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SUPPORTING BETTER PUBLIC RESPONSE BY ENHANCING WASTEWATER MONITORING WITH MACHINE LEARNING

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The New Zealand Water & Wastes Association Waiora Aotearoa

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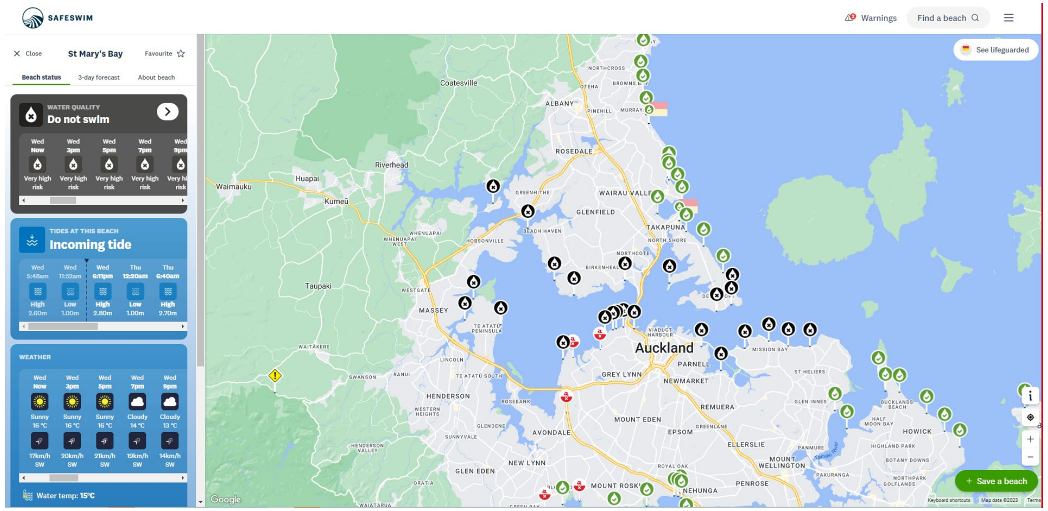
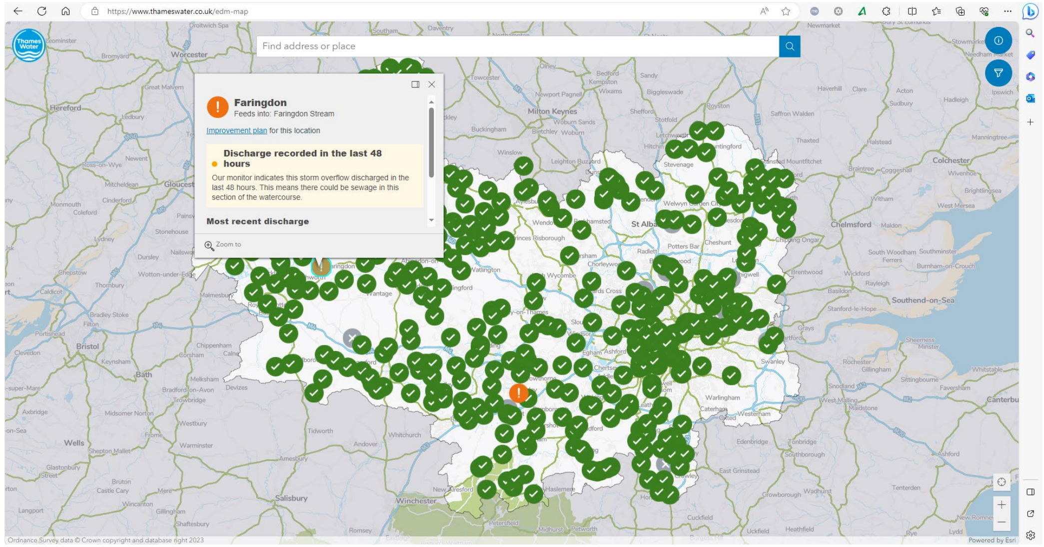
17-19 OCTOBER 2023
Tākina, Te Whanganui-a-Tara Wellington

Introduction

GLOBAL CONTEXT

- Wastewater overflows can affect **public health**, water quality, and the integrity of ecosystems.
- Increased **public awareness** in recent years.
- Focus on **reducing overflows** to improve community and environmental outcomes.
- New UK Plan for Water published in April 2023: by 2050, companies will not be allowed to discharge from storm overflows for more than **10 rainfall events** per year.
- The result: increase in **number of monitors** (Anglian Water 20,000 & Thames Water 18,500 by the end of 2025)

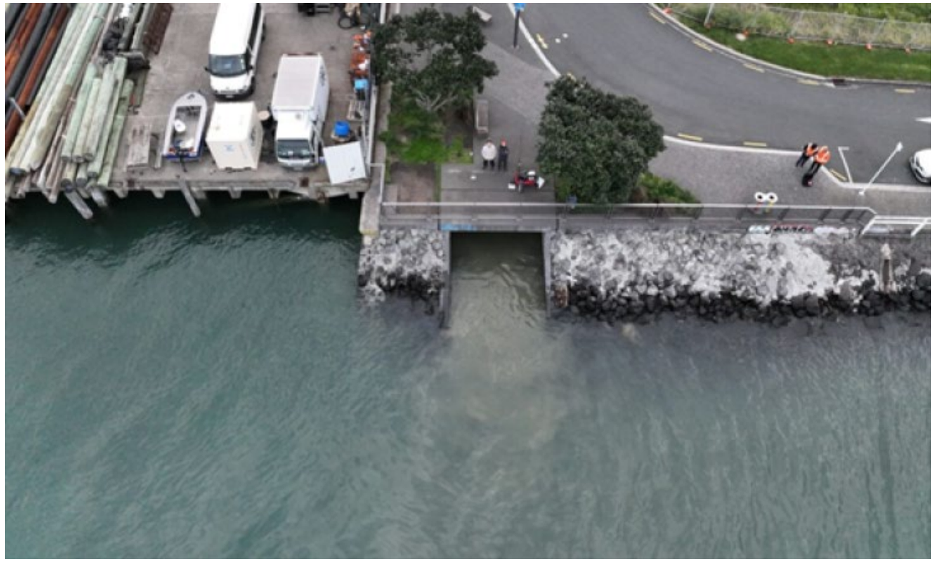




Introduction

OUR MONITORING JOURNEY

- Monitoring network performance and impacts is not a new concept
- Councils across NZ have been undertaking monitoring, modelling and data projects for many years
- Common themes for all clients:
  - Visibility of vast networks
  - Benchmark performance using data
  - Trigger operational response (alarms)
  - Justify improvement works
- Increased expectations with the associated demands on technology is a natural progression



Introduction

EVOLVING SOLUTIONS

- **Very very early -** visual. Sand on overflow weirs
- **State** – floats etc. on/off for every event but suffered accuracy and maintenance issues. Limited insights. Basic telemetry and download.
- **Time series level and basic alarm –** pressure and early ultrasonics enabled regularly sampled level data before and after overflow events enabling insights, however, reliability and power issues.
- **Data consolidation –** Data platform bringing together all data sources for central processing, display and alarming.
- **Modern sensing and advanced alarming** - reliable sensors, low power consumption, lower maintenance, integration with network of rainfall and other sources for powerful analytics. Multi-source alarming.

Introduction

FLOAT SENSORS ARE SUSCEPTIBLE TO FOULING AND THIS ONE ENDED UP BEING SUCKED INTO THE OVERFLOW PIPE WITH THE ALARM STUCK ON

Introduction

PRESSURE SENSORS WERE DESIGNED FOR TANKS AND THE FORM FACTOR LED TO FOULING

Introduction

EARLY ULTRASONICS REQUIRED POWER SUPPLY. 6M POLE BEING INSTALLED FOR EXPOSURE IN A BUSHED SITE

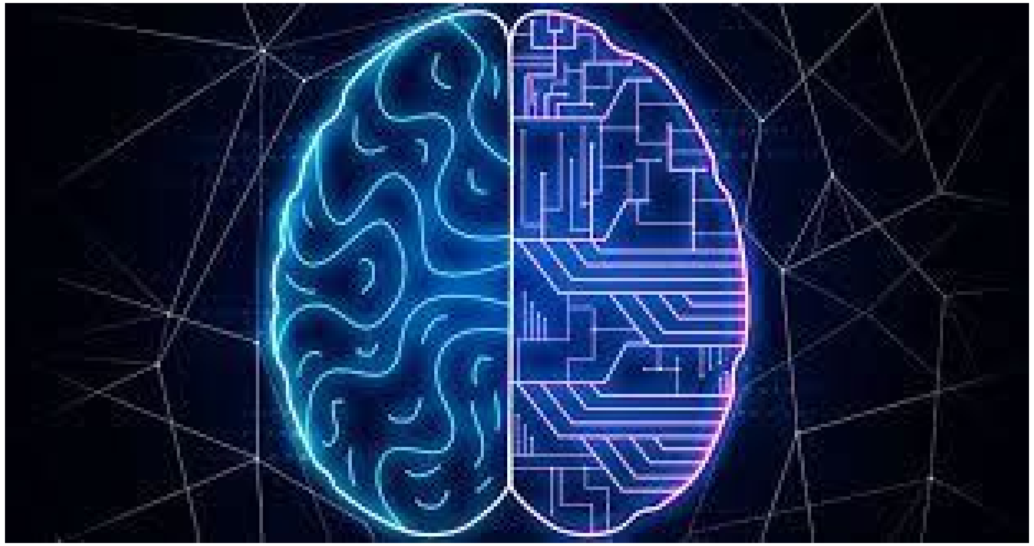
Introduction

WHERE TO FROM HERE?

- This paper showcases the next key development in operational monitoring and network management - machine learning

A focus on the flowing challenges

- Prediction of wet weather overflows
- Detection of blockages in sewer systems
- Inflow and Infiltration characterisation

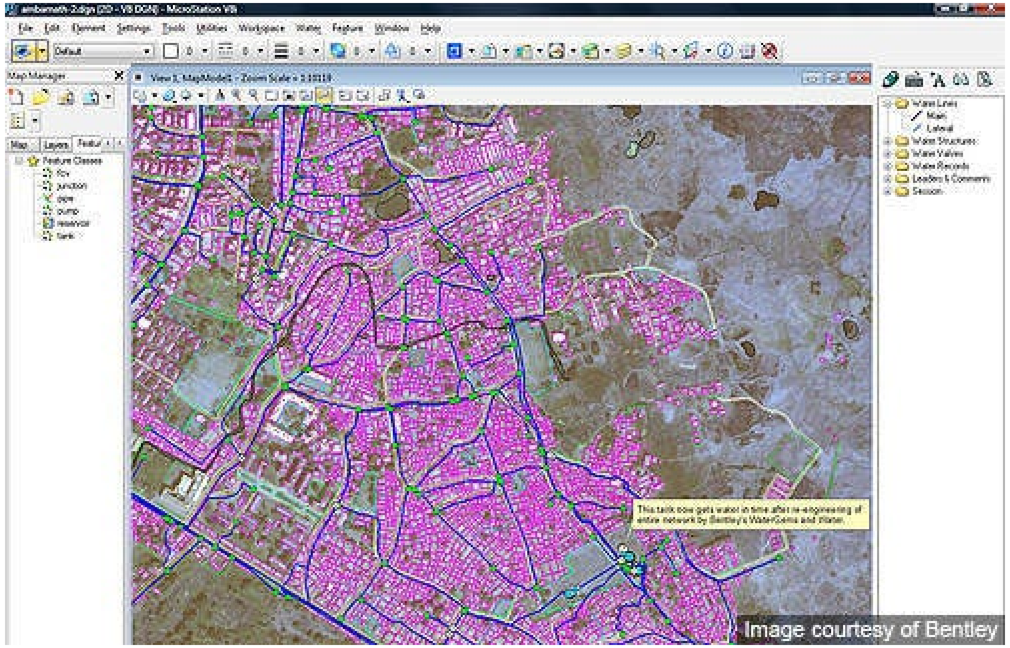


Prediction of wet weather overflows

CURRENT STATE

- **Monitoring**
  - Significantly improved data quality
  - Long term data record (5-10 years at some sites) for training data sets
  - Near real-time telemetry during events
  - No predictive functions

- **Hydraulic Modelling**
  - Physical representation of sewer network
  - Used for planning and capacity assessment
  - Lack flexibility to reflect changes in the system
  - Long run times

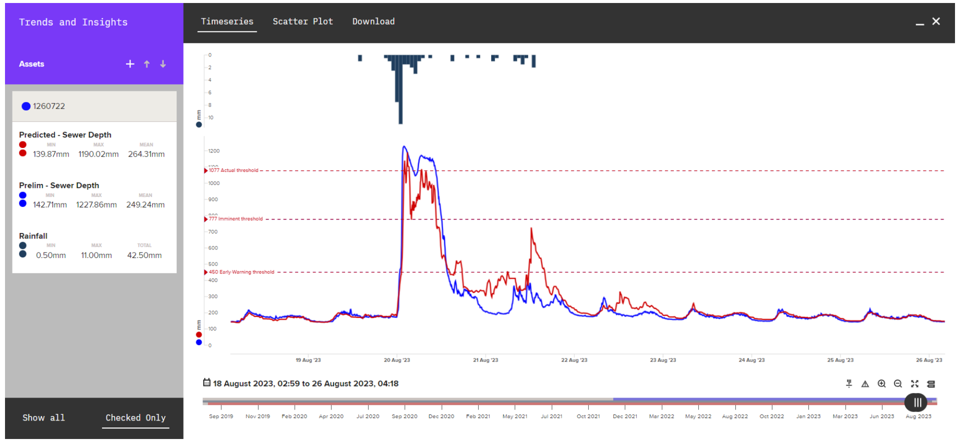


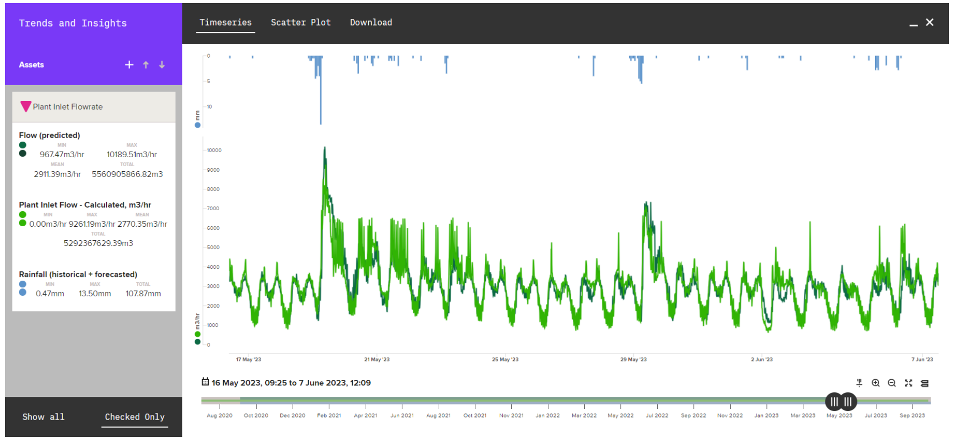
Prediction of wet weather overflows

OPPORTUNITY

- **Predictive Machine Learning Models**
  - Decision tree-based algorithm
  - Trained using historical sewer depth and rainfall data
  - Used 5 years of data and 27 sites for trial
  - Predict sewer depth 24 hours ahead
  - Updated as new rainfall forecast becomes available

- **Results**
  - Mean error of 0.188 or 3.6% of the depth range for trial dataset
  - Overflow events predicted within the hour ~91% of the time, alerting users up to 24-hours in advance if rainfall is forecasted
  - Some variation seen for low depth sites subject to more variation in their pattern





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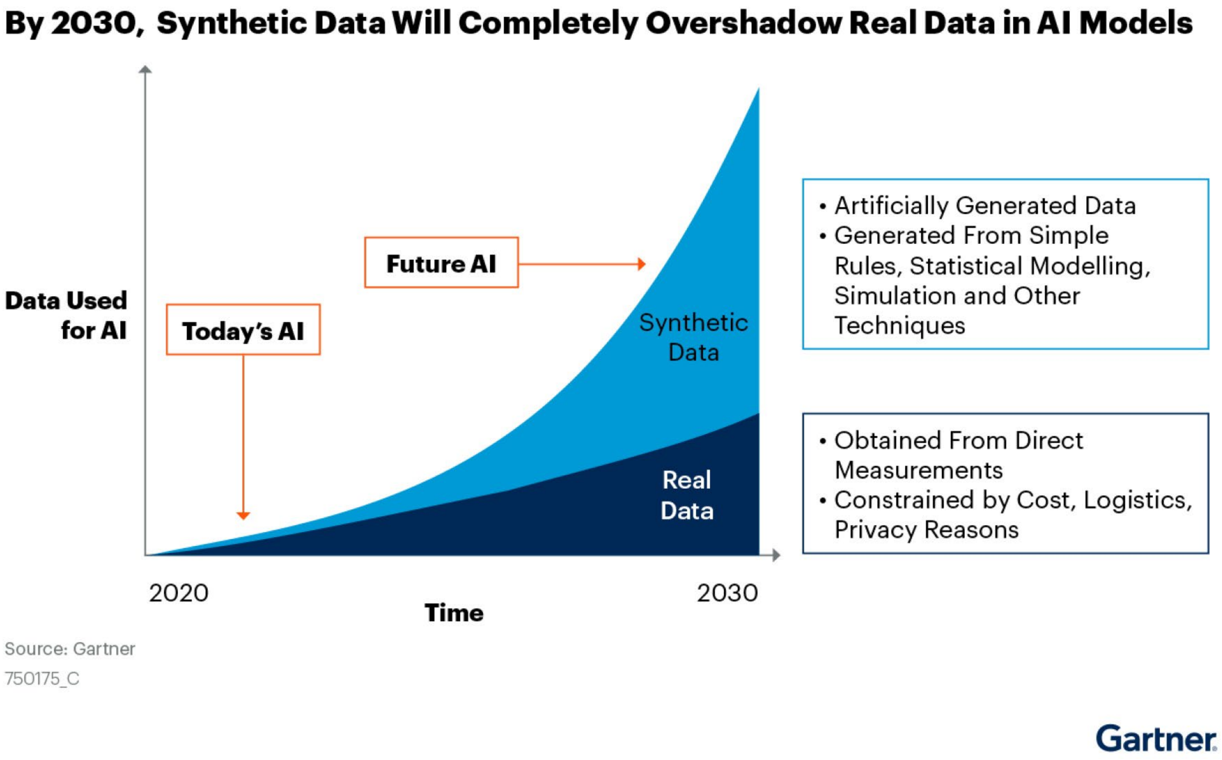
Prediction of wet weather overflows

OUTCOMES

- Use of wet weather forecast as **synthetic gauge** replacing actual monitoring equipment – safety and cost
- Can be used to forecast **impact** on receiving environment (Safeswim application)
- In the long term: Smart wastewater networks and **real-time controls**



Detection of blockages in sewer systems

CURRENT STATE

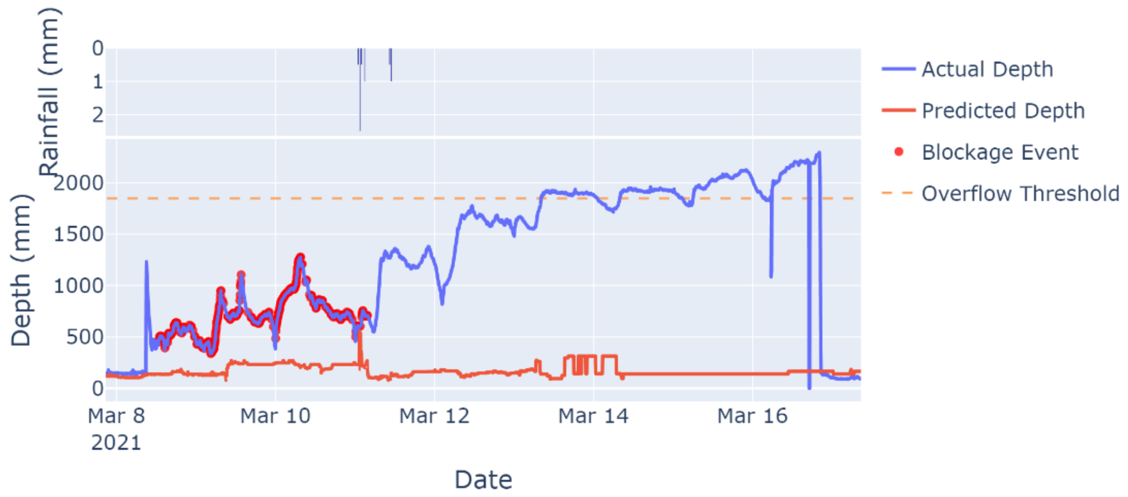
- **Monitoring**
  - Monitoring is essential as blockages and erratic behavior are inherently unpredictable
  - Rainfall and level determine if a threshold breach is related to rain or not (blockage)
  - Near real-time telemetry during events
  - Experienced staff who can identify early signs of blockage – Not automated

- **CCTV Inspections**
  - Identification of blockage prone locations
  - Regular inspections in these locations

Detection of blockages in sewer systems

OPPORTUNITY

- **Statistical Anomaly Model**
  - Combining forecasting model and statistical anomaly detection model
  - Identify deviations from forecasted depth
  - Rainfall analysis to identify “dry” conditions
  - Difference between significant and partial blockage



- **Results**
  - **74.0% precision on all data**
    2096 out of 2831 model labelled points were during an event.
  - **78.7% precision on all data when removing gauge with lower data quality**
    1925 out of 2445 model labelled points were during an event
  - **44.6% recall on event data**
    At least one anomalous value raised in 50 out of 112 labelled events

Detection of blockages in sewer systems

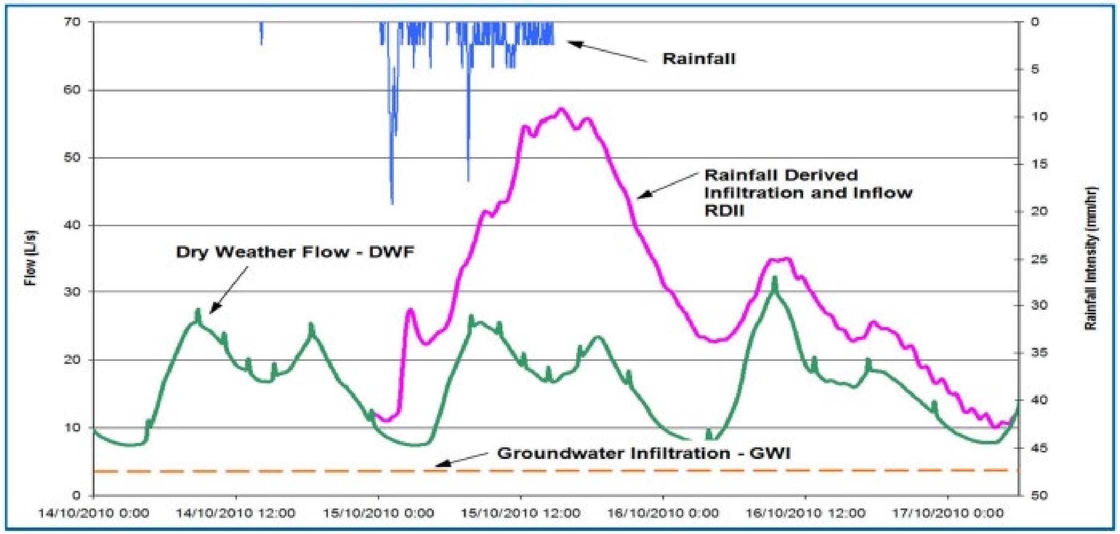
OUTCOMES

- More labelling and training required to identify blockage events
- Timely identification of blockages before actual overflows
- Reduces impact on receiving environment
- Requires less human resources for checking

Inflow and Infiltration characterisation

CURRENT STATE

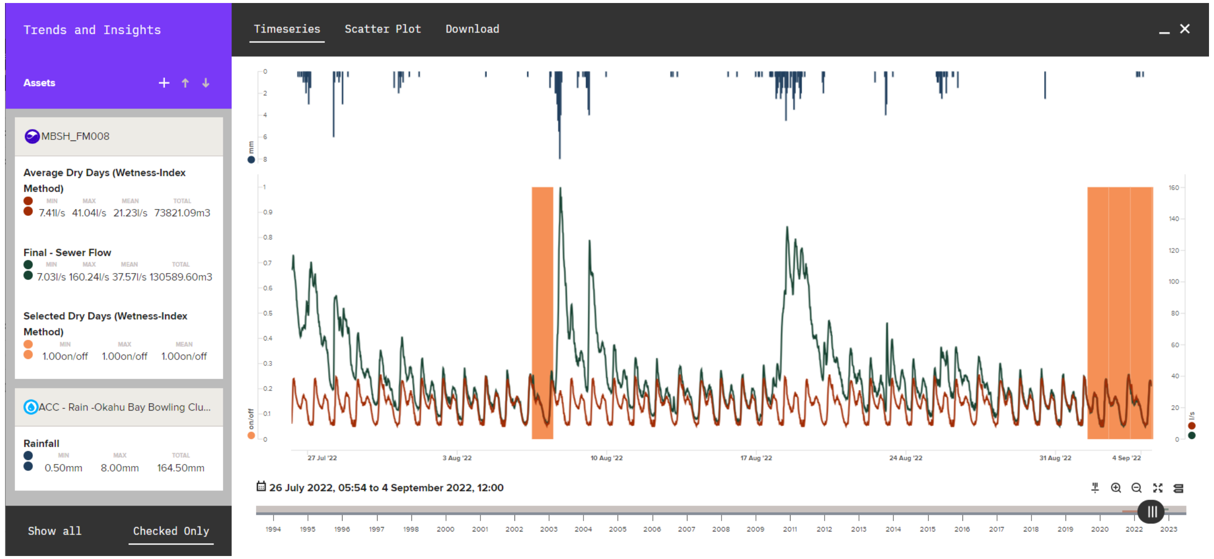
- II studies typically carried out during modelling process or annually
- Available guidance: Water New Zealand Infiltration & Inflow Control Manual 2nd Edition, March 2015
- Process often long and tedious, minimum automation
- Issue with consistency in calculations, and Benchmarking
- Cannot be used in real-time to have targeted monitoring programmes



Inflow and Infiltration characterisation

OPPORTUNITY

- **Real-time cloud computing**
  - Automated dry day selection
  - Based on antecedent wetness conditions
    $\sum_{Day=0}^{Day=14} 0.7^{day} \times Rain\ (mm)_{day} < 3.5mm$
  - ADWF updated hourly
  - RDII volume difference between computed ADWF and measured flow



- **Results**
  - Methodology tested for over 50 gauges for Watercare NP2M programme
  - Storm selection currently adapted for Australian conditions

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Inflow and Infiltration characterisation

OUTCOMES

- Time saving for hydraulic modelling and II reporting.
- Next steps: include population and catchment extent to derive II KPIs.
- Real-time analysis of network response, helps target network rehabilitation.
- Can also optimise flow gauging programme.

Conclusion

- **It's a journey.**
  - Data quality
  - Model training
  - Iterative process
- **It's an opportunity.**
  - Successful trial
  - Technology as an enabler to meet long term goals
  - Enables scaling
  - Technology needs to be part of wastewater overflow reduction strategy
- **It's only one piece of the puzzle.**
  - What to do with these results?
  - Overflows reduction require collaborative approach
- **What can you do now?**
  - Get your data ready with data analysis in mind
  - Work on a consolidated strategy including, monitoring, modelling, planning, renewals, rehabilitation, operations…
  - Start now

Questions/ Pātai?