STORMHARVESTER

CASE STUDY

INFLOW & INFILTRATION

Using AI to determine the root cause of storm overflows

Client Southern Water & Stantec | **Date** March 2024

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ABOUT
SOUTHERN WATER

Southern Water is the private utility company responsible for the public wastewater collection and treatment in Hampshire, the Isle of Wight and West Sussex, East Sussex and Kent, covering a total population of over 4.7 million people.

ABOUT
STANTEC

Stantec Inc. is an international professional services company providing services on projects around the world, with over 26,000 employees operating out of more than 400 locations.

TESTIMONIALS

“The I&I Detector has provided real value in quickly helping us not only identify sites where we have I&I problems but their causes.”

Richard Martin.

Head of Operational Waste Control, Southern Water

“The I&I tool has not only provided us with another tool to help reduce spills and pollution, but a data driven tool to help scope, size and prioritise the right solutions and investment. Another win for machine learning.”

Dr Nick Mills

Head of Storm Overflow Task Force, Southern Water.

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CHALLENGE

Wastewater utilities are continuously exploring ways of enhancing protection to the environment by reducing their number of spills into watercourses.

For Southern Water, this involved an analysis of what was causing spills by looking at event duration monitor (EDM) spill data. Wastewater utility companies want to determine how their network performs at each spill point.

The key questions to answer were if spills were:

- Driven by exceptional rainfall as intended.
- Driven by inflow and infiltration into the network.
- Due to operational issues (e.g. pump failure).

Working with Southern Water and Stantec, we used machine learning and hyperlocal rainfall to characterise spills and their determining factors. A major cause of spills for wastewater utilities is inflow and infiltration.

Inflow and infiltration (I&I) cause significant problems for wastewater assets and their operators. When sea water, river water, and the infiltration of groundwater enters the wastewater network, it can cause problems such as:

- Increased spills.
- Damage to sewer network infrastructure.
- Reduced network capacity for incoming sewage.
- Imbalance of microbiome in the treatment works and the need to treat larger volumes of wastewater than necessary (leading to increased costs and carbon footprint).

OUR APPROACH

Each site has been considered separately to allow for models to learn and predict site-specific patterns and behaviors. This gives a better indication of how sites behave after improvements have been implemented.

Once the machine learning algorithms had been trained for each site, we used the Network Visualisation module on our portal to identify locations within a network where I&I is present.

1. Machine learning algorithms learn how a site behaves under different conditions: periods of time when groundwater is low and not rising vs periods of time when groundwater is high or rising.
2. Isolate sites that behaved differently under varying groundwater conditions and identify sites where infiltration is contributing to spills.
3. Established a baseline performance for each site to measure improvements when solutions were implemented.
4. Compare and contrast the rates of spills when compared to rainfall events.

Figure 1

Shows the start of the visualisation during a time of low groundwater.

The amount of I&I observed at a sensor is described by its colour, with light green representing no I&I and red representing a large volume of I&I. As expected, the network sensors show no I&I at this time.

Network visualisation – Start of visualisation (low infiltration risk)

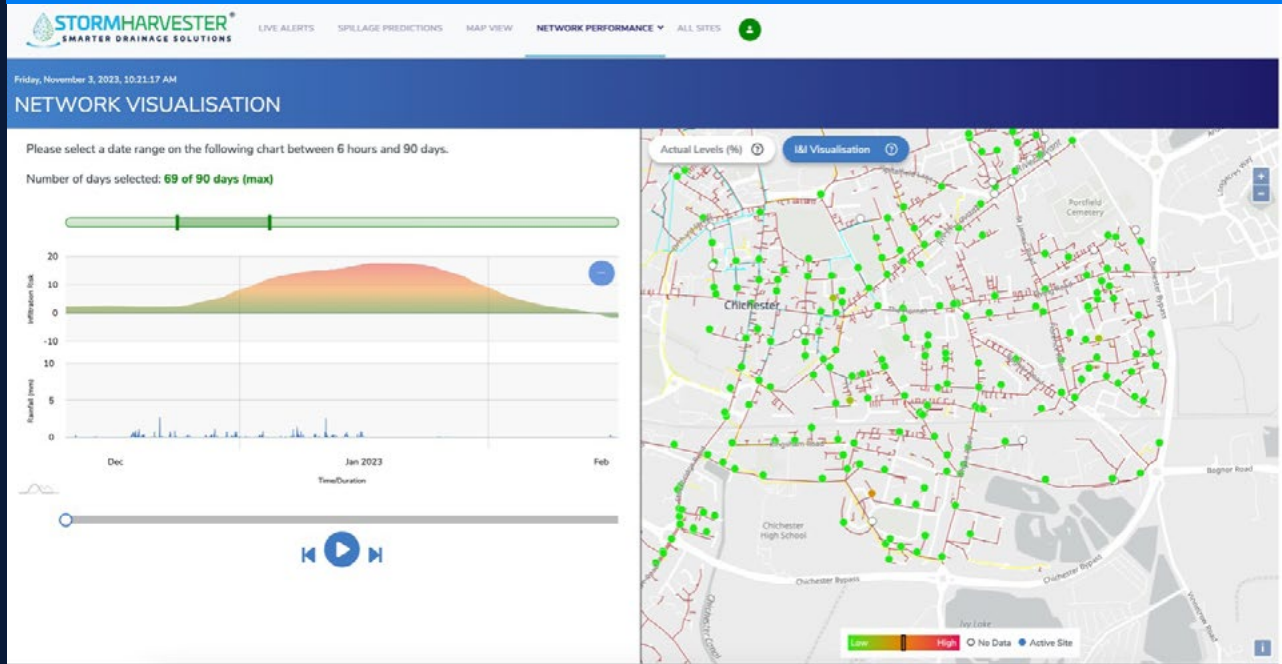
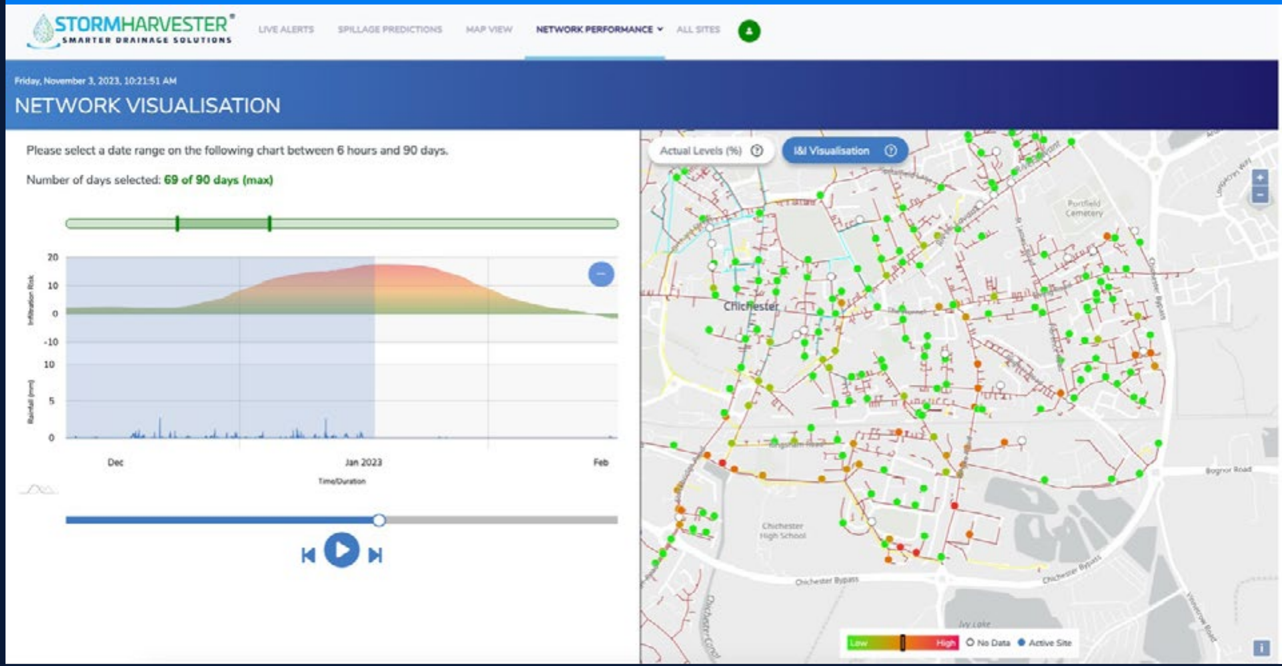


Figure 2

By comparison, this figure shows the middle of the visualisation, when the groundwater level is rising rapidly. Sensors where high levels of I&I are present appear in orange or red. This allowed us to identify the lines of sewer most impacted by I&I and the likely locations where I&I is entering the network.

Network visualisation – Middle of visualisation (high infiltration risk)



DATA

In order to verify the machine learning algorithms, the graphs in **Figure 3** and **Figure 4** were produced to analyse the raw sensor data. The graphs show the spill pattern at two Wastewater Treatment Works sites across three years. The machine learning algorithms identified I&I at site 2, but not at site 1.

Each red dot on the graphs represents a day the site has spilled, and the blue dots are days the site has not spilled. The first two graphs give an indication of the intensity and total rainfall each day respectively while the bottom graph shows the local groundwater level.

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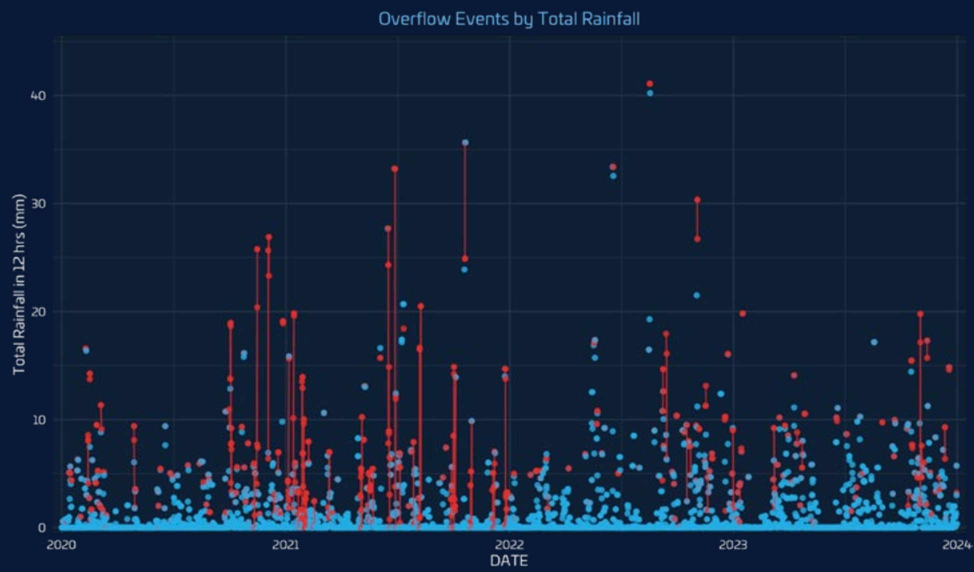
FIGURE 3

Site 1 overflow event analysis

No inflow and infiltration



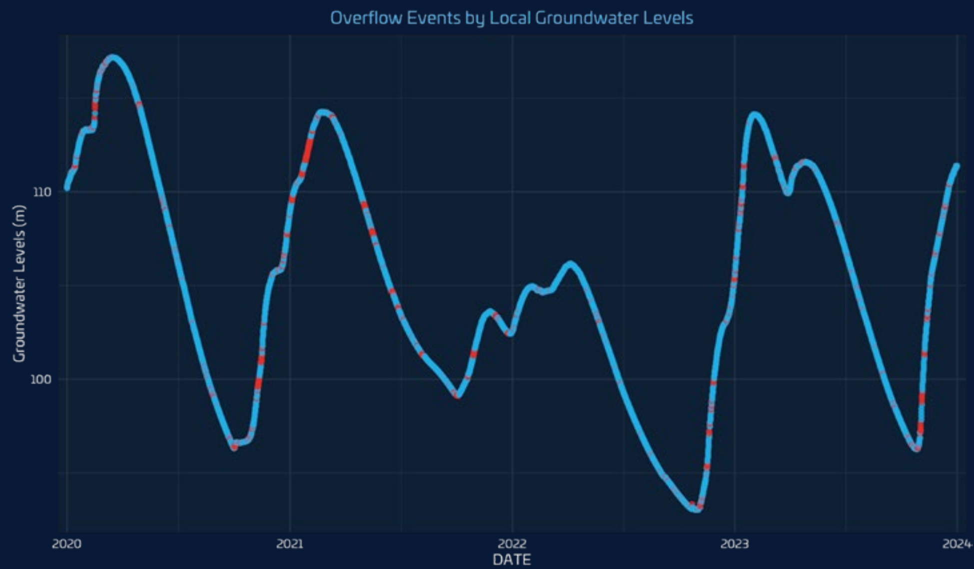


TABLE 1:

% Chance of Spilling with a x mm/hr rainfall event with no I&I detected.

% Overflow Chance with 5mm/hr Rainfall Event	**88**
% Overflow Chance with 10mm/hr Rainfall Event	**94**
% Overflow Chance with 15mm/hr Rainfall Event	**100**
% Overflow Chance with 20mm/hr Rainfall Event	**100**

SITE 1:
NO I&I

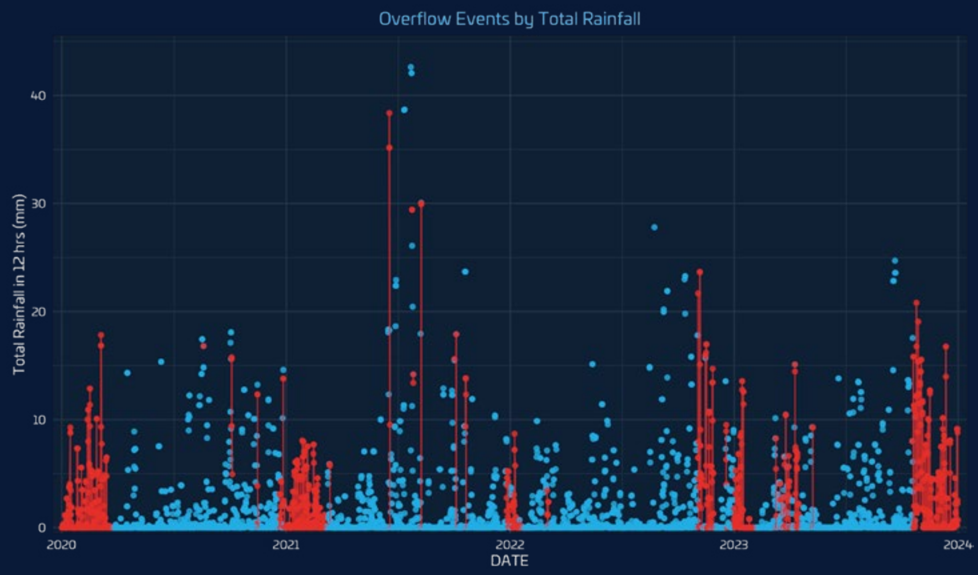
From the graphs in **Figure 3** it is evident that this site does not have capacity to deal with excess rainfall as it is spilling consistently throughout the year.

There are no seasonal patterns that correlate with groundwater levels, and there are little to no spills on dry days.

FIGURE 4

Site 2 Overflow Analysis

Inflow and infiltration Present



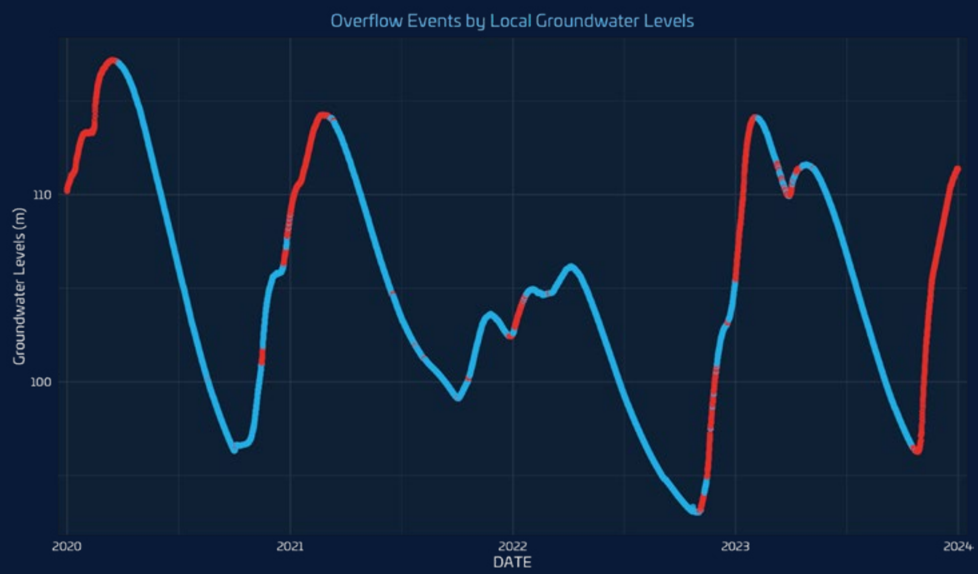


TABLE 2:

% Chance of Spilling with x mm/hr Rainfall Event at a site where I&I has been detected.

% Overflow Chance with 5mm/hr Rainfall Event	**40**
% Overflow Chance with 10mm/hr Rainfall Event	**43**
% Overflow Chance with 15mm/hr Rainfall Event	**38**
% Overflow Chance with 20mm/hr Rainfall Event	**9**

SITE 2:
I&I IDENTIFIED

This second site shows a different spill pattern where the spills occur disproportionally during the winter periods. The site spills every day for a long period every winter when the groundwater level rises, even on days with no rainfall. During the summer when groundwater is low, the site rarely spills and only when there has been significant rainfall.

THE RESULTS

Using the trained machine learning algorithms for all sensors in Southern Water, we discovered that a large number of spills came from a small number of sites, and 25% of spills occurred at sites with I&I present.

The correlation to rainfall was not directly apparent for I&I and further analysis found a correlation existed with levels and rates of change of groundwater sewer levels. If a site is reactive to rainfall, you would expect the site to not spill with lower quantities of rainfall and begin to spill with larger quantities.

At sites with I&I, such as site 2 in the previous example, the site doesn't spill during the summer months with larger rainfall events but spills continuously from January to April with considerably smaller rainfall events.

NEXT STEPS

This insight has proven to be invaluable to Southern Water and from this they have been able to create a more targeted WINEP – water industry national environmental plan.

This project has also allowed Southern Water to consider new solutions to reduce spilling. Rather than traditional solutions e.g. increasing the capacity of the network – there can instead be a focus on how to limit the I&I paths into the network. E.g. lining sections of the sewer network or locating and removing old connections from local springs and streams.

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