Sydney Water Innovations in Acoustic Sensing – Small Mains

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What do leaks and breaks mean for Sydney Water?
- Sydney Water experiences around 6,500 leaks annually
- 8% of unaccounted water loss
- 60%-70% of leaks in small distribution pipes
- 175 breaks are on critical water mains
- $80 million spent on renewals and maintenance

How does Sydney Water handle leaks and breaks?
- We rely on our customers and staff to report leaks and breaks
- Reactive measures
Context

Improving Leak Detection – a Sydney Water-UTS collaboration

• Machine learning based pipe failure prediction has been used to prioritise siting of the 229 permanent acoustic sensors across five Central Business District (CBD) areas since December 2019.

• A MNF driven analysis has led to 150 lift and shift sensors being deployed across three small pressure zones (<2500 properties).

• Data from acoustic sensors has been analysed, with signal processing algorithms developed to automate the analysis and increase the reliability of leak alarms.

• A web portal has been developed, which hosts the data from the range of acoustic sensor models in one location for ease and efficiency within Sydney Water's wider IT systems.
Methodology and Process

Pipe failure prediction tool
Acoustic sensors
Common web portal
Use of pipe failure prediction model

- 80% of the predicted failure locations are within 200 m to the actual failures
- Capability to forecast and plan water main maintenance with high confidence predictive analytics.

![Graph showing distance of predictions to actual failure locations (m)](image)

- Attribute-based map layers
- Tree canopy map layers
- Topography map layers
Pipe prioritisation for sensor deployment

- Sydney Water and UTS have developed a data-driven solution for pipe failure prediction.
- The solution consolidated domain knowledge and advanced machine-learning techniques to obtain a cost-effective approach to water pipe failure prediction in the water network.
- The developed failure prediction tool is used to prioritise the high-risk pipes for sensor deployment.

Pipes are selected based on:
- Pipe material (DICL and CICL)
- Year laid (before 1990), and
- Pipe diameter (</=300 mm)
**Acoustic sensors: Deployment process**

1. Logger locations planned in GIS
2. Deployments rolled out - sensor provider technicians and Sydney Water Network technicians
3. Sensor data and automatic leak alerts available in online portals (sensor providers)
4. Advanced interpretations for leak detection (UTS analysis)
1. Logger locations planned in GIS
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Acoustic sensors: Deployment process
Acoustic sensors: Logger deployments

- >200 permanent loggers deployed across Sydney (targeting CBD areas)
  - First deploy in Sydney CBD Dec 2019
  - Other areas rolled out between March – May 2020
- >100 L&S loggers deployed in three discrete pressure zones
- Sensors are installed on pipeline fittings, e.g. hydrants, valves.
- Data recorded 2-4am for analysis
Acoustic sensors: Individual web portal leak alarms and limitations

- Sensor portals provide automatically generated leak alerts which are raised based on noise level thresholding
  - LOTS of false positive leak alarms
  - AND! No leak alarms for "quieter" leaks
- UTS screens data weekly to determine likelihood of leakage
- Time and frequency domain signal processing

Sebalog N-3 signal processing example - before and after repair of leak found in Liverpool, caused by a hole on a 50mm service; spectrograms (left), power spectrum density plot (right)

HWM leak alarm level & spread threshold

Von Roll leak alarm - Simple noise threshold

Primayer leak correlation alarms
Web portal system
Results
Permanent acoustic sensors: Deployments and leak locations

Sydney Water online acoustic sensing success in CBDs

(Updated 19 April 2021)

Leaks found
- Hydrant ~25%
- Main tap ~25%
- Private ~17%
- Valves ~17%
- Service ~10%
- Main break ~4%
- Meter tap ~2%

Acoustic sensors and (+pressure transient sensors)

Online leaks detected

Leak types:
- Hydrant ~25%
- Main tap ~25%
- Private ~17%
- Valves ~17%
- Service ~10%
- Main break ~4%
- Meter tap ~2%
Permanent acoustic sensors:
Learnings from sensor data - Quiet leaks

- Loggers SWP12/13 in Penrith – not flagged by HWM system as a leak until noise was significantly louder
- UTS analysis revealed likely leak present ~end Nov 2020
- SW field investigation located leaking disconnected main tap ~end Feb 2021
- UTS analysis revealed further likely leak present early March 2021

Persistent leak noise after repair
Permanent acoustic sensors: Learnings from sensor data – False positives

- Loggers SWCBD44 in Sydney CBD – flagged by HWM system as a leak.
- UTS analysis revealed NO likely leak present (noise too inconsistent) & logger located between two major construction sites for new metro stations with 24 hour underground drilling starting early 2021.
- SW field investigation – no leaks found.

SW field feedback

UTS analysis

Previous confirmed leaking hydrant

Non-leak noises
Permanent acoustic sensors: Results overview – Leaks found

Since Dec 2019, in 5 CBD areas:
• 79 possible leaks detected
• 59 leaks confirmed
• 2 main breaks confirmed
• ~60% of leak locations match with pipe failure prediction tool model
• Most leaks were hidden (not surfacing), some discharging into stormwater pits
Lift & Shift Acoustic Sensors:
Leaks detected in three pressure zones

Wahroonga - Meter tap leak

- **40 Primayer Enigma**
  - 6 leaks confirmed
  - 1 potential private leak awaiting further investigation

- **100 Gutermann ZoneScan 820**
  - 3 leaks confirmed – visible & small

- **70 HWM PCorr+**
  - 0 leaks detected
  - Main users assessed no contribution to MNF

- **70 HWM PCorr+**
  - 7 leaks confirmed
  - 2 main breaks confirmed

Bantry Bay – Hidden main break

16 leaks
2 main breaks
Most leaks were hidden

Bantry Bay – Hidden main break
Common web portal

- UTS has developed a web portal that consolidates all six sensor providers' sensor data. It can also incorporate the pipe failure prediction tool to produce regular reports on leaks and high-risk pipes.

- The web portal is comprised of the following components:
  - Dashboard: on sensors, e.g., sensor IDs, asset IDs, alarm status, pressure zones, etc.
  - Map view: visualises the sensor data on a map viewport. End-users can zoom out the map to check more details.
  - List view: shows the sensor data in list format. Filter functions are also provided.
Value

- Total estimated savings:
  - 3564.32 ML
  - $7.98 M
- An estimated 700ML/year, $3M in water production costs have been saved in the Sydney CBD alone
- Savings will increase with the growth of sensor deployments
- Validated model predicting 80% failures within 200m
- Validation process of preventive leaks successful
- Sydney Water has a plan to install sensors in 118 small zones and a few larger zones
Conclusions

- Integration of acoustic sensors are a proactive solution to detecting hidden leaks
- Prediction using machine learning will reduce sensor false alarms and provide reliable leak alerts
- Common web portal from the business leads as usual
- Sydney Water will reduce
  - customer disruption
  - reduce unaccounted water loss
  - allow proactive targeted by correlation.
- Acoustic sensing will be integrated into the active leak detection program
- Acoustic sensing adaptation and the related know how is world class innovation in action