CHAIRE INDUSTRIELLE CRSNG EN EAU POTABLE

CHAIRE DE RECHERCHE DU CANADA EN PROTECTION DES SOURCES D'EAU POTABLE

POLYTECHNIQUE MONTRÉAL

Tracking the contribution of multiple treated wastewater and CSO discharges at drinking water intakes by online *E. coli* monitoring

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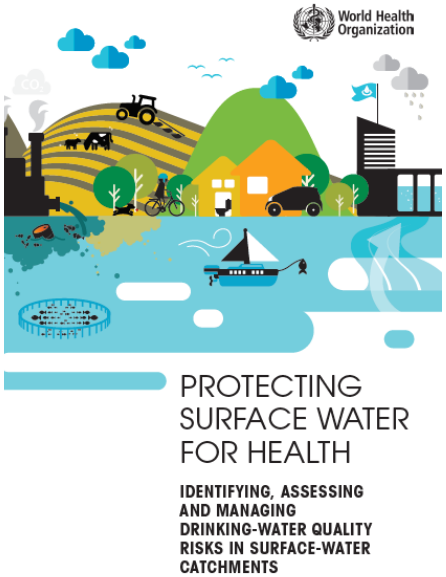
Protecting surface water for health

- **Drinking water supplies**
  - Surface water impacted by increasing anthropic pressures
  - Water safety plans - multi-barrier approach for safe drinking water supply
  - 1st barrier: selection and protection of drinking water sources

- **Monitoring of source water quality**
  - Low frequency, long sample-to-result time
  - Inappropriate for microbial hazard identification

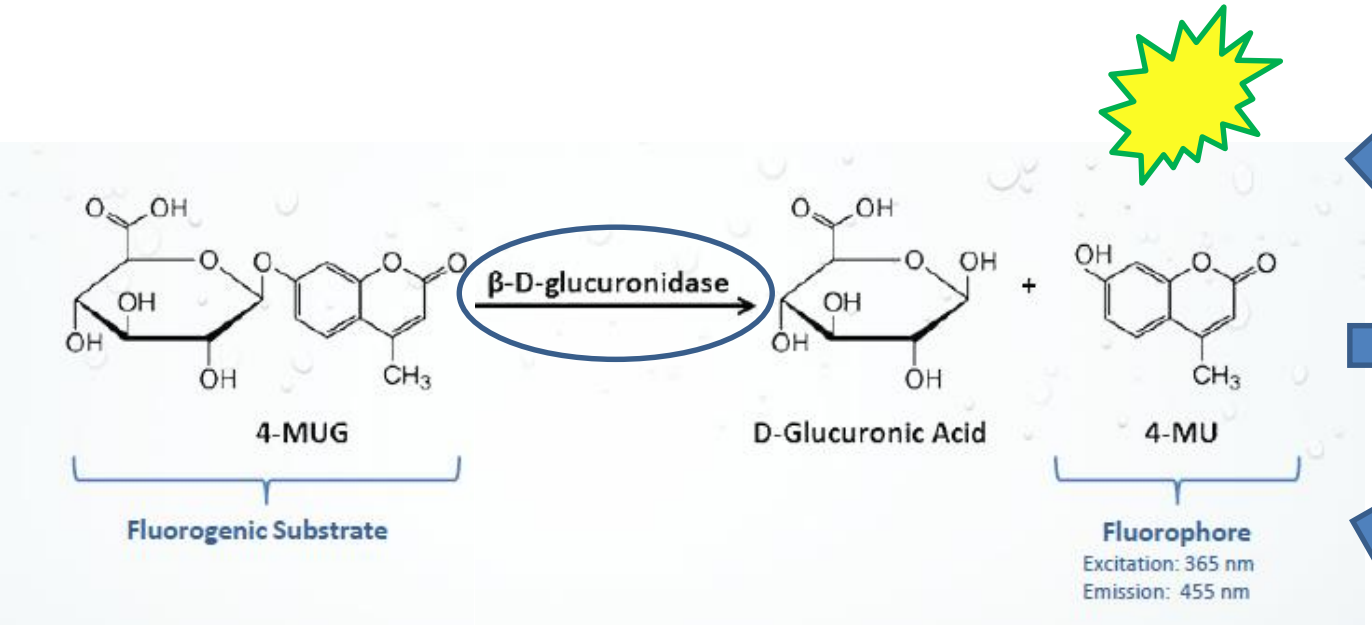
- **Need to better understand the source**
  - Online, rapid, accurate and user-friendly and methods
  - Guide for hazard identification, source appointment
  - Early warning tool for intermittent contamination events



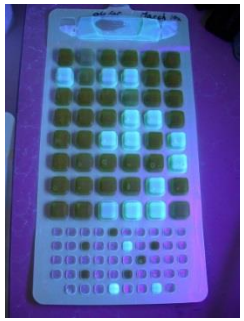
WHO, 2016

Escherichia coli monitoring 2.0

Measurement of β-D-glucuronidase (GLUC) activity



Koschelnik et al. 2015



Autonomous | **Online** | **Near real-time**

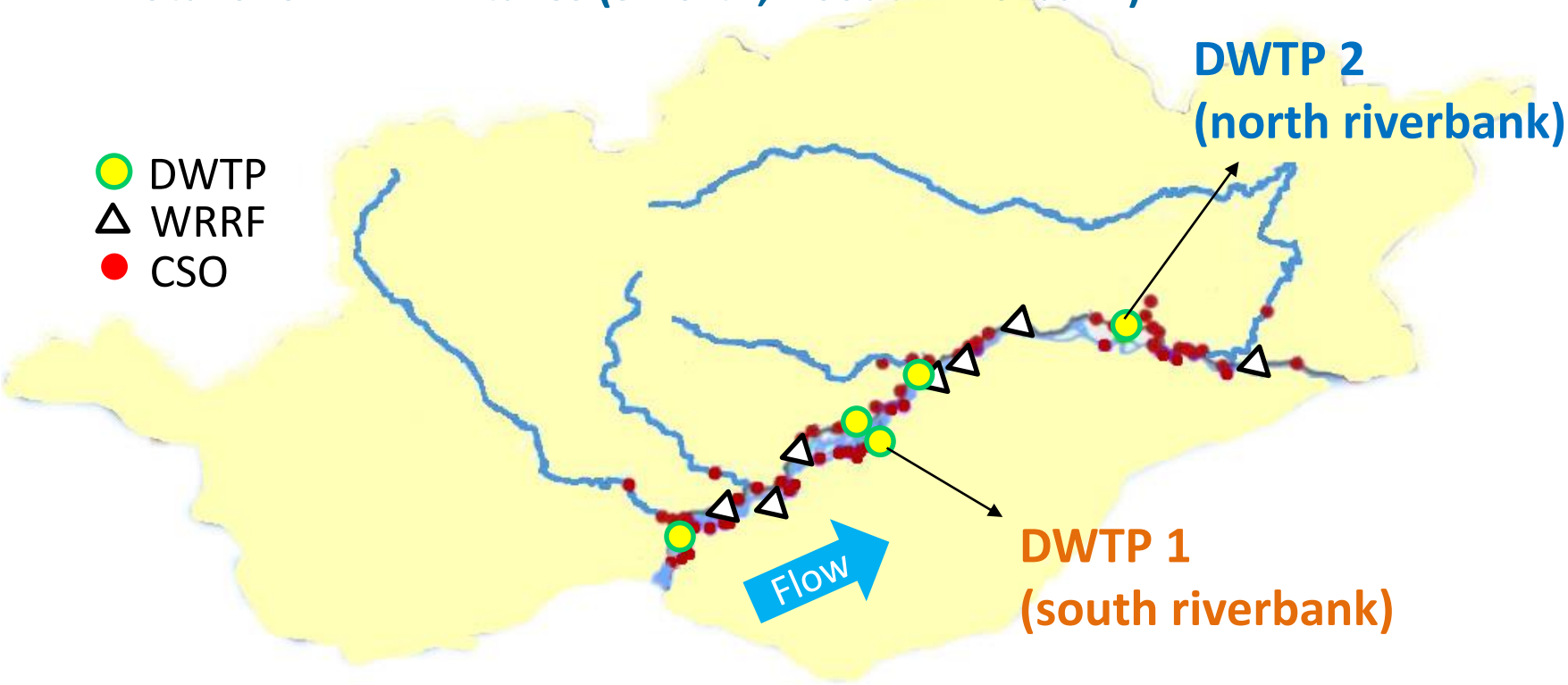
Objectives

- **Using near real-time monitoring of GLUC activity (*E. coli*)**
  1. **Characterize temporal scales of *E. coli* dynamics in an urban drinking water supply**
  2. **Identify periods of microbial challenge for drinking water intakes**
  3. **Investigate the cumulative impact of water resources recovery facilities (WRRF) and combined sewer overflows (CSO) on the faecal pollution burden at urban drinking water intakes**

Methodology

Catchment characteristics

- **Urban river in the Greater Montreal Area**
  - **Highly impacted by (un)treated wastewater discharges**
  - **Total of 7 WWRF and >150 CSO discharge points**
  - **Total of 5 DWTP intakes (3 north, 2 south riverbank)**



Methodology

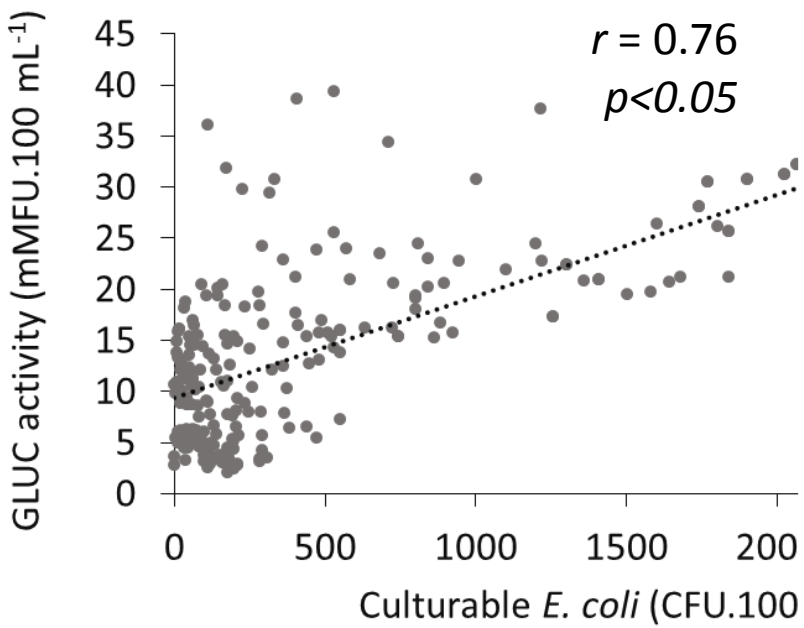
Data acquisition

- **Autonomous near-real time measurement of GLUC activity**
  - **Min. 12 - max. 24 measurements per day**
  - **GLUC activity expressed in mMFU.100 mL^{-1}**
- **Intensive sampling at DWTP intake after rainfall and/or snowmelt**
  - **DWTP 1: February and April 2017**
  - **DWTP 2: March 2018**
  - **Analyses**
    - **Enumeration of culturable *E. coli* (MI agar and Colilert)**
    - **Quantification of protozoan parasites (USEPA method 1623.1)**
    - **Quantification of enteric viruses (qPCR)**
    - **Quantification of wastewater micropollutants**
- **Data collection on catchment characteristics and on local hydrometeorology**

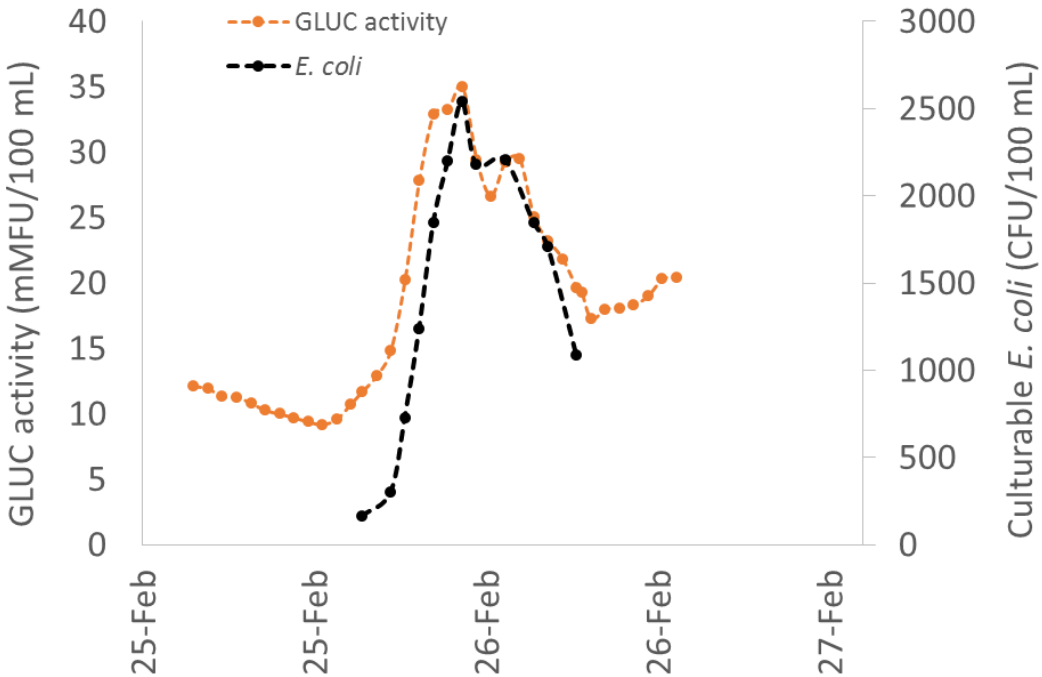
GLUC activity

How does it correlate with E. coli?

>1.5 year monitoring data
(n = 249)

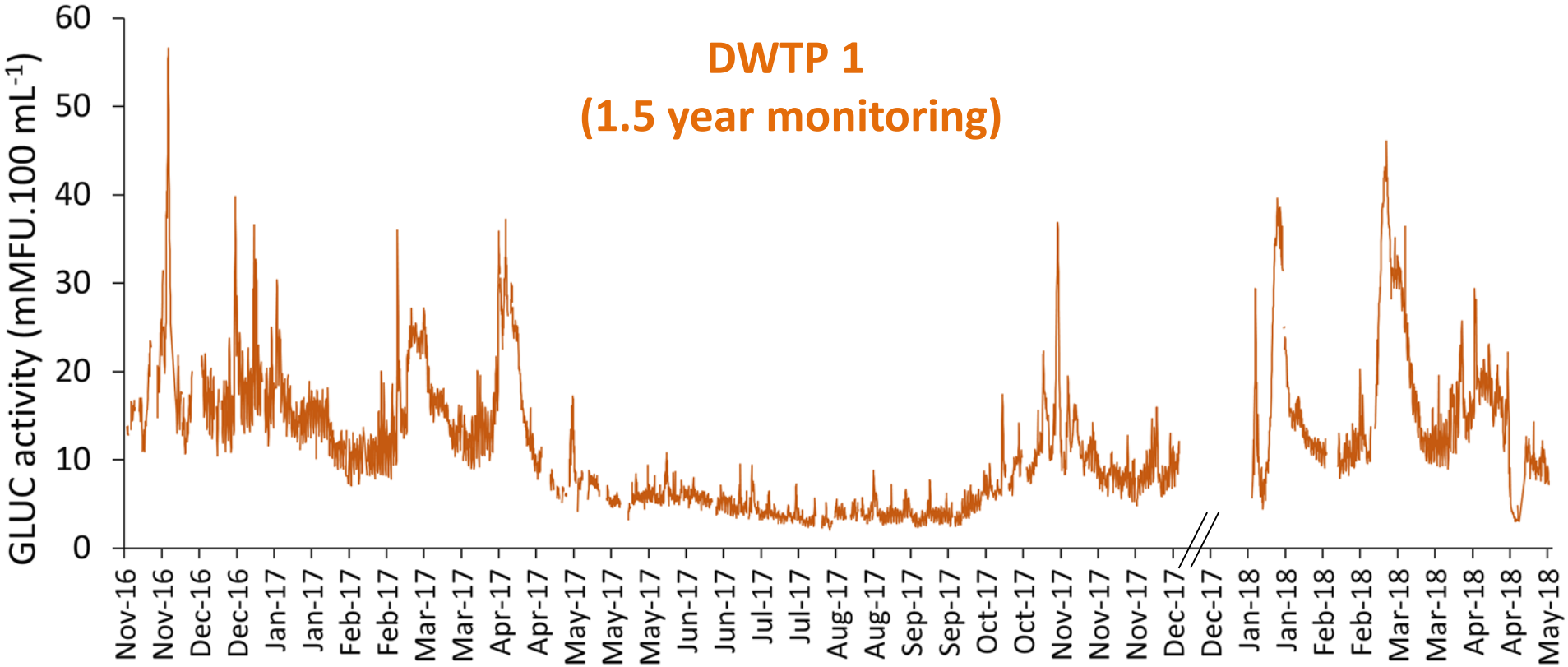


Peak pollution event
(25-26 Feb 2017)



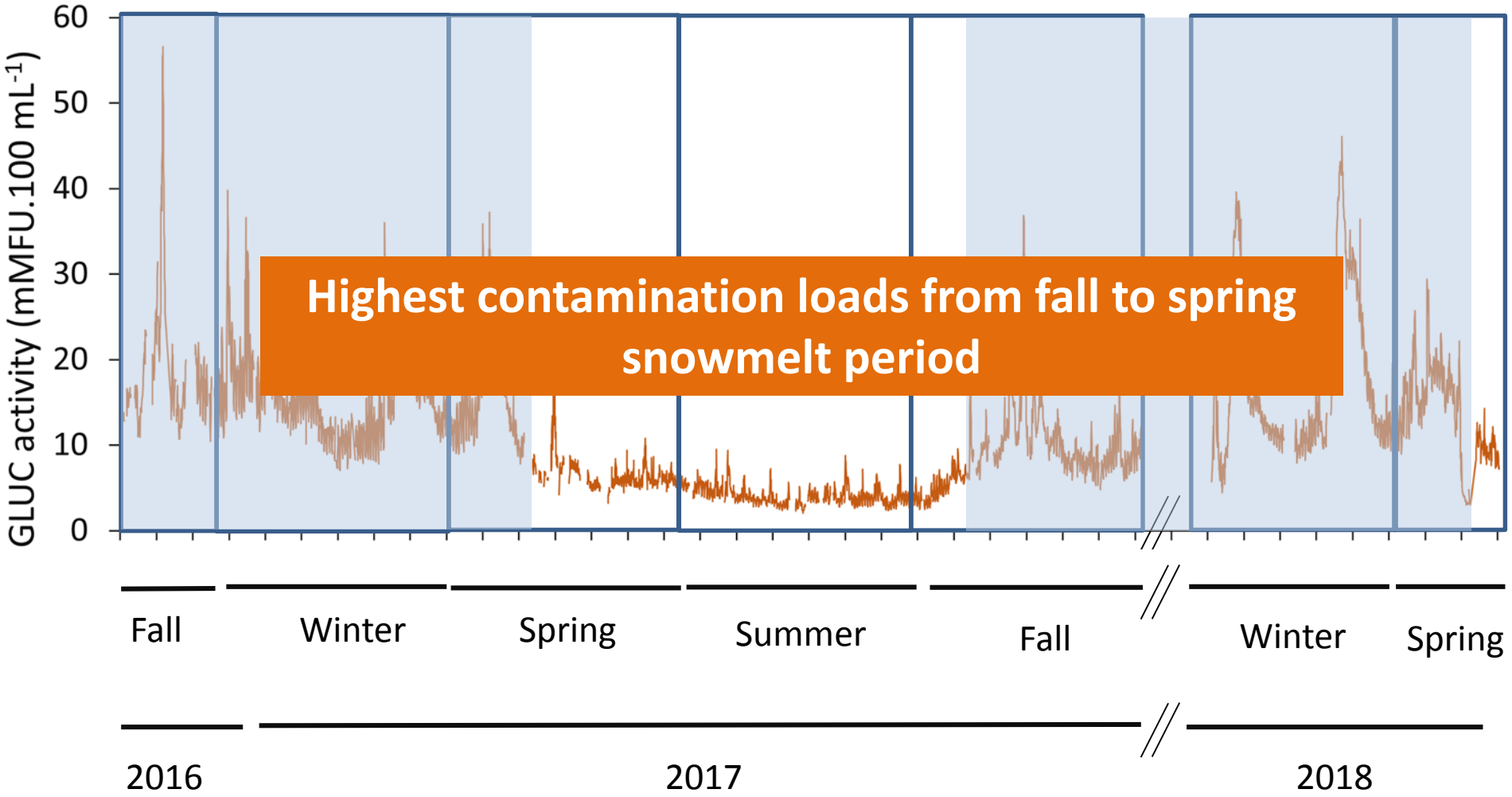
GLUC activity monitoring (1.5 year)

Temporal scales of variation



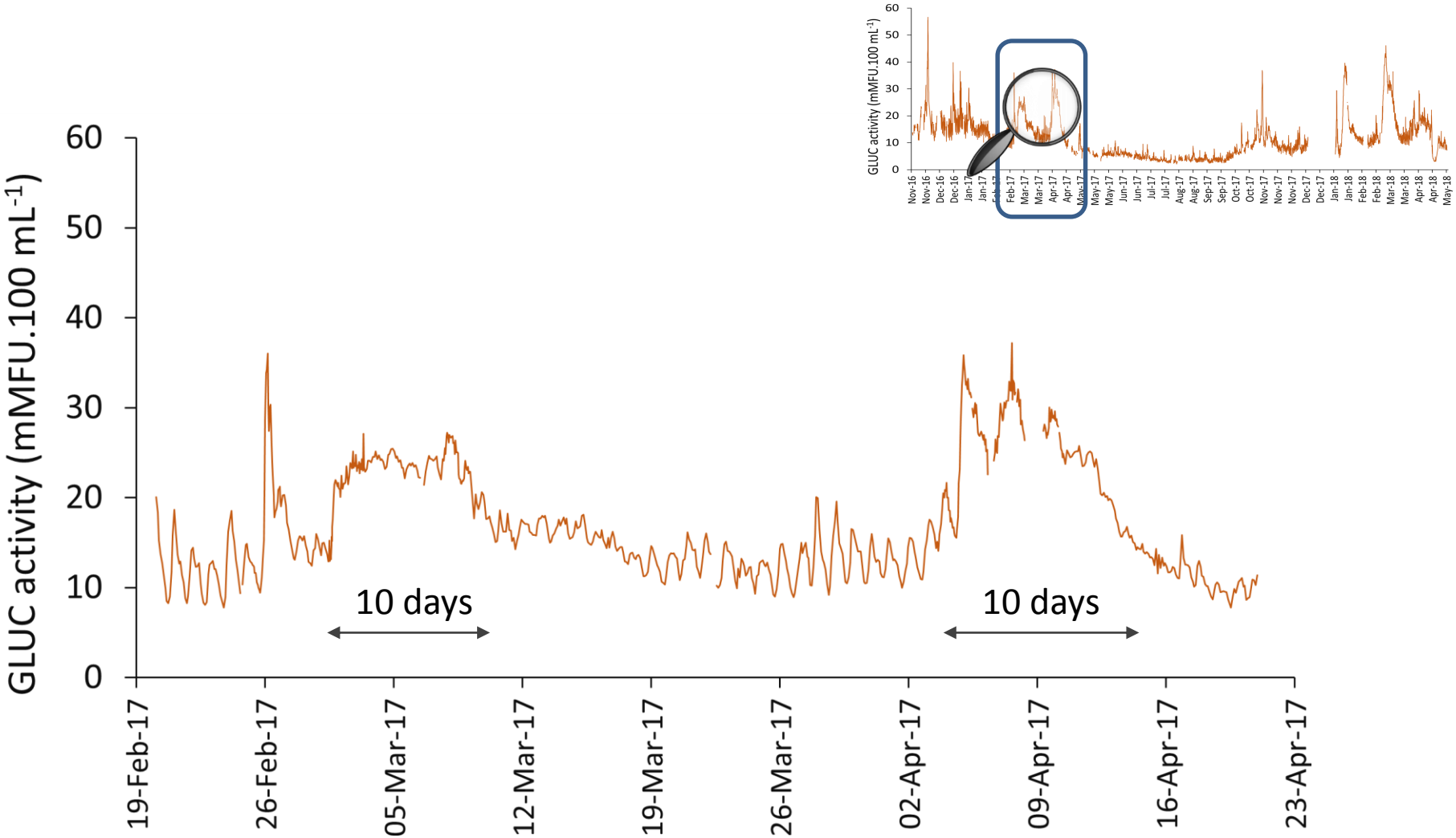
Temporal scales of variation

1 - Seasons



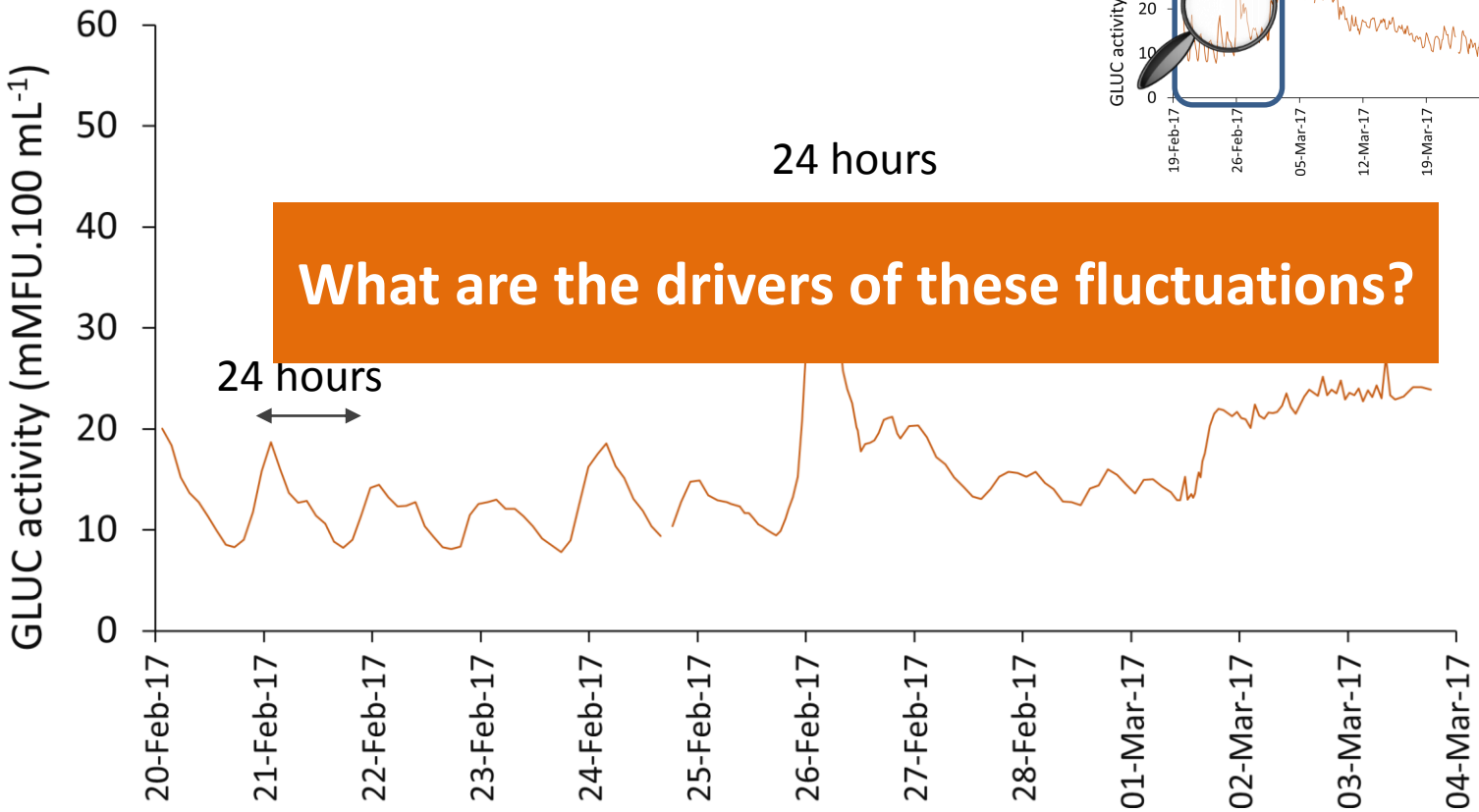
Temporal scales of variation

2 – Days

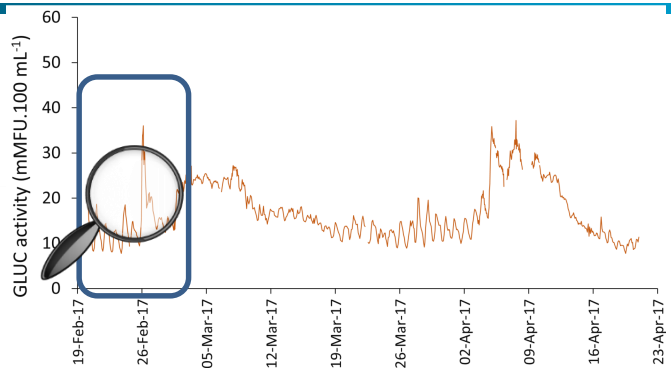


Temporal scales of variation

3 – Hours

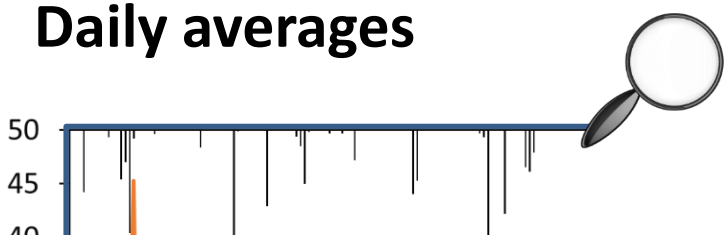


What are the drivers of these fluctuations?



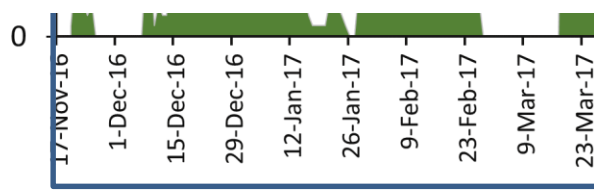
Drivers of GLUC activity temporal dynamics
Rainfall and snowmelt

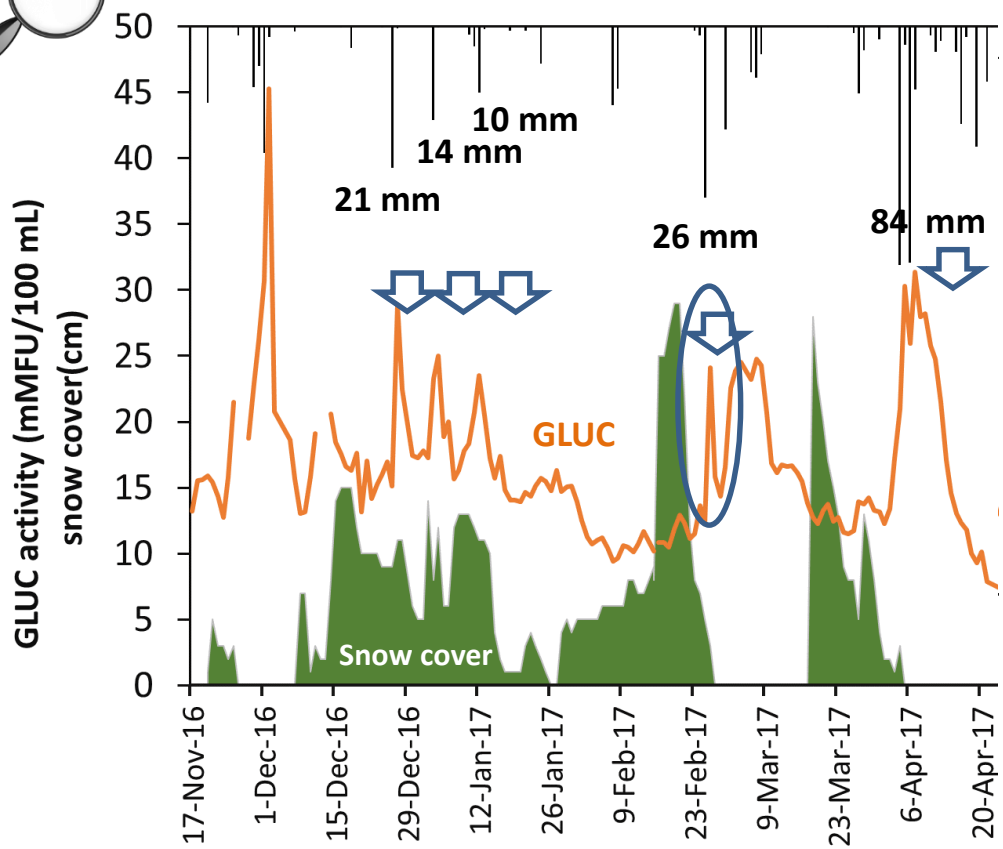
- **Daily averages**



Local snowmelt + rainfall

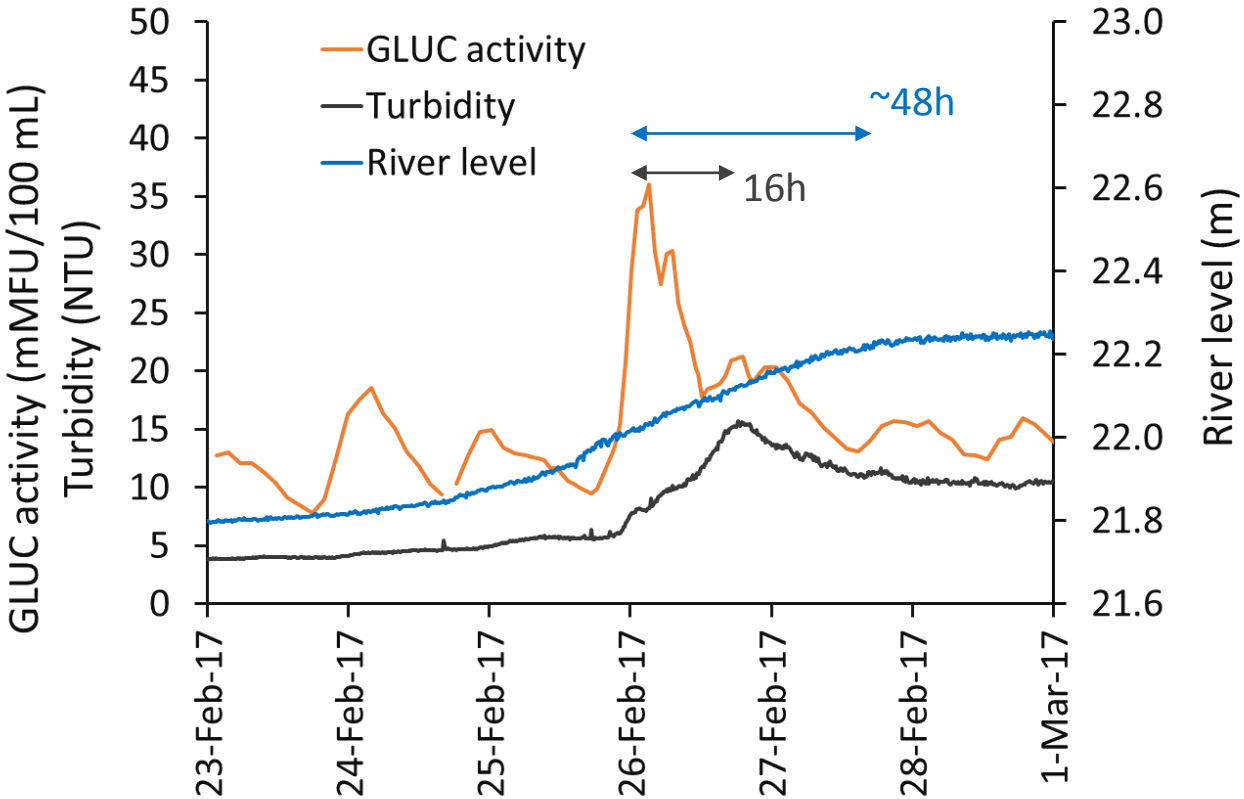
Contamination peaks





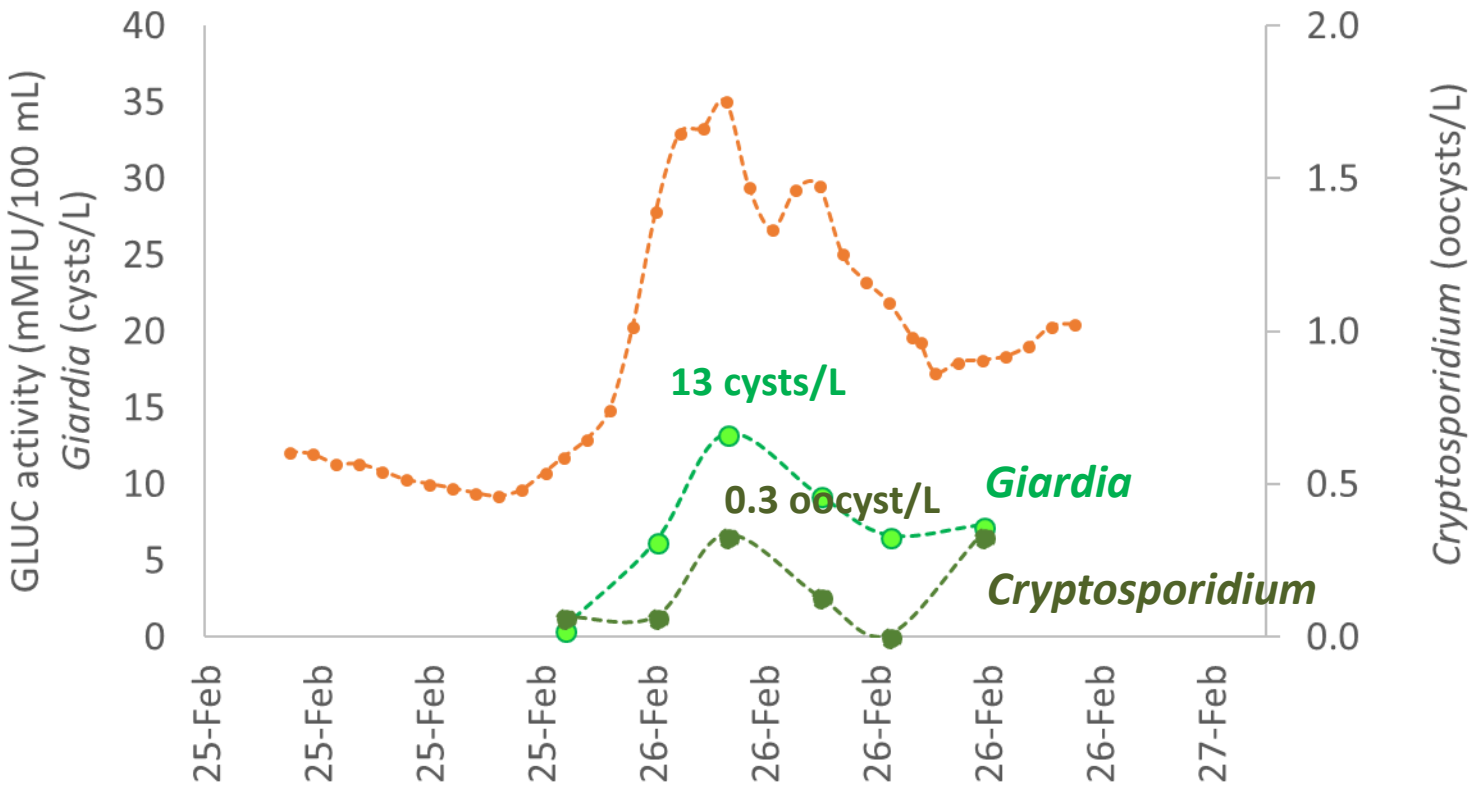
Intermittent contamination peaks
Impact of local point pollution sources

- **Microbial peak concentrations occur before turbidity and hydrologic peaks → strongly suggests impact of local sewage by-passes or CSOs**



Intermittent contamination peaks
Impact of local point pollution sources

- **Temporal dynamics of *E. coli* and pathogen concentrations at the intake**

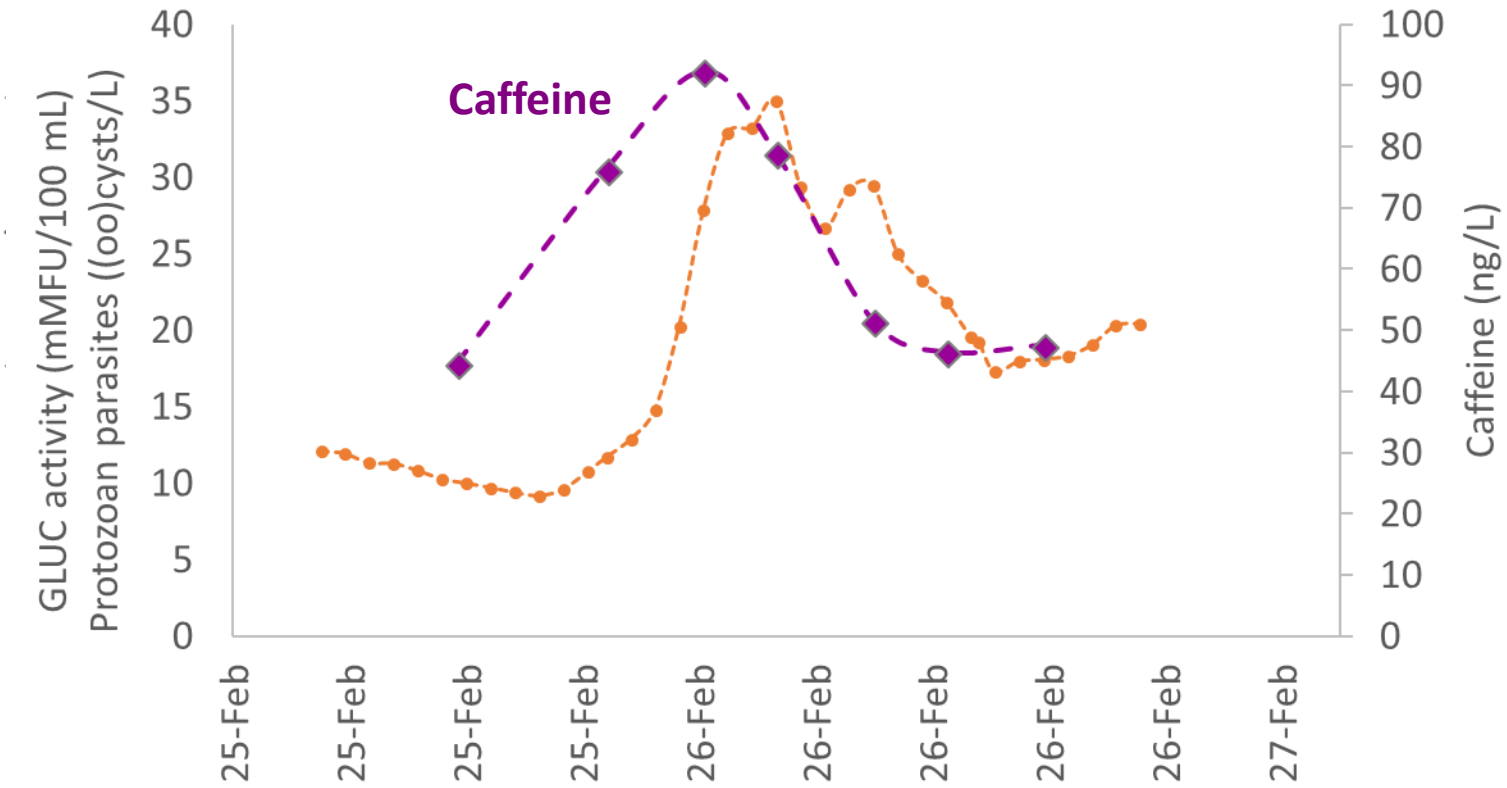


Pathogens follow the same dynamics as GLUC activity and *E. coli* during peak contamination event

Intermittent contamination peaks

Impact of local point pollution sources

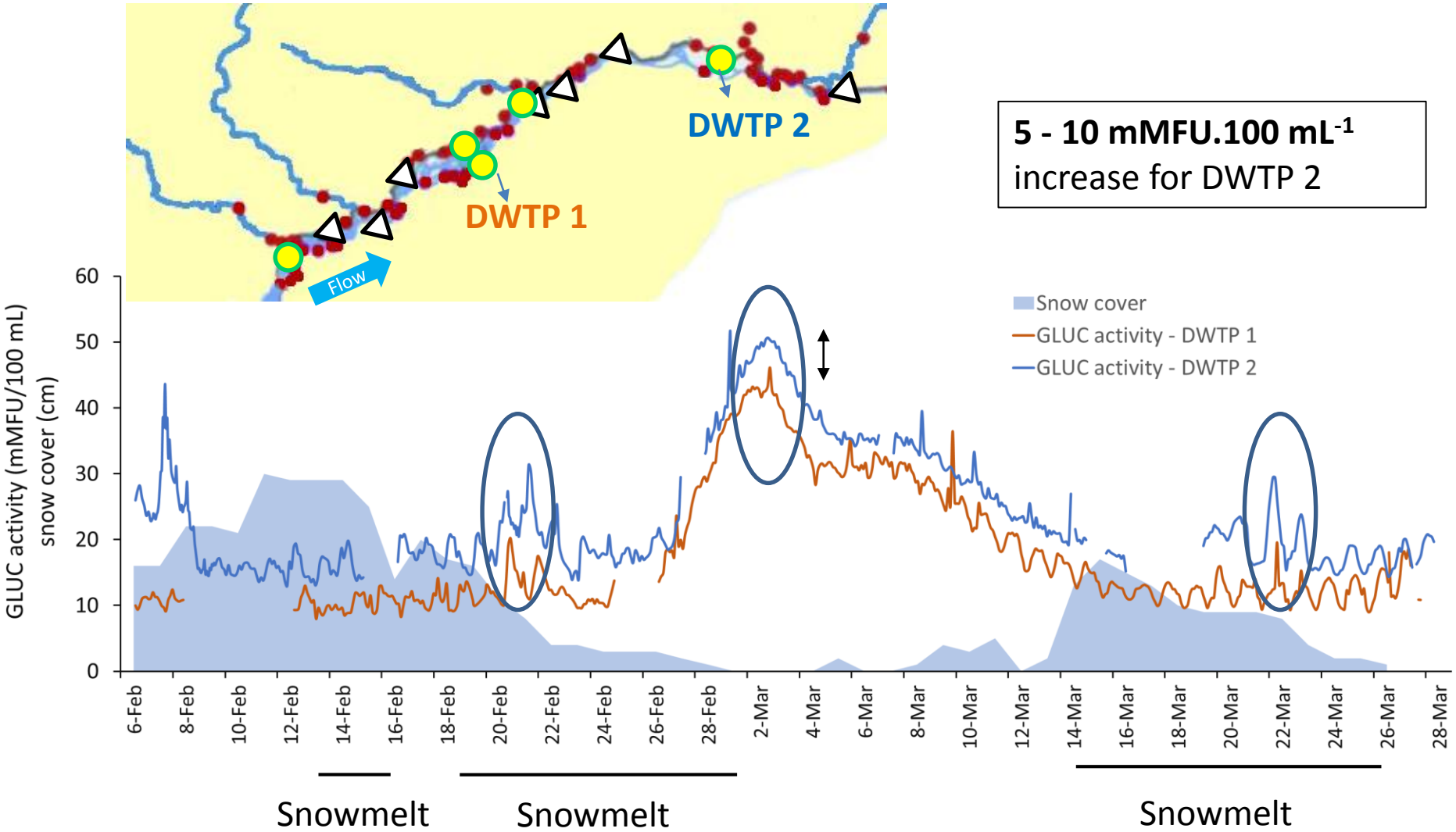
- **Temporal dynamics of WWMPs concentrations at the intake**



Caffeine also follows similar dynamics as during peak contamination event

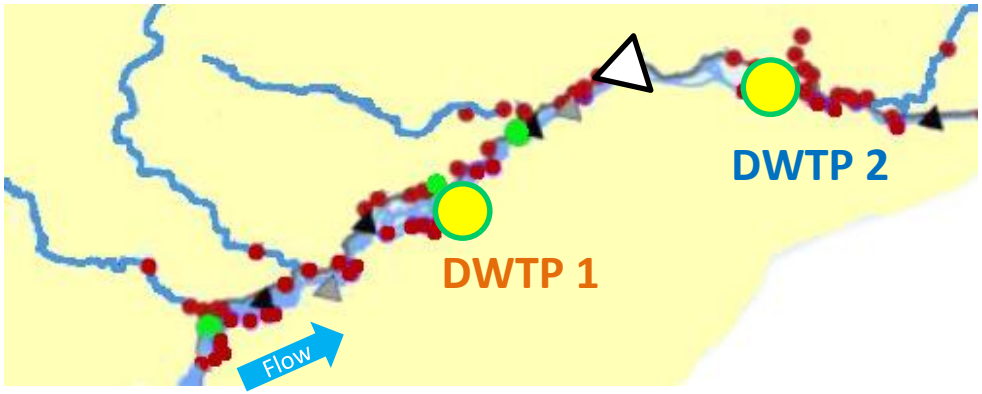
Cumulative impact of WWRF & CSO discharges

Increase in GLUC activity at downstream DWTP 2



Cumulative impact of WWRF & CSO discharges

Increase in GLUC activity at downstream DWTP 2



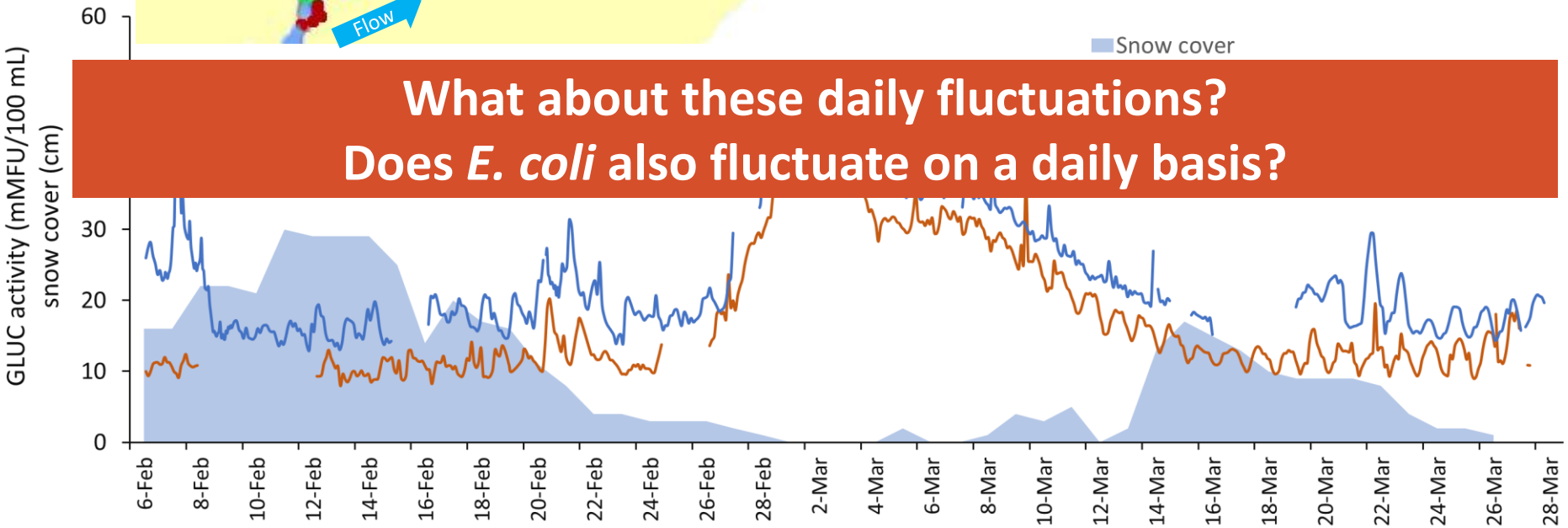
February 7, 2018

Planned WWRF sewage by-pass

→ GLUC activity peak at DWTP 2

What about these daily fluctuations?

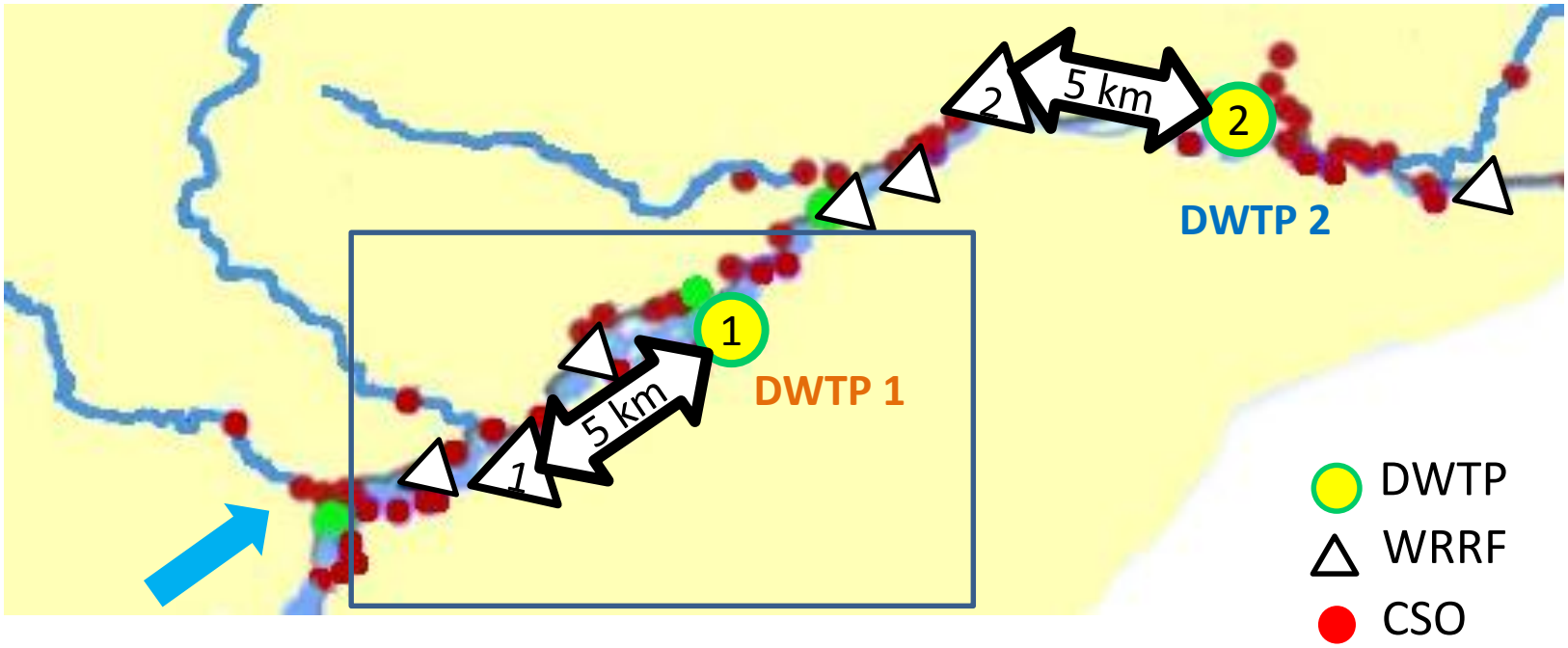
Does *E. coli* also fluctuate on a daily basis?



Recurring daily GLUC activity fluctuations

Impact of upstream treated effluent discharges?

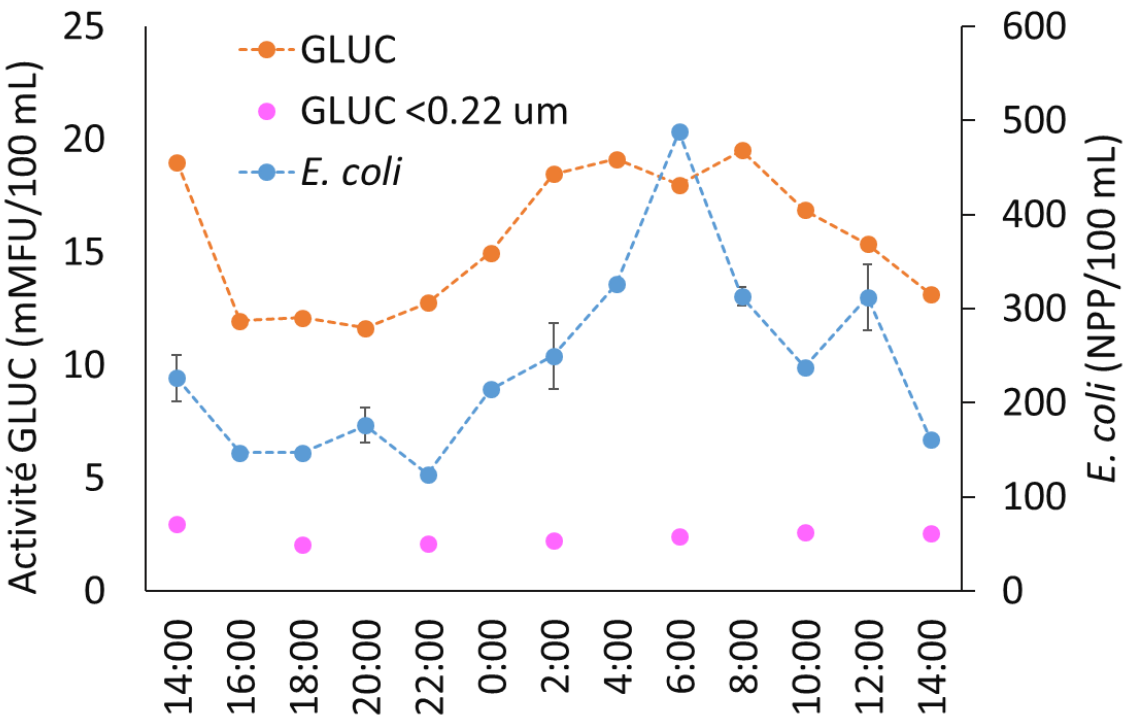
- **5 km between closest (same riverbank) WRRF effluent discharge and respective DWTP**
- **Mixing in the river unlikely to occur within this distance**
- **But: no hydrodynamic model of the river currently available**



Daily GLUC activity fluctuations

What about E. coli *concentrations?*

- **Intensive sampling during 24 hours at DWTP 1**
  - **Enumeration of culturable *E. coli* by Colilert Quanti-Tray/2000**
  - **GLUC activity in raw *vs* soluble (<0.22 µm) water fraction**



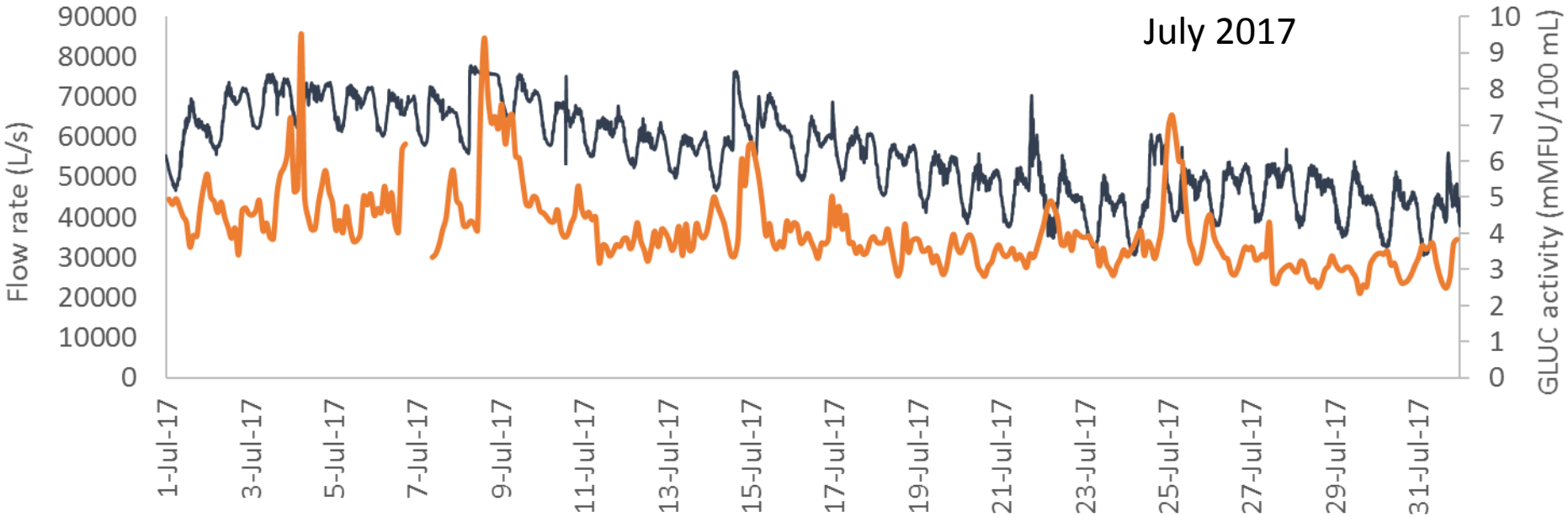
***E. coli* and GLUC activity follow same daily pattern**

GLUC activity in "soluble fraction" = 12 to 19% of total GLUC activity (<u>constant</u>)

Impact of upstream discharge of treated effluents

- **Time series analysis for cross-correlations between**
  - **Flow rate at WWRF inlet (raw sewage)**
  - **GLUC activity at downstream DWTP 1 intake**

Lag time = 8.5h



Flow rate raw sewage **GLUC activity**

Conclusions

- GLUC activity fluctuates from months to hours in drinking water supplies
- Rainfall and snowmelt are the main triggers of intermittent contamination peaks → fall and winter = critical periods
- Our findings show that:
  - GLUC dynamics follow *E. coli*, pathogen and WWMP dynamics
  - Fecal contaminant peak not synchronous with turbidity or flow rate peak

  → impact of local CSOs and/or sewage by-passes

  - Cumulative impact of CSO and treated effluent discharges
  - Daily fluctuations in GLUC activity/*E. coli* reflects signature of treated effluent discharges
- Online near-real time monitoring = useful tool to better "know your catchment" and identify microbial hazards and their sources
- Guide for pollution source remediation actions

Acknowledgments

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- Participating municipalities and plant staff
- VWM Solutions GmBH

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