Service Reservoir Performance Ranking for Proactive Asset Maintenance

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Introduction

- Service reservoirs (SRs) are a critical component of Drinking Water Distribution Systems (DWDS) and are known to contribute to the degradation of drinking water quality from treatment to tap. However, little is known about the maintenance requirements of these important infrastructures. Currently SR maintenance is performed following purely time-based schedules, meaning that failures can run for long periods of time prior to intervention or that operations can be carried out when unnecessary.
- There are many different challenges and obstacles preventing water companies moving toward a proactive maintenance of SRs. The focus of this research project is on the following aspects:
  ▸ Understand how to make the best use of existing data to inform **proactive SR maintenance**,
  ▸ Integrate this knowledge into a framework that allows SR ranking to inform **operational decision-making**.

1. Service Reservoir Ranking

- To ensure that water entering the DWDS is safe and compliant to standards, water quality at service reservoirs is monitored by **regulatory sampling** at the outlet of SRs. The monitored parameters include:
  › Temperature,
  › 3-day CFU,
  › Free and total chlorine,
  › Total and confirmed E.coli.
- There is an opportunity to try and use regulatory water quality data to help inform the performance of SRs, mining the data for more useful information than retrospective analysis of rare bacteriological failures.
- **Flow cytometry** (FC) is gaining interest in the water sector and has been applied to some service reservoir sites. This provides an additional potential source of valuable information to mine from the data.
- Five existing UK-based datasets collected at different SR sites from the same network have been processed. Ordering the CFU averages and total/intact cell count percentiles has allowed to rank SRs, providing new useful insights on **water quality and SR performance.**
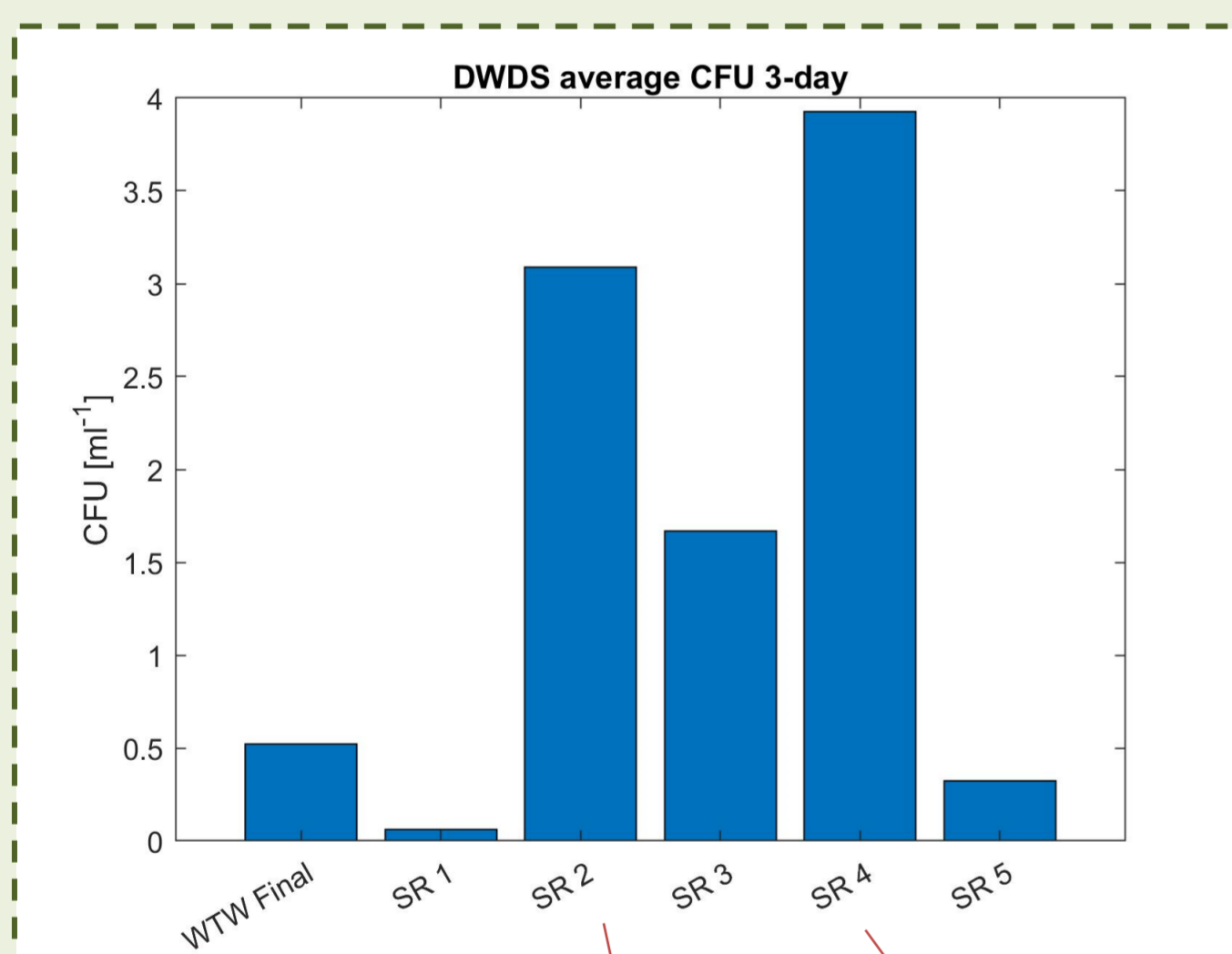

Figure 1 – *Average heterotrophic plate counts from regulatory sampling at the outlet of five service reservoirs sites and the final effluent from a WTW (2015-2020).*
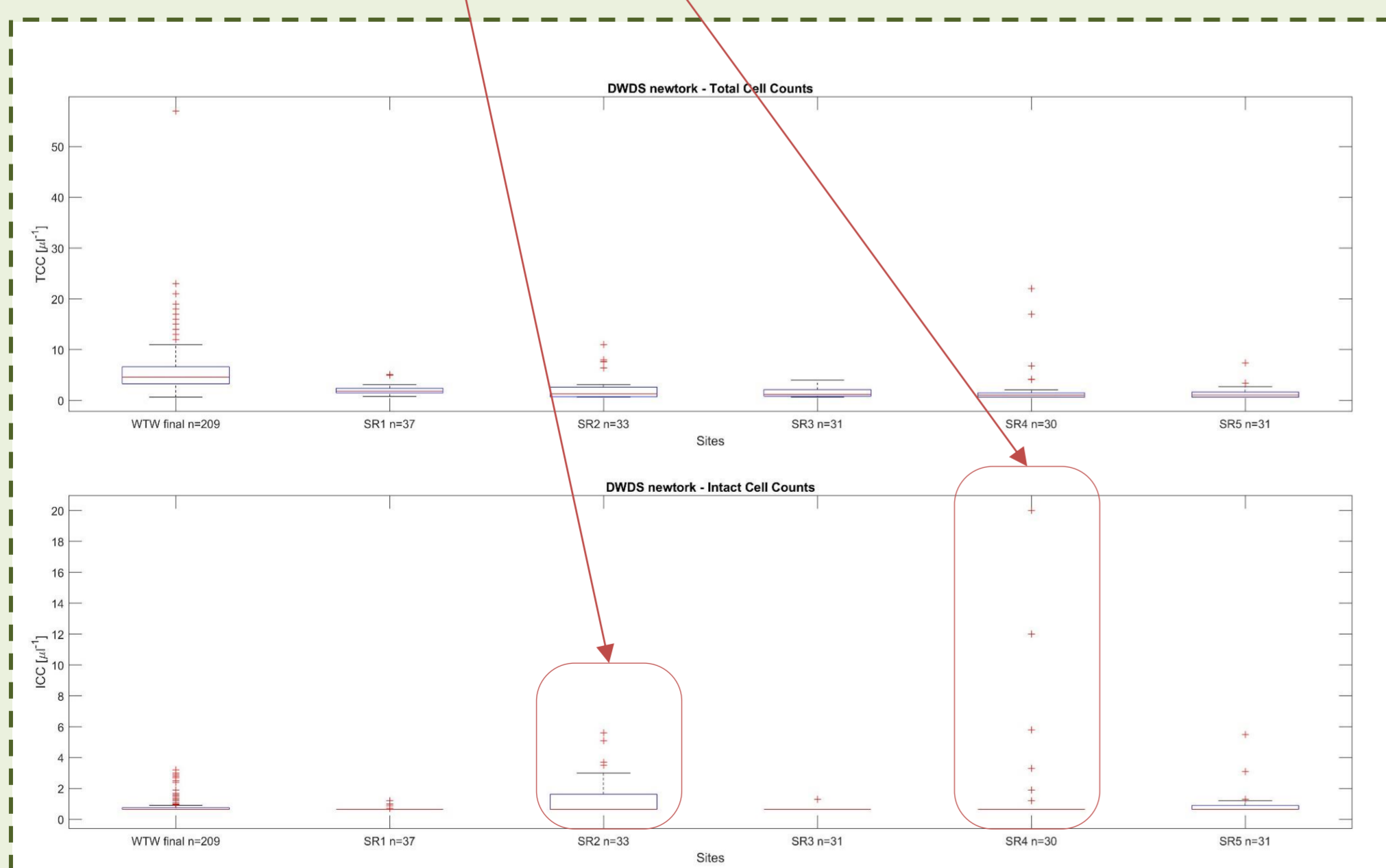

Figure 2 – *Box-plots of FC analysis performed on samples collected at the outlet of selected sites (2015-2020) show that sites with higher CFU values also have higher intact cell counts.*

2. Hydraulic Performance Assessment

- Water utilities currently evaluate only the daily and weekly average volumes inside SRs, however there are many opportunities to use existing **real-time hydraulic data** for other purposes.
- To evaluate water tightness and water age within SRs, time series analysis of hydraulic parameters (flow and levels) was performed, solving the continuity equation in differential form to calculate **mass balances**.
- Daily residence times were also calculated, and a threshold of 48 h was applied to highlight when **increased water age** constitutes a possible risk to both chemical and microbial water quality.
- The water quality and hydraulic information can consequently be combined for SR ranking to inform **maintenance needs and operational decisions**.
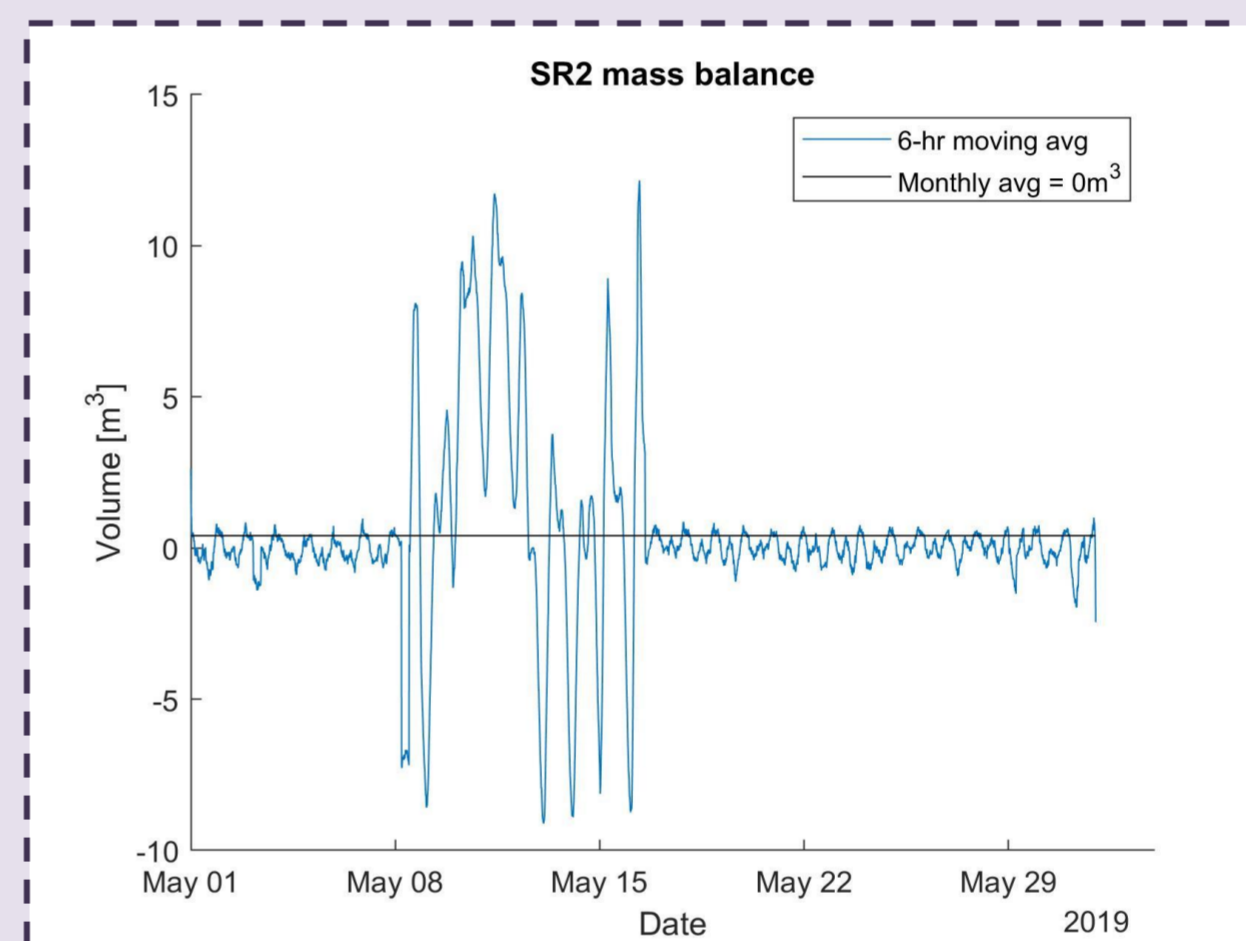

Figure 3 – *Mass balance performed on site SR2. The plot shows oscillations of the variation in volume around the average value of zero, with a sudden change in the in the second week of May 2019.*
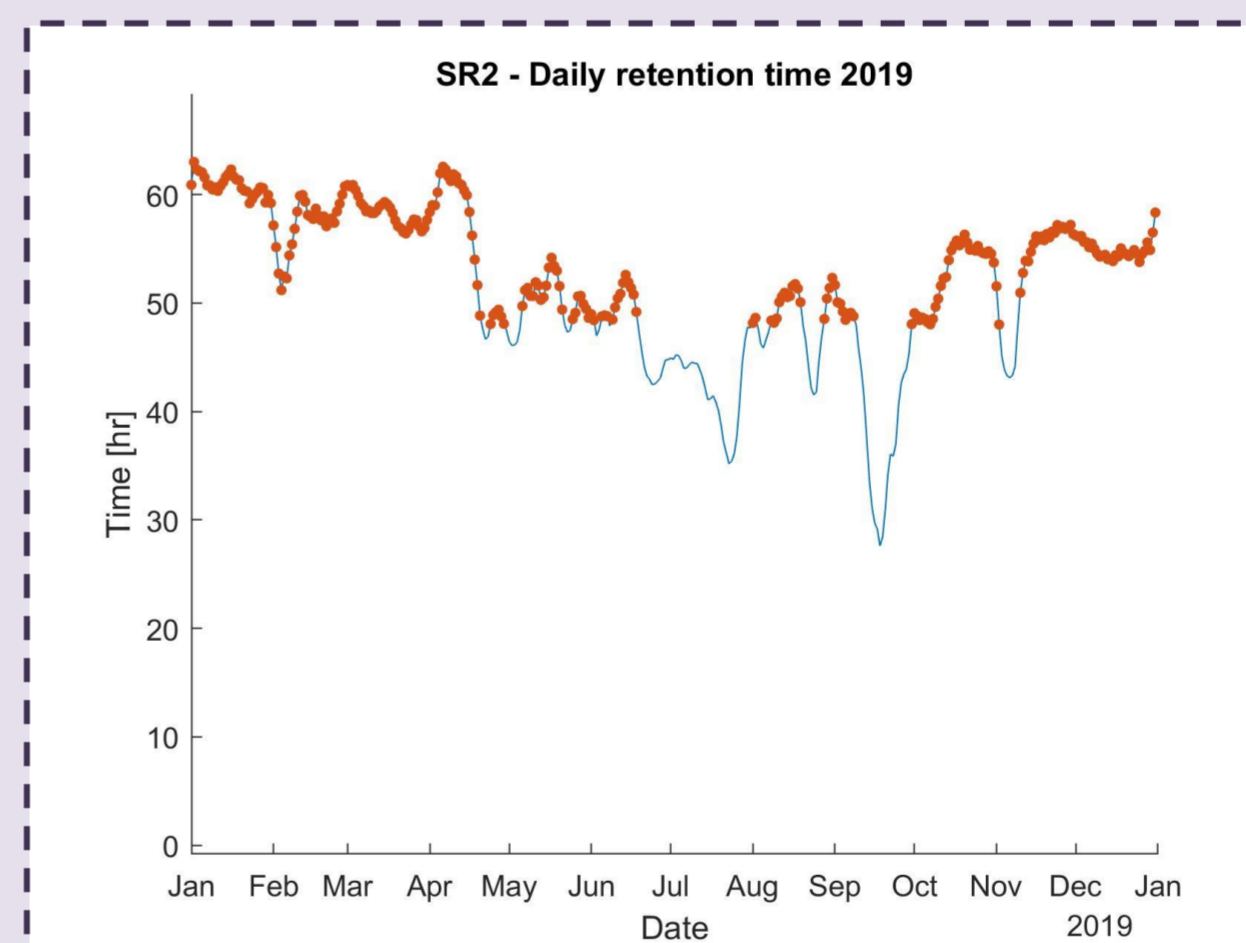

Figure 4 – *Daily retention times calculated for service reservoir site SR2, highlighting data points with T>48 h. The time series shows that SR2, which presented high CFU and intact cell counts, has elevated retention times for long periods of time throughout the year 2019.*

Summary and Future Work

▸ Uniting regulatory sample analysis and flow cytometry data provides new insights on **SR water quality**.
▸ A new approach to mass balances can identify irregular volume variations within the SRs which suggest **operational problems** or **ingress/loss of water**, providing information on the hydraulic performance of SRs.
▸ The novelty of this project is to combine water quality and hydraulic data analysis to rank **SR performance**.
▸ Future work will involve deploying more intensive monitoring following to SR ranking, to confirm if maintenance is needed in high-risk sites and collect information to investigate **root causes of failures**.

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