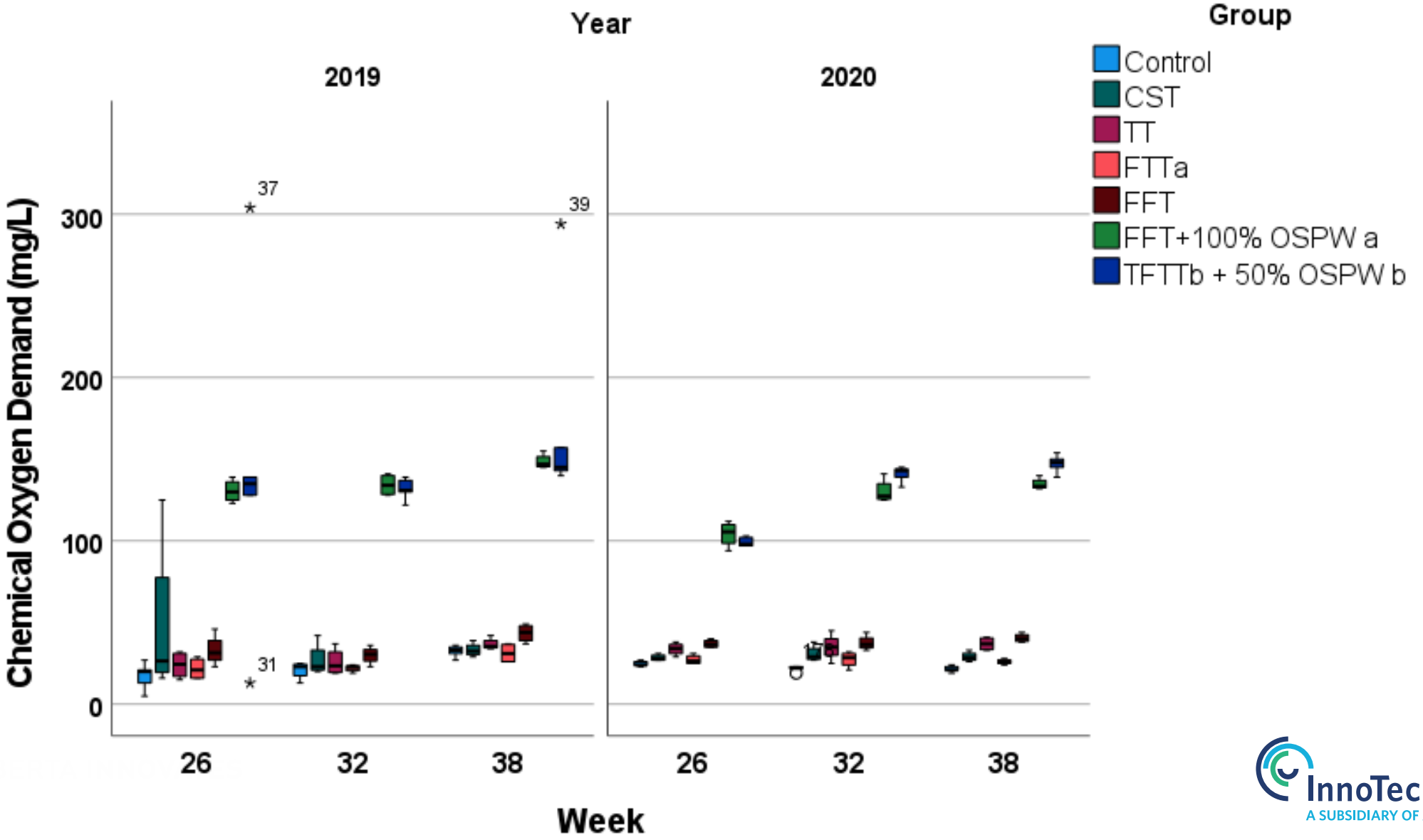




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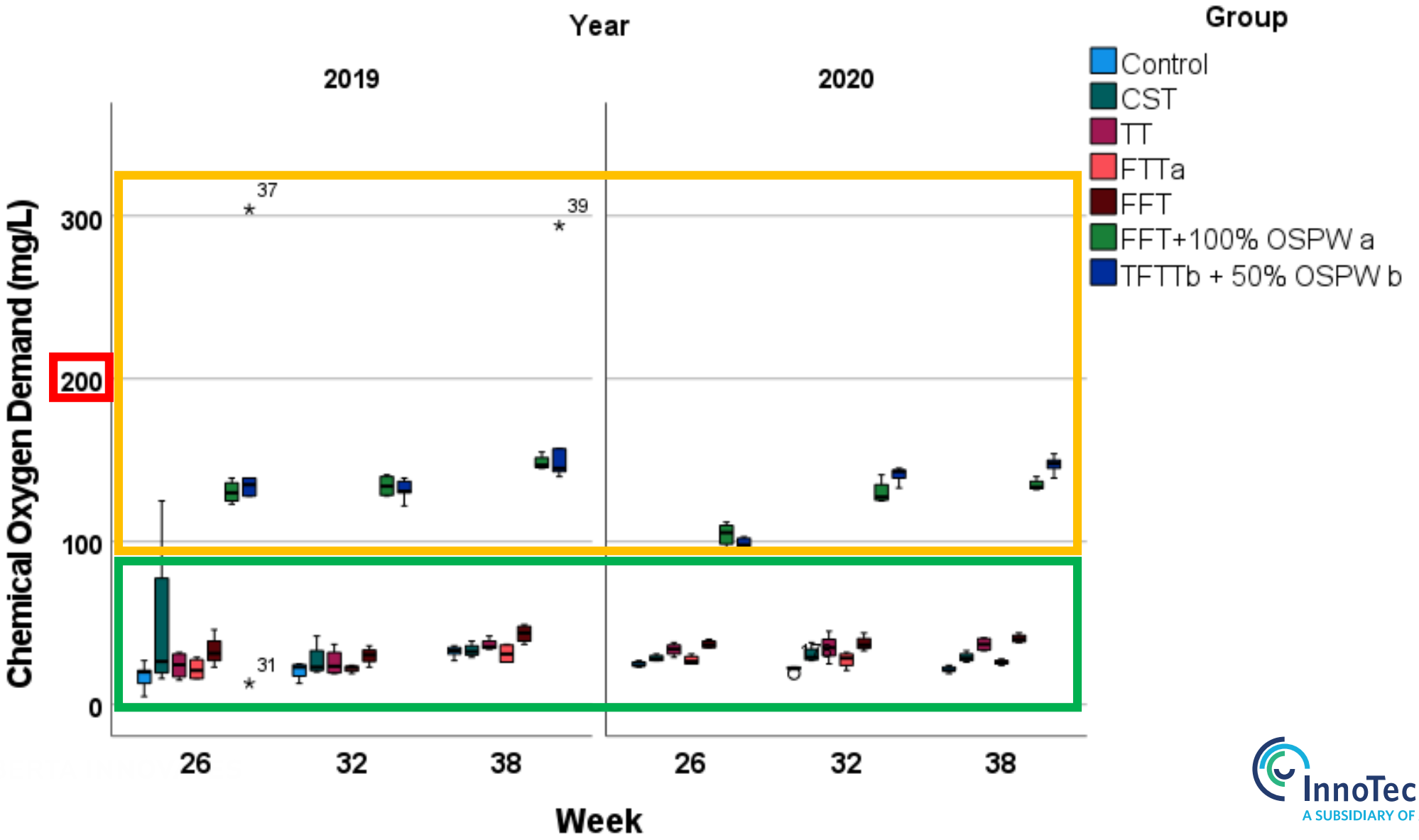




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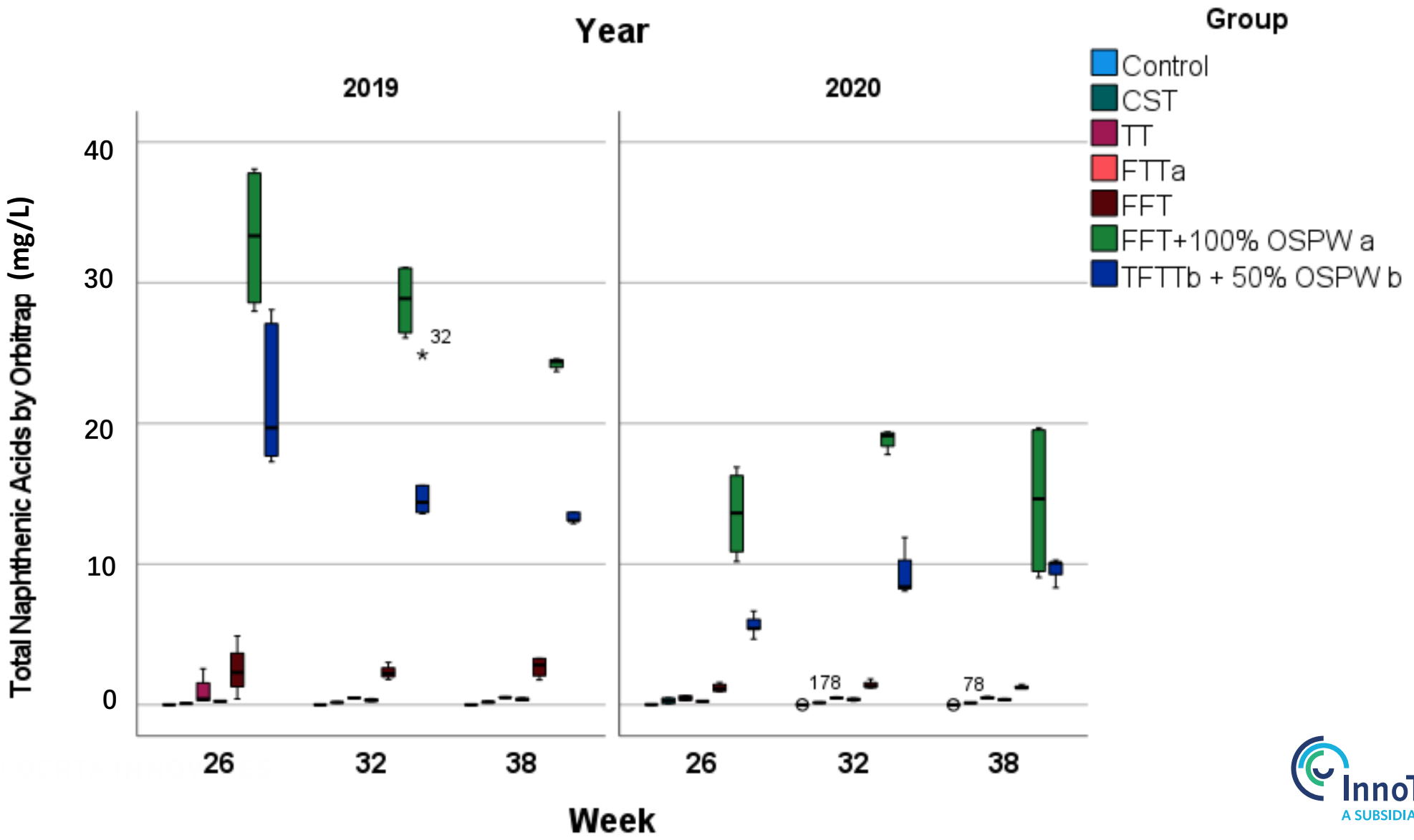




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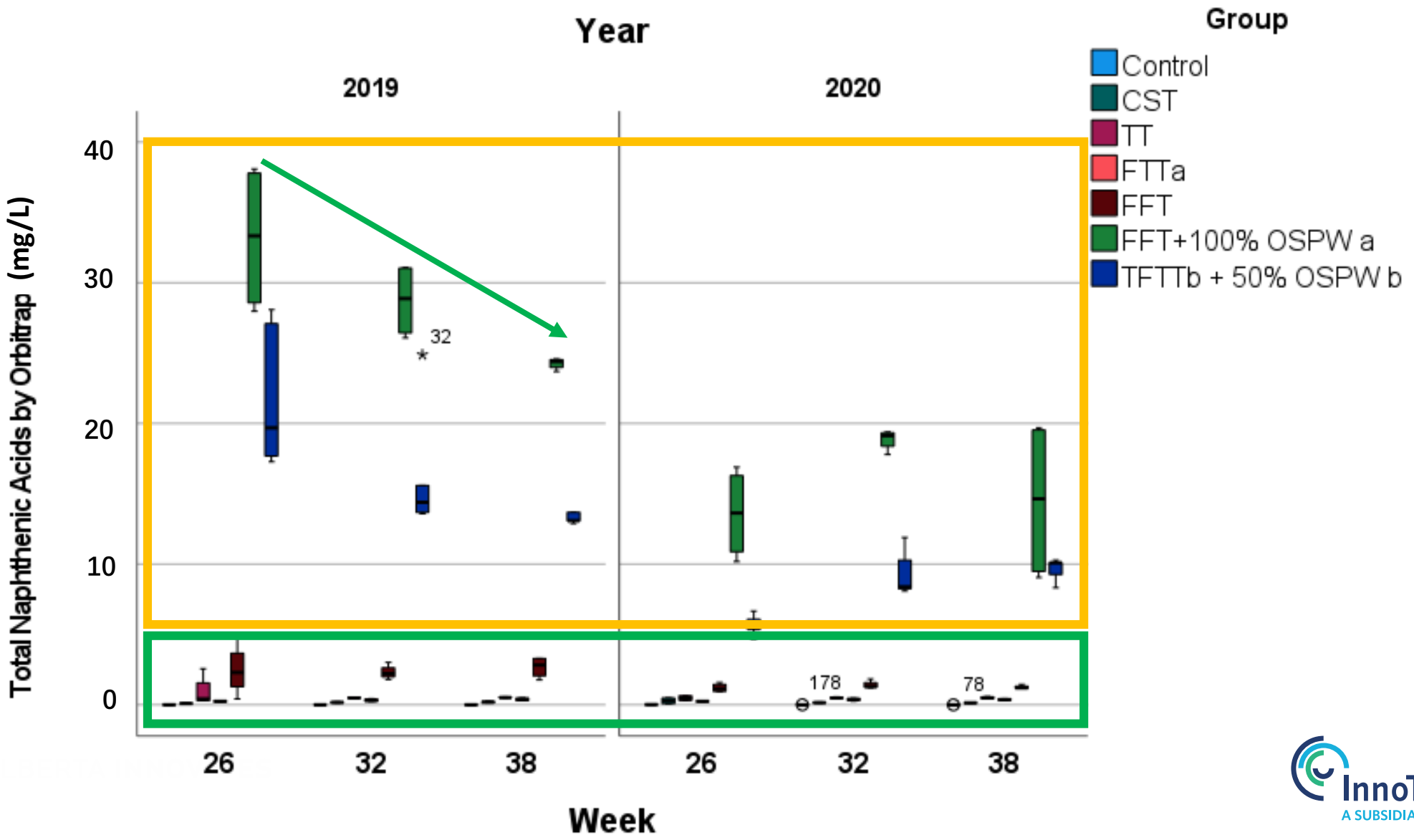




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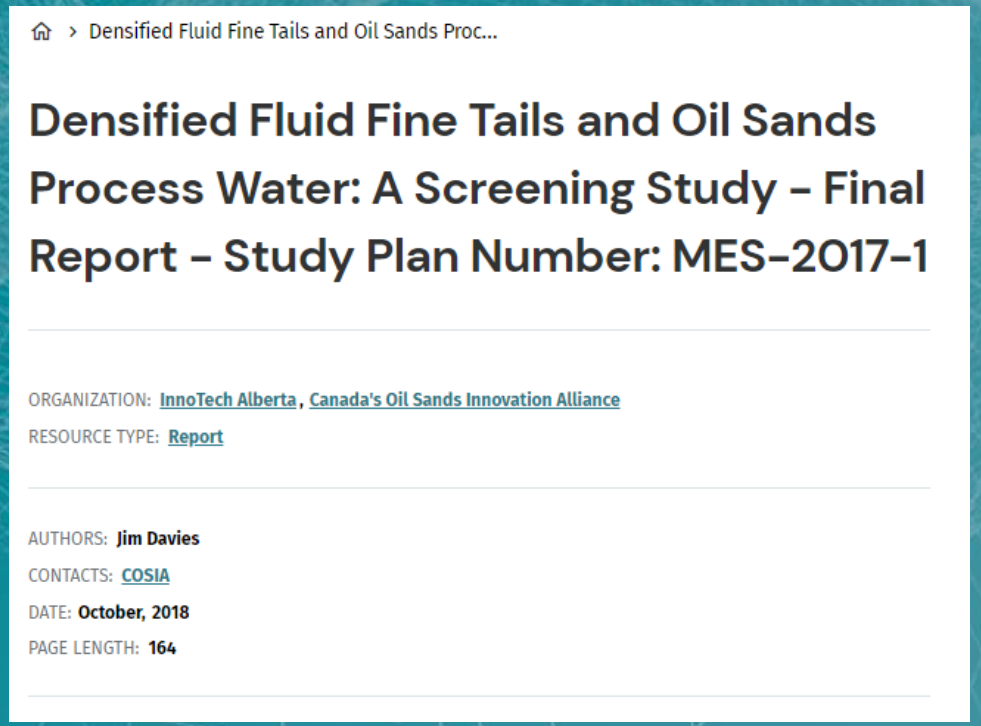
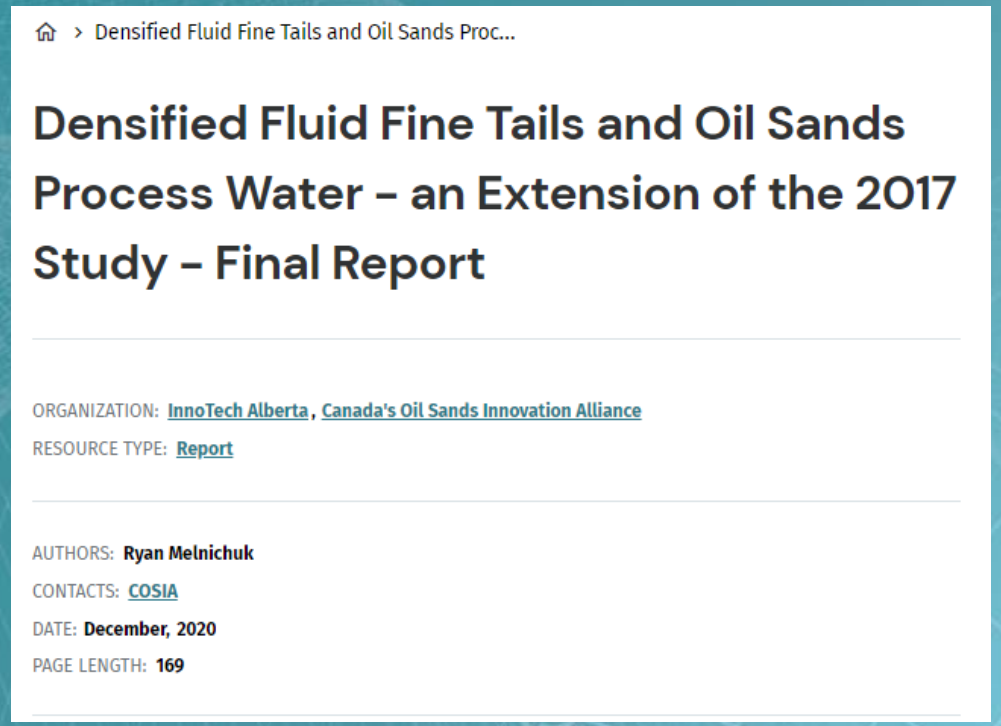
# Lessons learned and next (current) steps

- Not all tailings/OSPW are the same and not all plants respond to tailings or OSPW in the same manner
- Naphthenic acids decrease through time
- Multivariate analysis of all data collected to date (2017 to 2020)
- Potential for future studies with focused hypotheses that are informed by work to date

# Publicly available reports




https://www.cclmportal.ca/resource/densified-fluid-fine-tails-and-oil-sands-process-water-screening-study-final-report-study

https://www.cclmportal.ca/resource/densified-fluid-fine-tails-and-oil-sands-process-water-extension-2017-study-final-report

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# THANK YOU

for your attention and interest

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# Questions?