Overcoming the Challenges of Smart Water Quality

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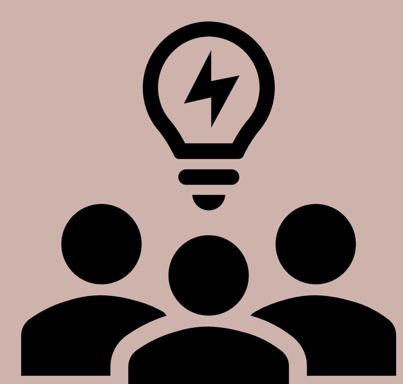
Introduction

- Water quality monitoring in drinking water distribution systems (DWDS) is essential to ensure safe water delivery and evidence asset performance to justify capital or operational investment.
- It is widely believed that continuously monitoring water quality at high-frequencies along DWDS can enhance network performance and resilience, yet such results have yet to be realised. Challenges and barriers that are preventing utilities from obtaining actionable information can be categorised into:
  1. **Vision and strategy**
  2. **Quality of data measured**
  3. **Data analysis**

1. Vision and Strategy

- Successful smart water strategies must start with a clear and well-defined vision; why is monitoring required and how will the data be used. This vision should inform operational strategy: what sensors are needed, how many, and where; as well as the maintenance and data analysis requirements.
- As smart water quality is a relatively new pursuit, there is a lack of evidence of what sort of outcomes are possible. Without this knowledge, it is impossible to start with a clear vision and strategy.
- This work will evidence the range and variety of decisions that could be informed by working with multiple spatio-temporal data sets.



2. Quality of Data

- Sensors link the physical and digital worlds, but they require domain knowledge and skill to operate. This is perhaps even more critical for sensitive water quality sensors typically deployed in underground chambers when designed for lab environments.
- **Calibration**, **installation**, and **maintenance** require an appreciation for the underlying sensing mechanism as well as care and attention by trained professionals.
- Undertaking **pre and post deployment validation** processes and **in-service sensor data checks** can facilitate data quality assurance.

Pre-deployment Validation

Pre-deployment validation procedures are under investigation, using a permanent reference turbidity sensor and handheld chlorine samples.

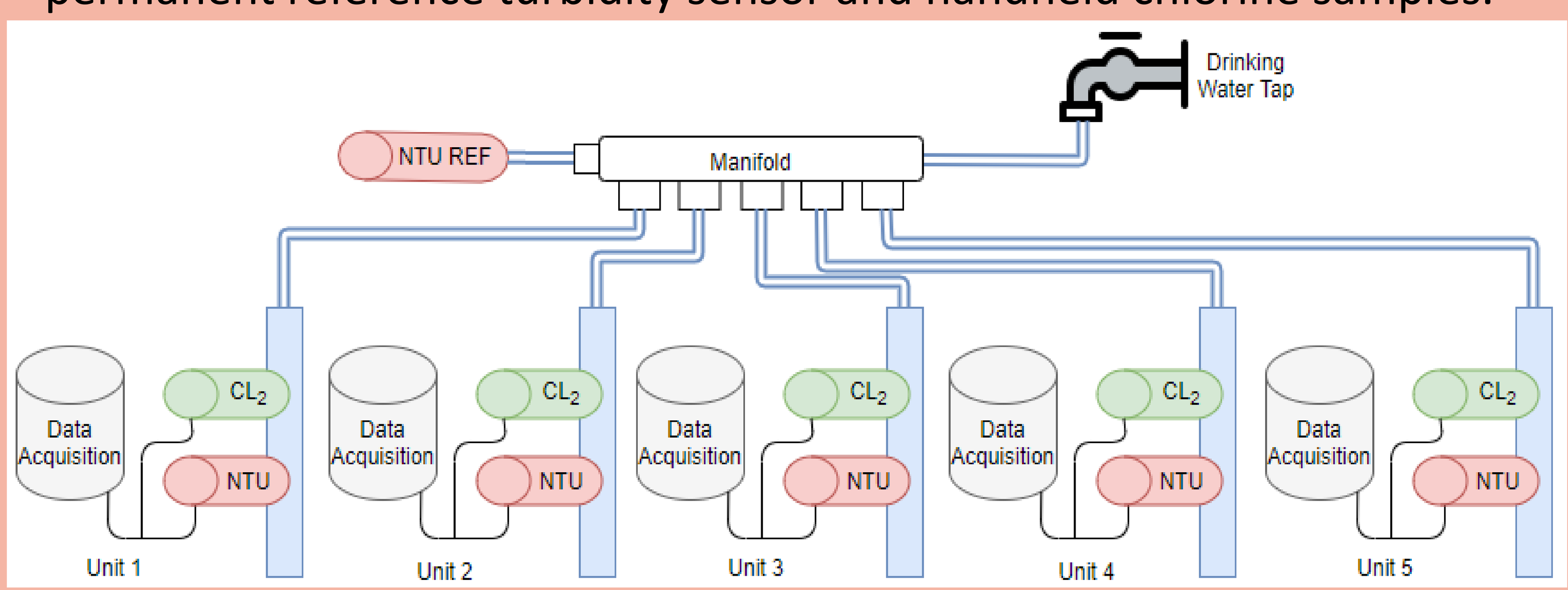


Fig 1: lab validation setup for 5 turbidity (NTU) and chlorine (cl_2) sensors

✓ Sensors can be deployed with increased confidence after their performance is validated

In-service Validation

- Chlorine sensors use membranes that can degrade and lose sensitivity.
- Turbidity sensors use optics that are sensitive to fouling.

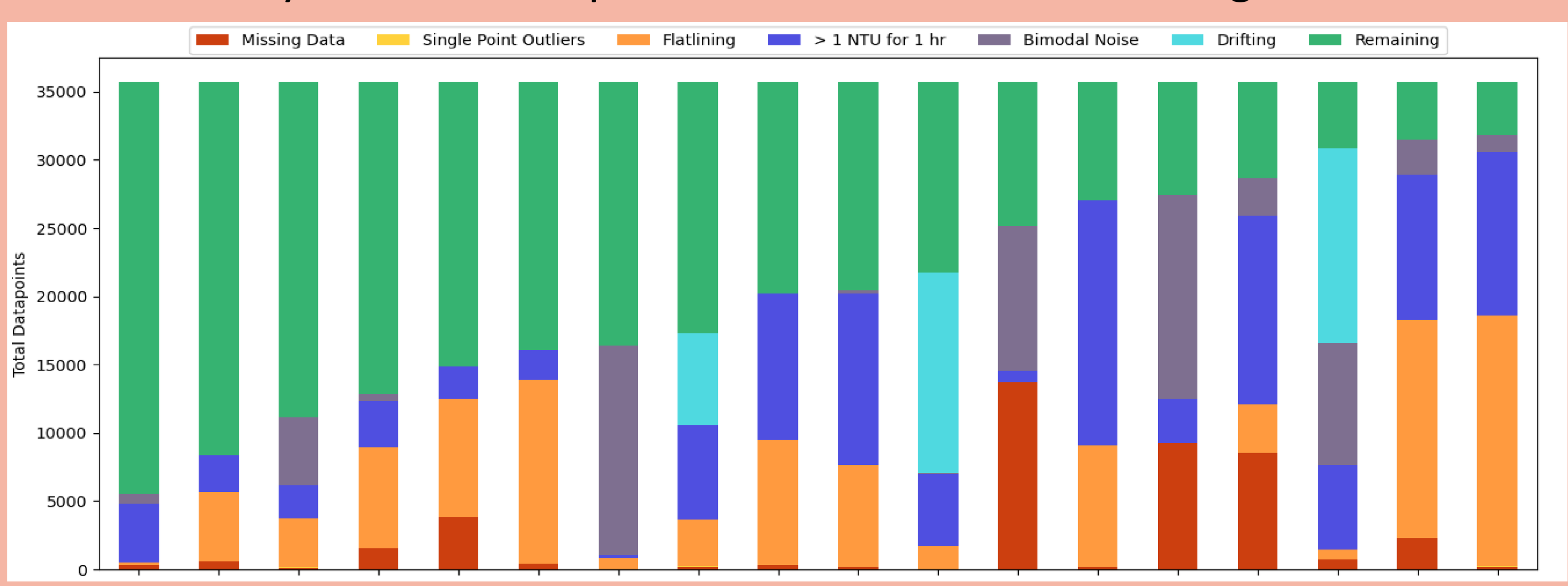


Fig 2: sensors ranked by field performance according to data quality rules

✓ In-service data checks improve data quality by informing sensor maintenance.

3. Data Analysis

- Water quality data has been used to determine asset performance, including event detection, trend investigation and root-cause analysis.
- Examples below demonstrate the use of water quality data to infer **hydraulic transit times** (Fig 3), **detect anomalous events** (Fig 4), and **track discolouration material** (Fig 5).

Hydraulic Transit Times

Time-lagged correlation between sensors infers network connectivity and hydraulic transit times, supporting hydraulic modelling and tracking network events.

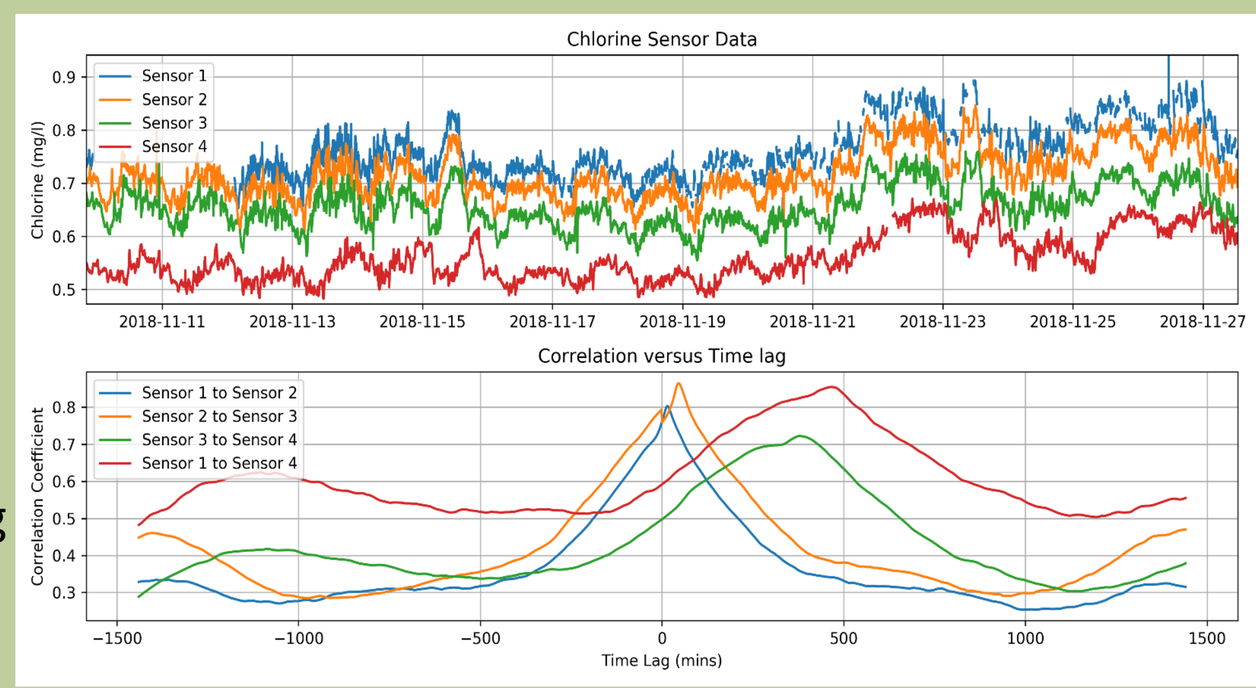


Fig 3: Top: 4 chlorine sensors. Bottom: Correlation curves between each of the sensors.

Anomaly Detection

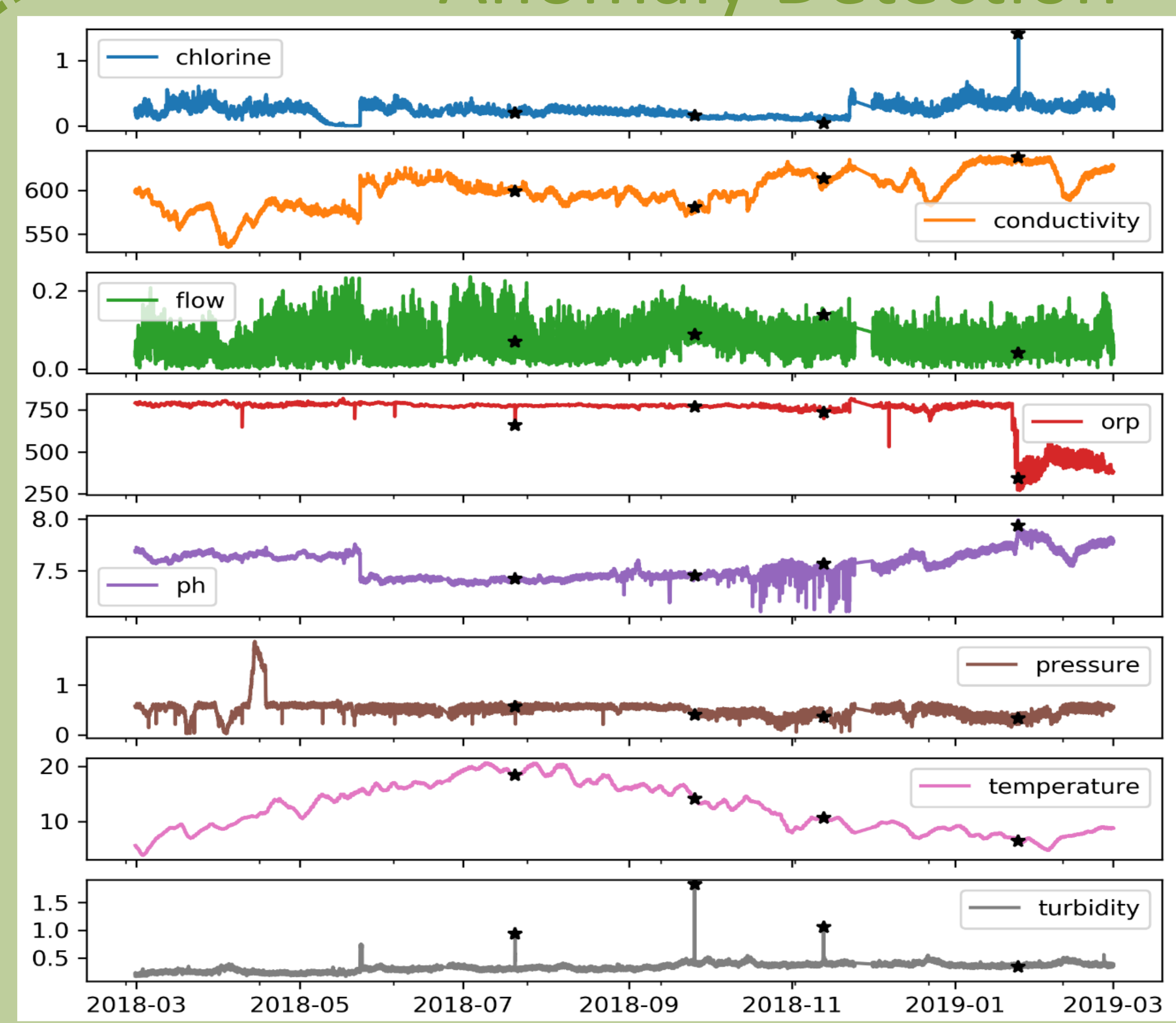


Fig 4: anomalies (marked as black dots) detected on multi-parameter data set.

Anomalous events often need to be investigated further. The anomaly detection method used here successfully identified unusual events by first reducing the dimensions in a multi-parameter data set.

Material Tracking

Combining flow data with turbidity has been used to quantify network material flux, which can be used to understand discolouration events and locate network hotspots.

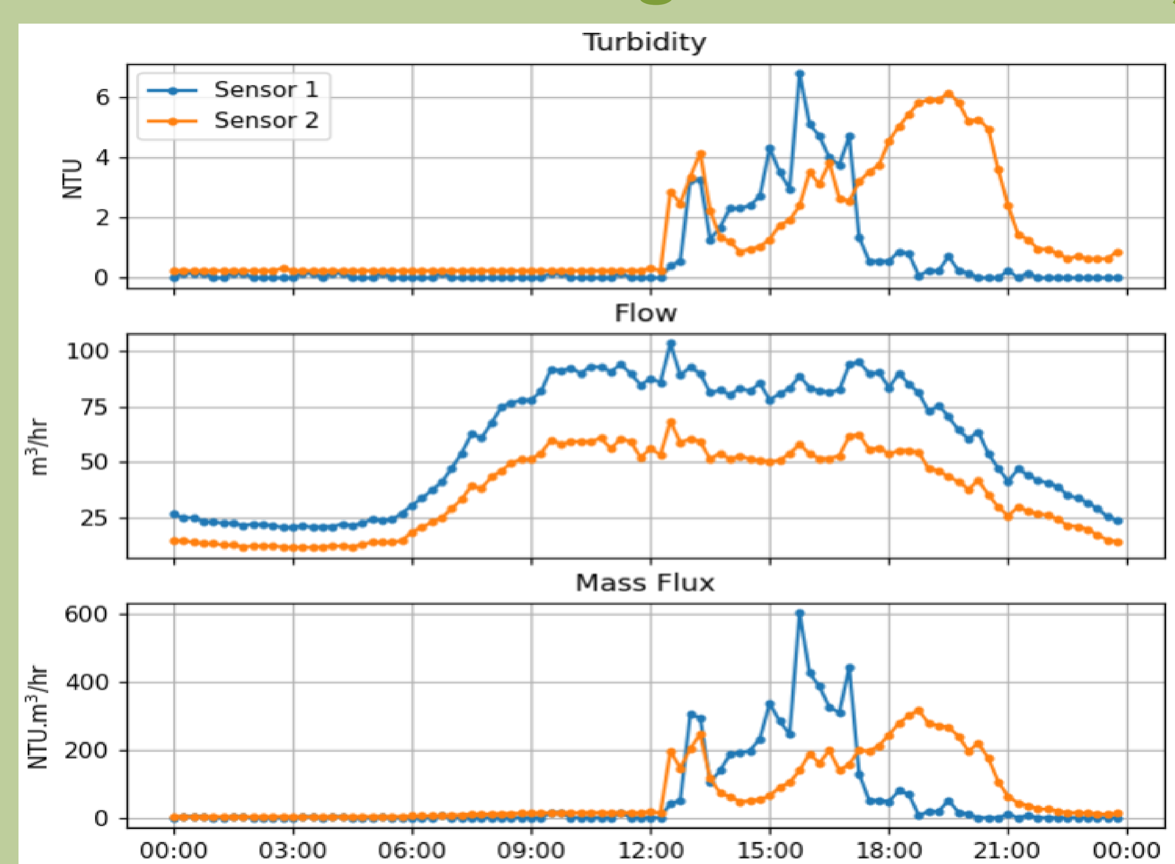


Fig 5: material flux calculated for 2 sensors with Sensor 2 downstream of Sensor 1.

Summary

- The challenges and barriers preventing utilities from extracting actionable information from newly available smart water quality technologies can be overcome with well-defined vision and strategy, effective data quality assurance, and targeted data analysis.
- This work is demonstrating the range and variety of decisions that can be informed from analysing different spatio-temporal water quality data sets. By evidencing what is possible, this work will enable the development of clear project visions and strategies that will allow utilities to optimise their use of smart water quality technologies.

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