# Harvesting Data from Rainwater Systems


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# Project Background: Goals

1) Identify a case study site that has characteristics similar to a “water stressed” community of the future.
2) Install rainwater management systems
3) Capture data to evaluate benefits at a plot scale…
4) … to support understanding of potential performance at a street / city / national scale

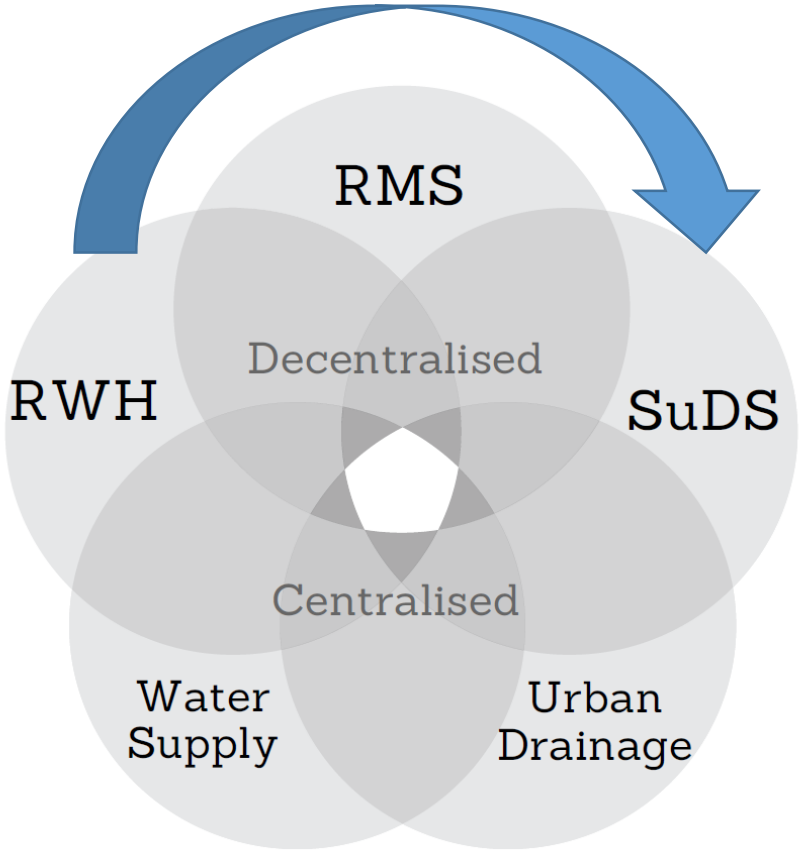
# Presentation: Goals

1) Need to retro-fit RWH
2) Rainwater management systems
3) Case study installation
4) Data harvesting
5) Preliminary data analysis
6) Conclusions

# Is there a need to retrofit rainwater systems?

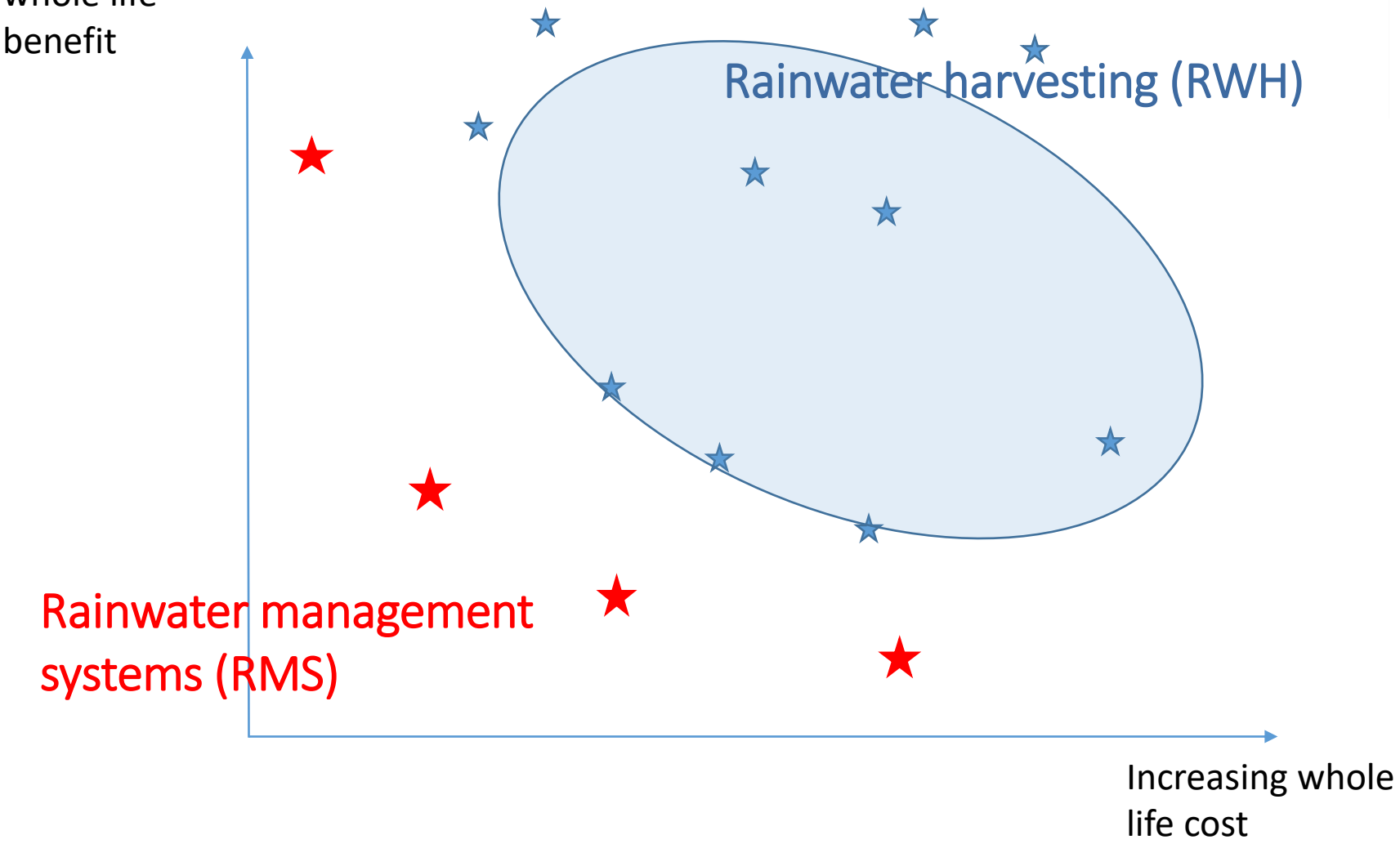
- The current UK water supply surplus of 12% is due to change by the 2050s to a water **deficit of 8-22%** of total water demand (Defra 2017).
- We are facing the "**jaws of death**" within 25 years : the point where water demand from rising population surpasses the falling supply resulting from climate change (Sir James Bevan)
- The Environment Agency projects **surface water flood damages** to exceed £27bn per annum by 2080

# Rainwater Management Systems

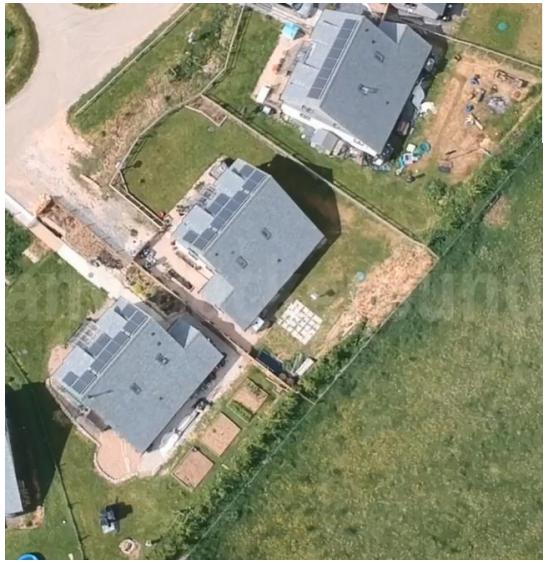



- **RWH** – single function, single benefit.
- **RMS** – multi-function and/or multi-benefit:
  - Reduced water demand
  - Reduced energy (embodied and operational)
  - Reduced stormwater discharges
  - Increased resilience and sustainability

# Rainwater Management Systems



# Case Study - Broadhempston



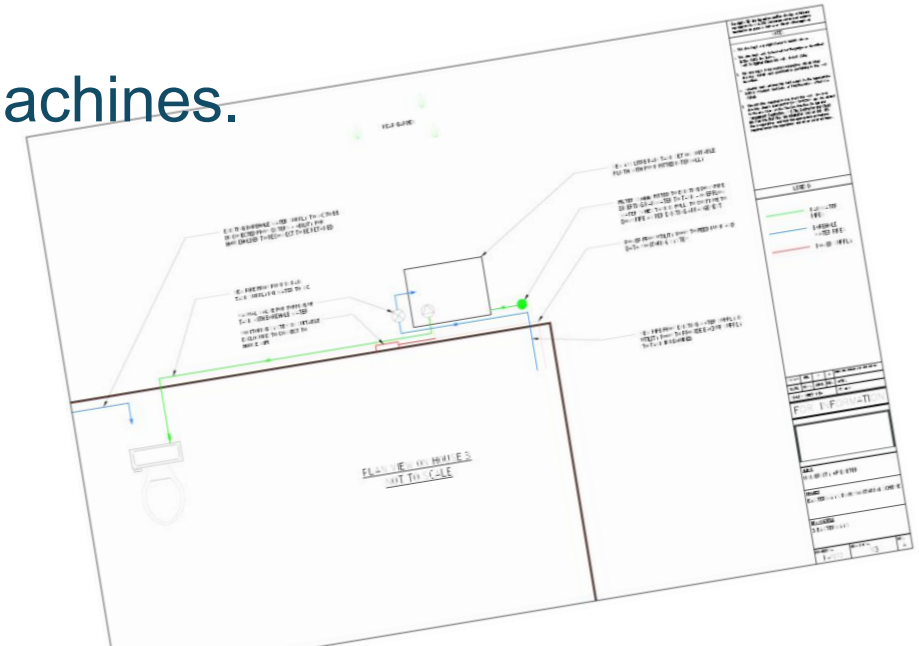
6 ‘eco-houses’

# Installation uptake

- Design solutions developed and presented to householders at a **community meeting**.
- ALL 6 householders approached accepted the **“free”** offer.
- Homeowners pay for the **electricity**.
- One homeowner has plumbed in his own **washing machine.**
- Two others **want to do the same** but are happy to wait until we have 12 months data from the systems as they stand.

# Installation Design

- Householders have high water awareness as their borehole frequently “runs dry”.
- Rainwater was considered by all to be a precious resource
- Monitoring package integrated into the installations.
- 800l tank and auto pump system + monitoring system installed (x6)
- Homeowners have downstairs WC flushed by rain (but have another upstairs).
- Keen to have the rainwater fed into their washing machines.



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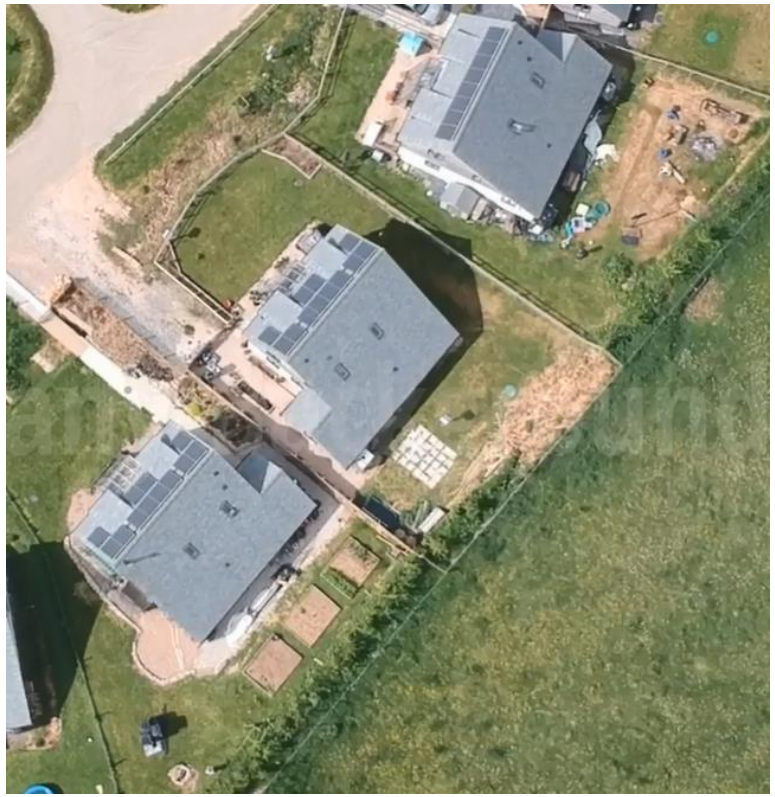
# Completed Installation

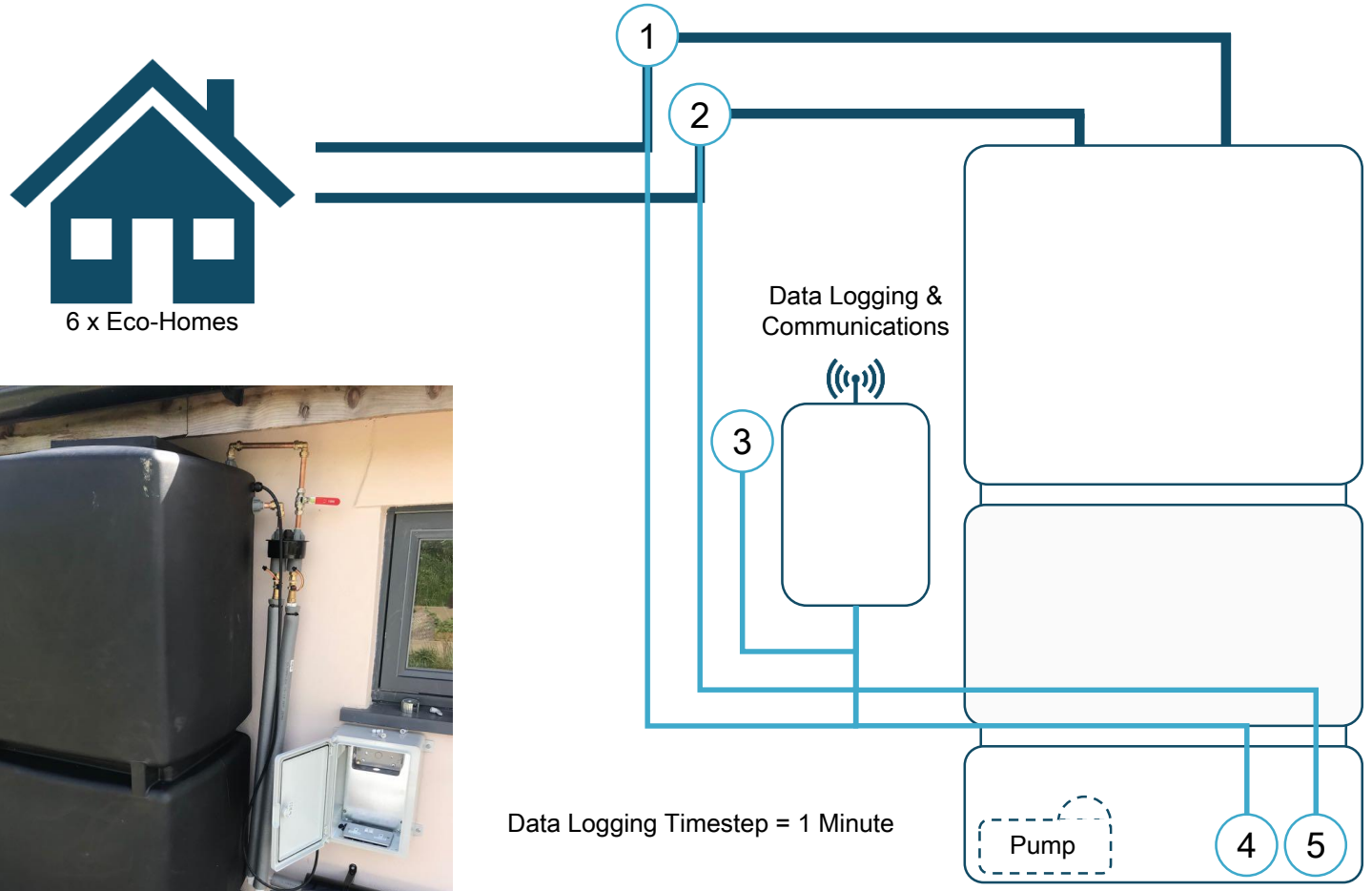
- Single pitch roof A > 50m$^2$ feeds a single downpipe.
- Black pipe duct houses: power, pumped rainwater and mains top up pipes.
- Box on wall houses monitoring system /pump controller.

# Completed Installation

- Bespoke “washroom safe” kinetic power radio button activates the pumps to fill the cistern after each flush
- Each house also has an upstairs WC



# Harvesting Data: sensors






**Flow Sensor 1**

1 Potable Water Backup Supply to RMS

*Flow (Litres), Flow Rate (Litres Min$^{-1}$), Cumulative Flow (Litres)*

**Flow Sensor 2**

2 Rainwater Supply to Household

*Flow (Litres), Flow Rate (Litres Min$^{-1}$), Cumulative Flow (Litres)*

**Temperature Sensor 1**

3 Ambient Temperature

*Instantaneous Temperature (Celsius)*

**Temperature Sensor 2**

4 RMS Water Temperature

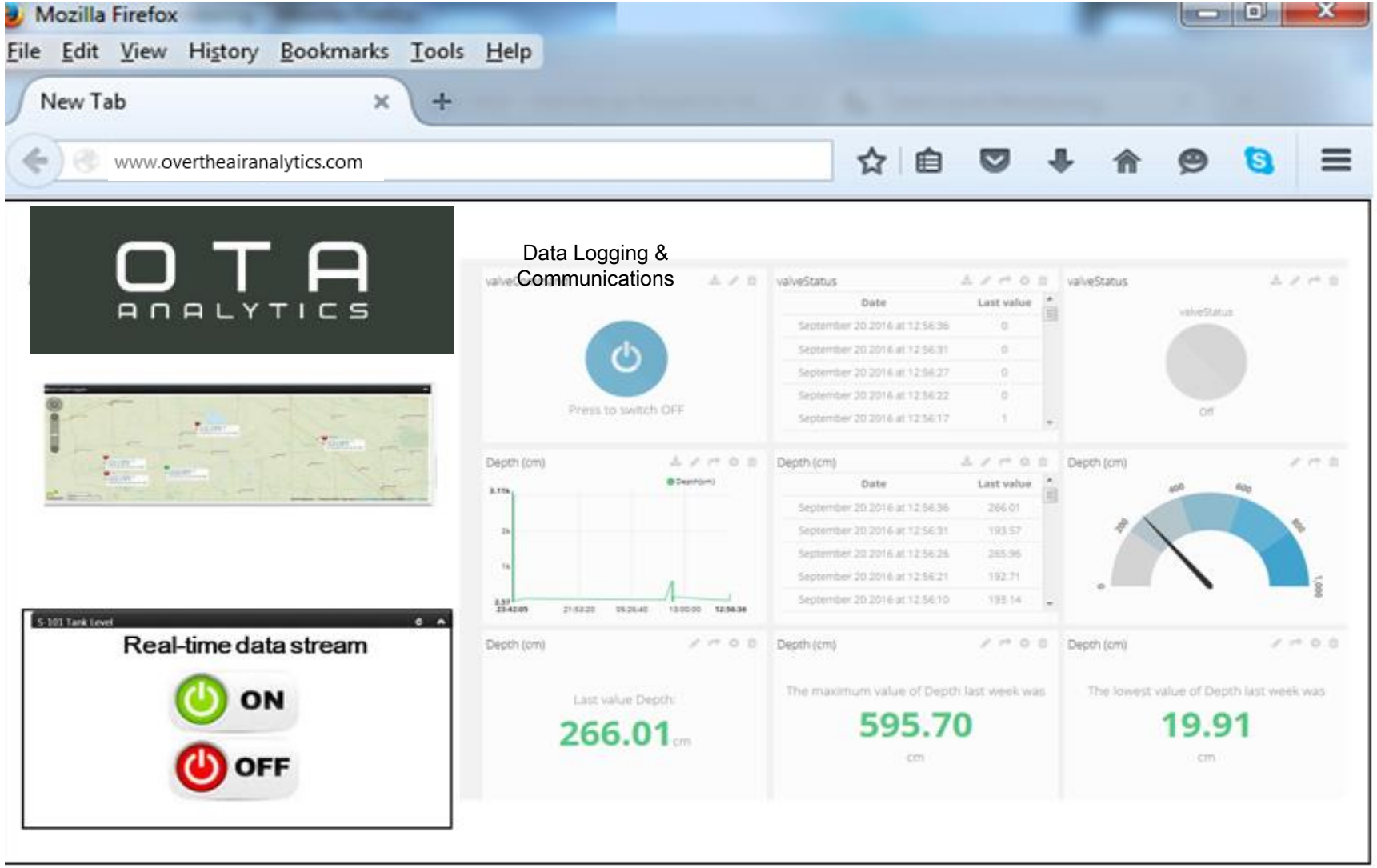
*Instantaneous Temperature (Celsius)*

**Level Sensor 1**

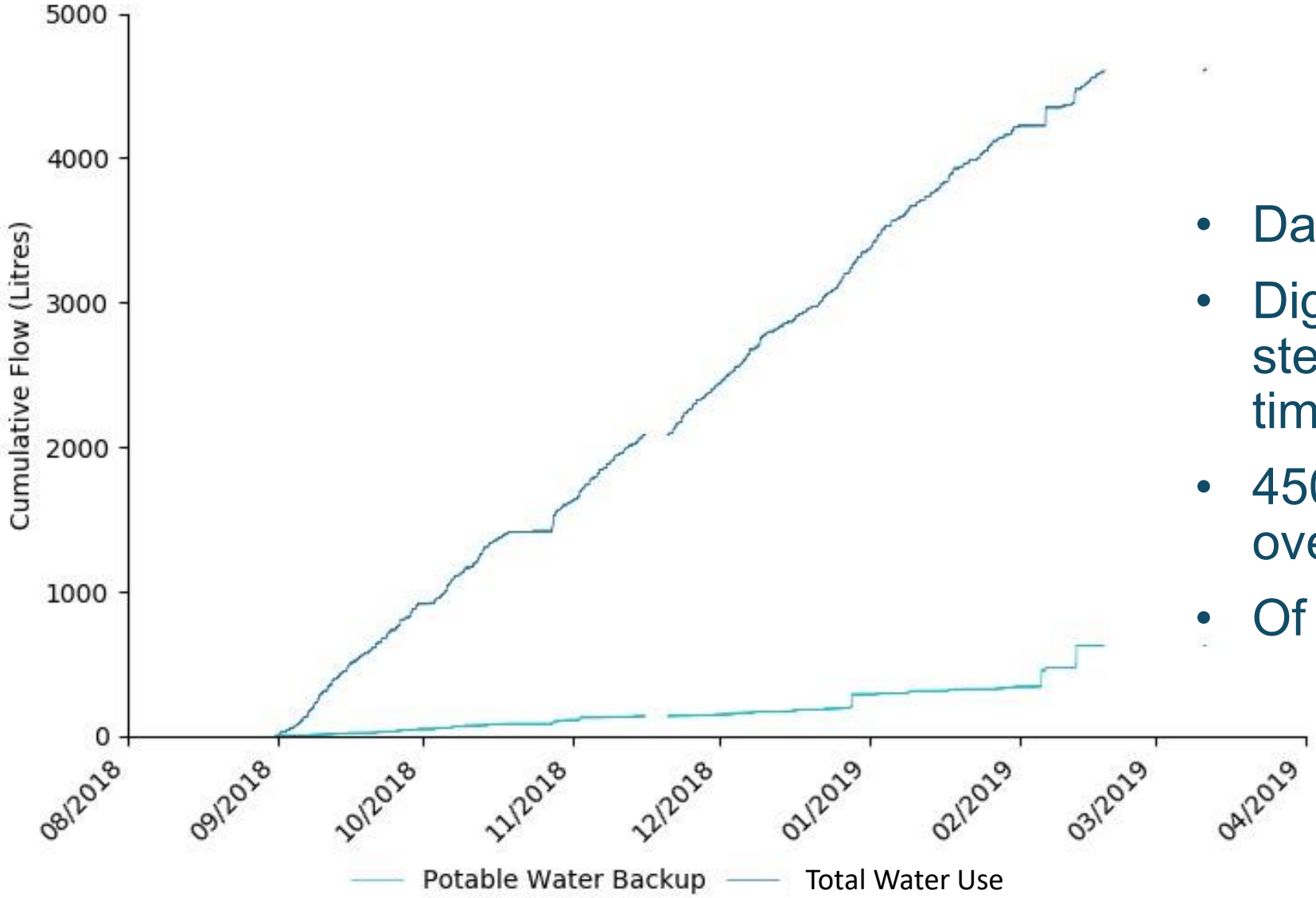
5 RMS Water Level (m H2O)

*Analogue Gauge Pressure (4-20 mA), Water Level (m H2O)*

# Harvesting Data: remote monitoring

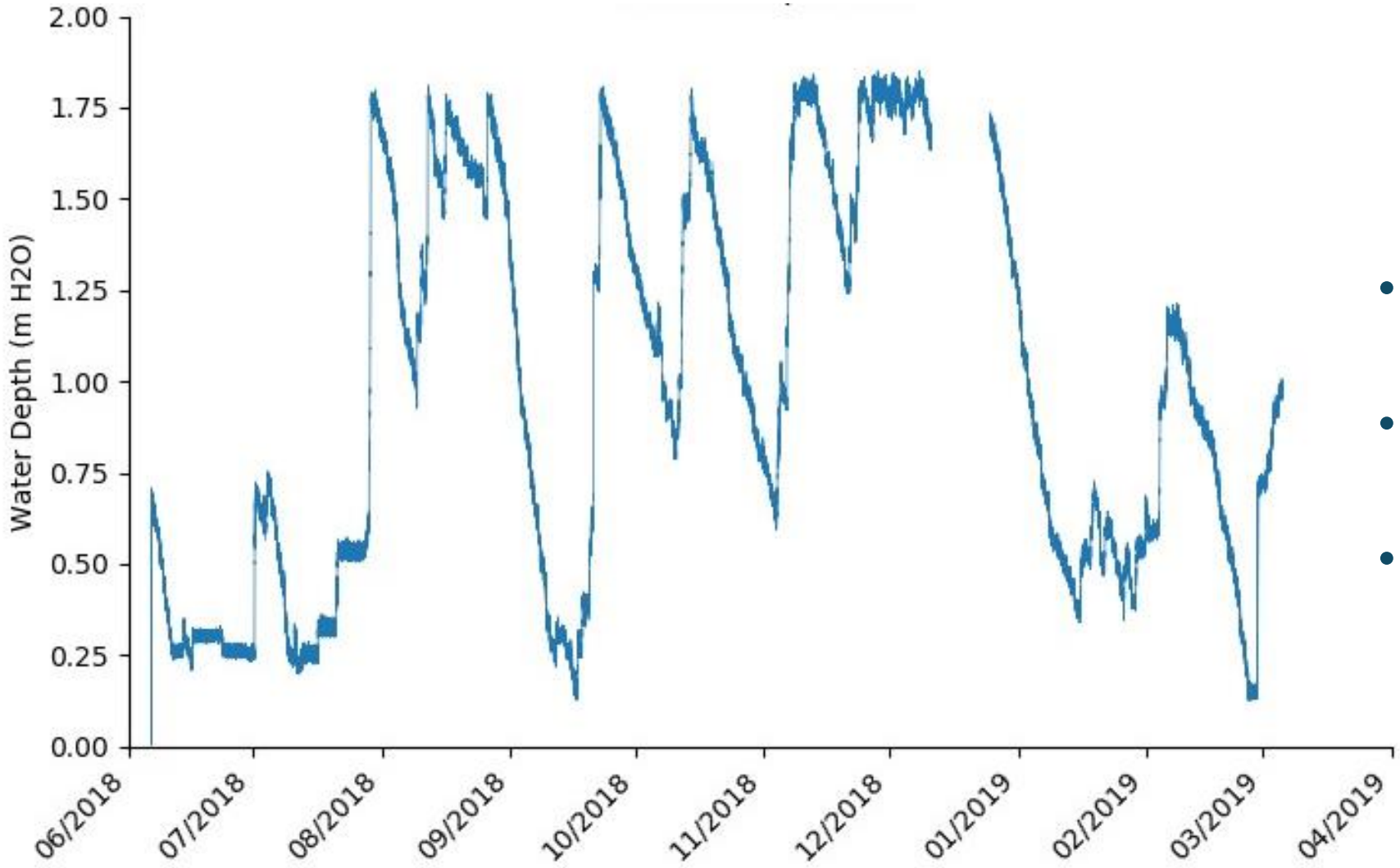


# Preliminary Data Analysis 1



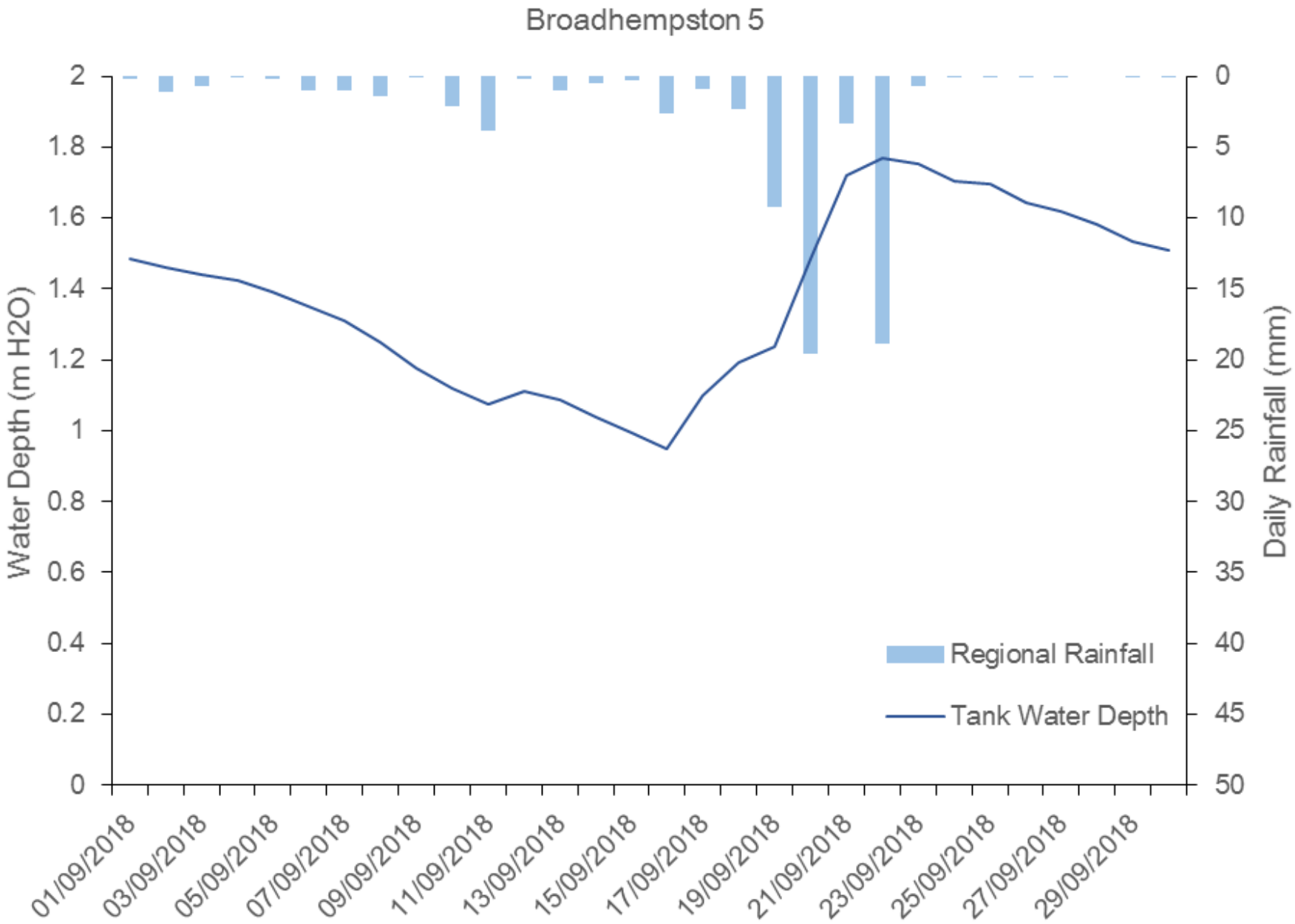

- Data for one house.
- Digital flowmeters demonstrate steady water demand over time
- 4500 litres rainwater flushed over 6 months.
- Of which 800 litres from mains.

# Preliminary Data Analysis 2




- Nine months plot of tank water depth over time
- Do our modelling tools match these data?
- Is there anything else we can infer form these data?

# Preliminary Data Analysis 3




- One month plot of tank average daily water depth over time
- Plot of daily rainfall depth

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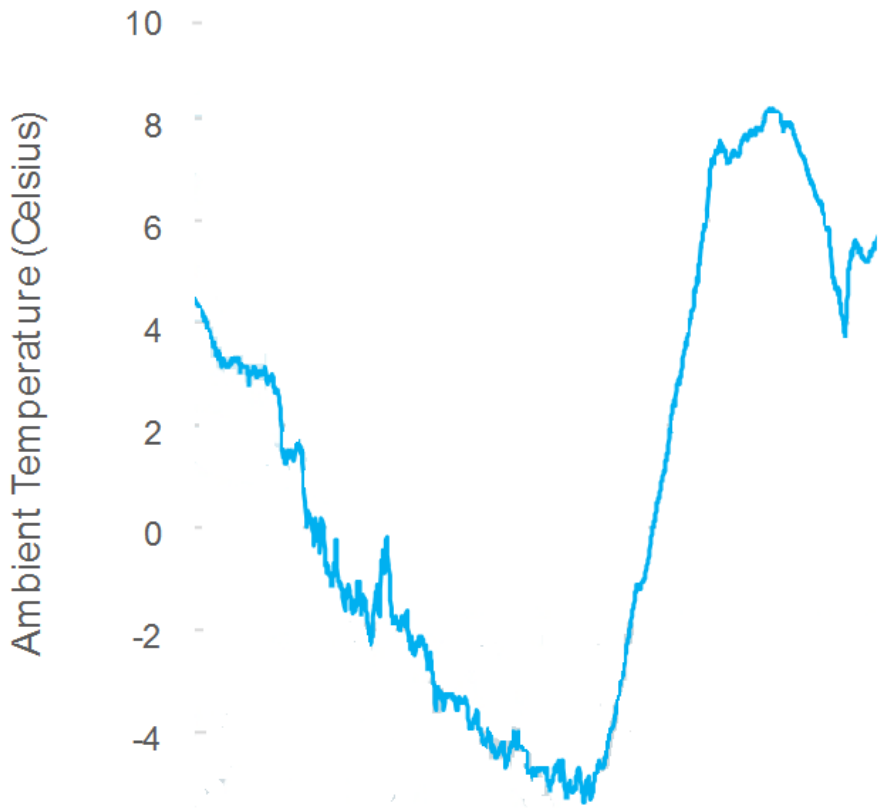
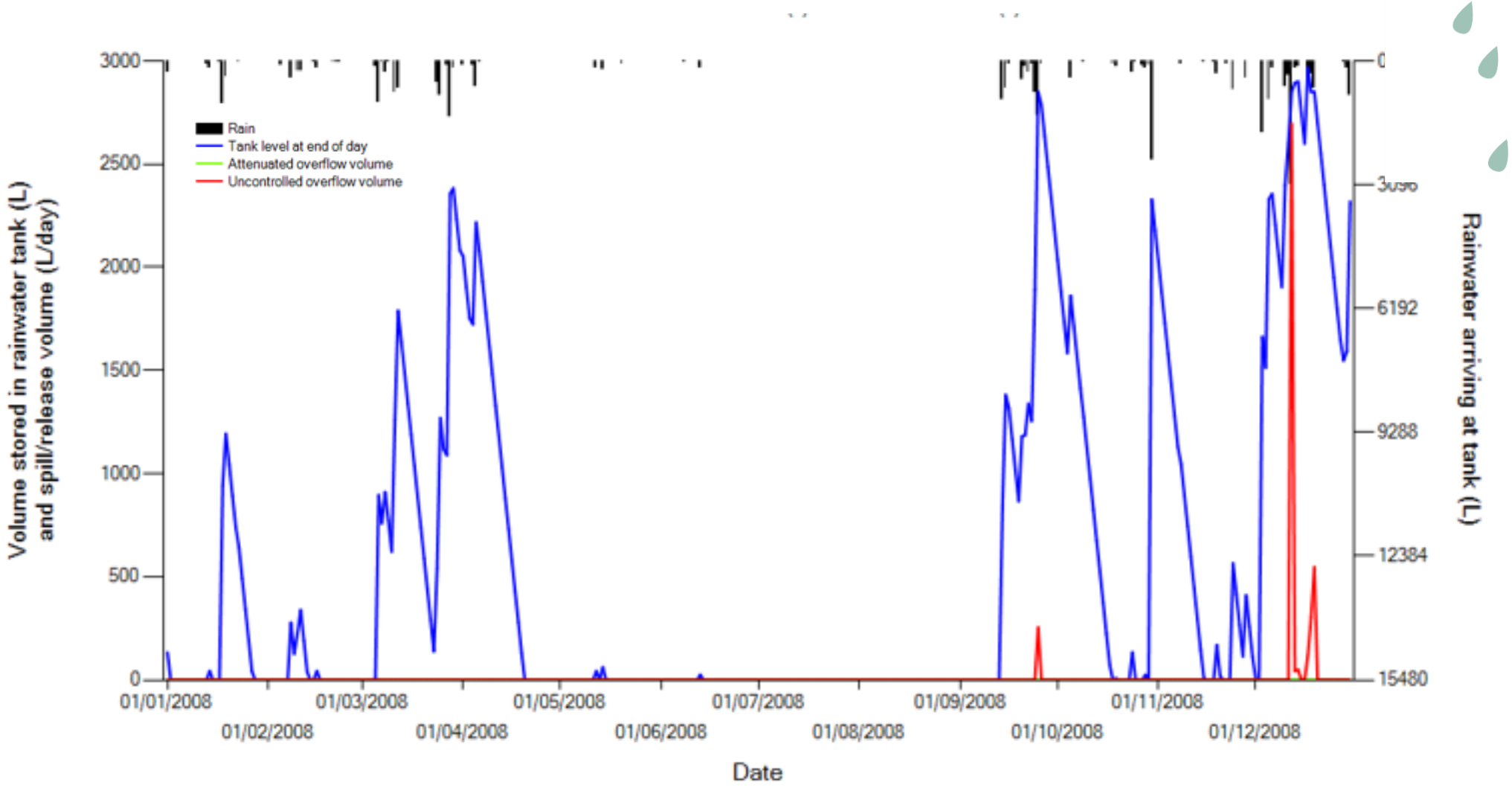
# Real-world practicalities!

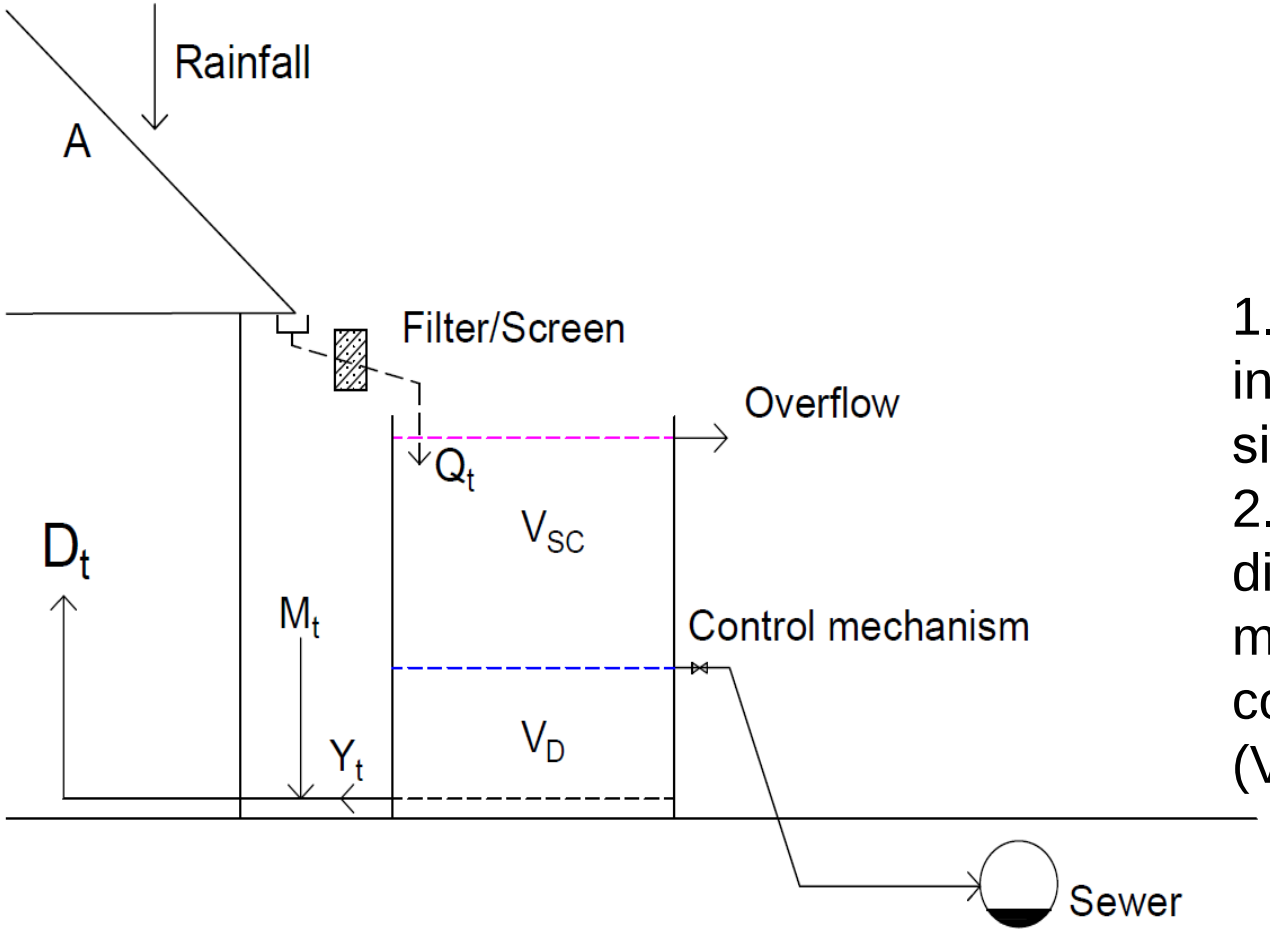



- Digital flowmeters do not perform accurately when measuring liquids that have entered a solid state

# Next steps: validate models



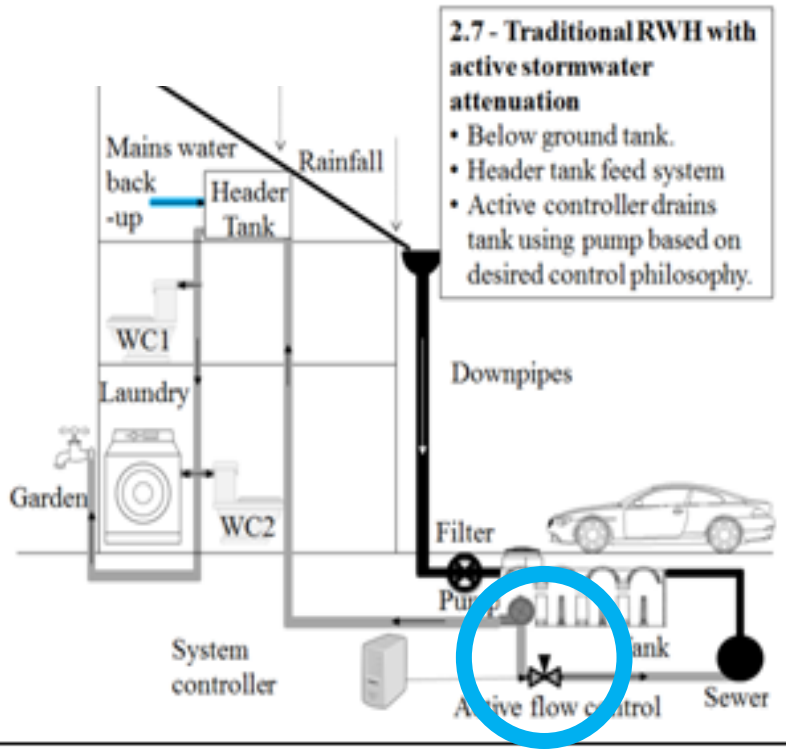
# Next steps: reconfigure for runoff control



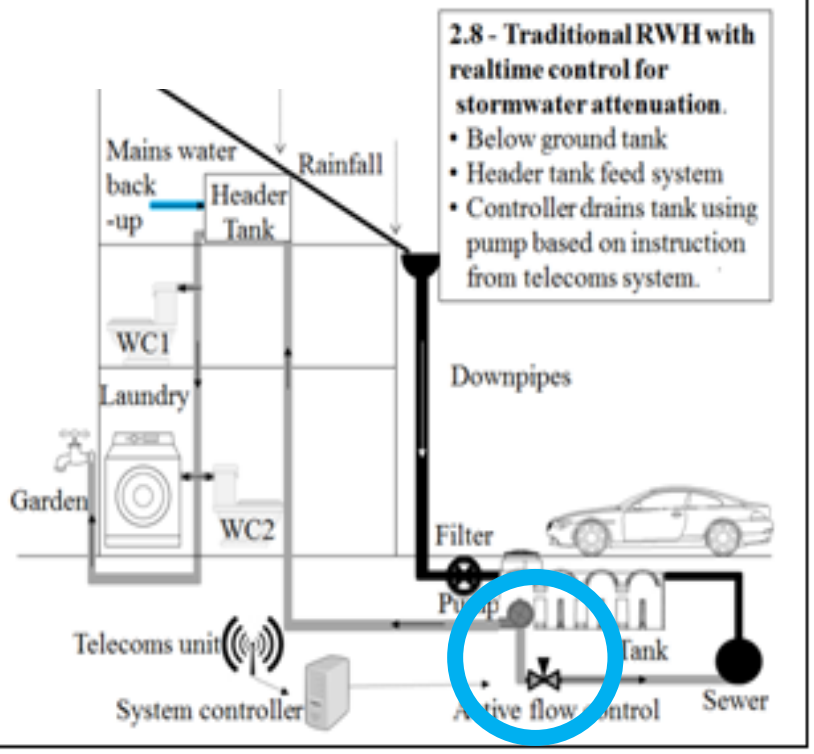

1. **Standard:** water supply plus indirect stormwater management – single 'oversized' tank ($V= V_D+V_{SC}$)
2. **Passive:** Water supply plus direct, passive stormwater management – two tanks (or tank compartments), 50/50 split ($V_D=V_{SC}$).

# Next steps: active control?

Local control




Global control




# Conclusions

- Great opportunity here to build a detailed and long-term **database** of a developing rainwater management system
- **Engaged users** who have a real need for the system and are were willing to allow system **retrofits.**
- Future potential to test concepts around **community ownership** and **on-going maintenance**
- There is significant potential to **develop the systems** from ones purely designed for water supply augmentation to ones designed with additional flood control functionality.
- Opportunity to think about and design **upgrade paths** (e.g. tank reconfiguration and/or active control)
- Also potential to **compare different approaches** side by side

# Conclusions

- Currently evaluating the uses of the emerging high resolution data set such as: **model calibration/verification, design development, fault detection,** and **user interfaces**
- Looking at the potential to upscale our modelling approaches at a plot scale, to evaluate such systems at **city scale**
- Other benefits can be achieved by design & operation optimisation: **pollution control** (CSO reduction), **climate change adaptation** (variable tank splits), **resilience enhancement** (supply failure) and **reduction in urban heat island effects.**
- Demonstrate how widespread decentralised rainwater management systems can support and enhance **integrated water management.**

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