PUB SINGAPORE'S NATIONAL WATER AGENCY

Managing Singapore's Used Water Network

Wong Kin Wee
Principal Engineer
Water Reclamation (Network) Department0

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- Singapore's Water Loop and Used Water Network
- Overview of Public Sewerage System
- Objective of Sewer Analytics & Management System (SAMS)
- Ultrasonic-Pressure Hybrid Sensors
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- Presentation by DHI Water & Environment

PUB's Water Loop

PUB's used water network is part of the water loop that we manage

From sourcing, collection, purification and supply of drinking water, to treatment of used water and turning it into NEWater, drainage of storm water

3 Strategic Objectives of the Water Reclamation Network

- Public health
- Prevent pollution to environment
- Safeguard used water as a resource

Singapore's Public Sewerage System

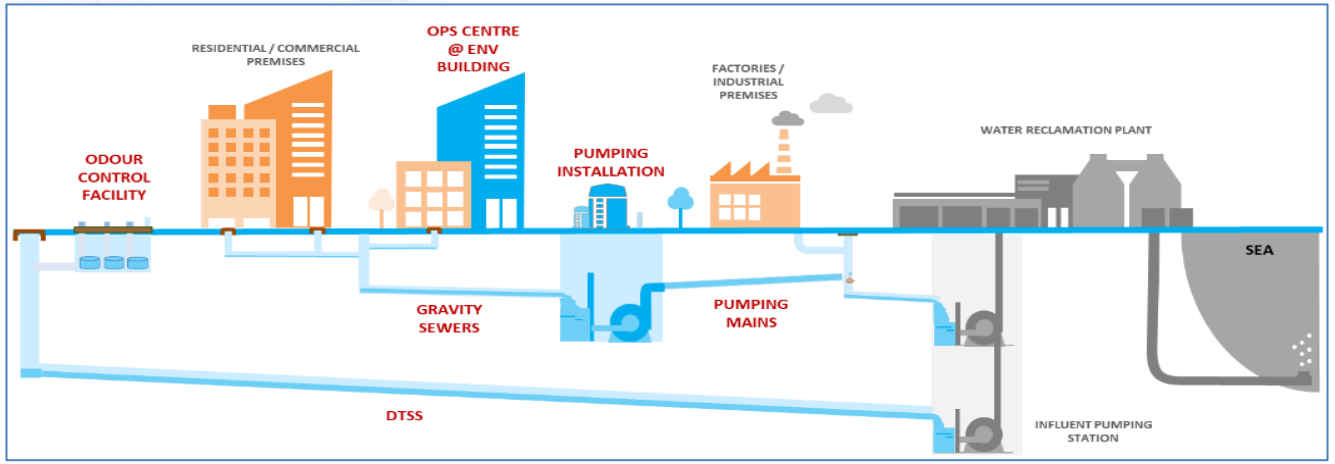
Key Figures

3,600 km of Sewers & 100,000 Manholes

48 km of DTSS Tunnels

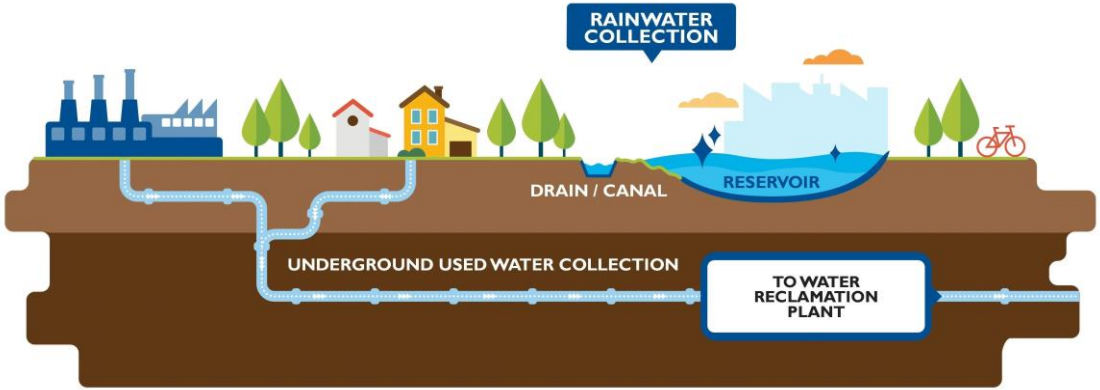
10 Odour Control Facilities

72 Pumping Installations & 70 km of Pumping Mains



Used Water Network as A Separate System

- Separate collection systems for used water and rainwater
- Used water – Recycling to become NEWater
- Rain water – Treatment to become potable water
- Maintenance to prevent overflows and safeguard public health

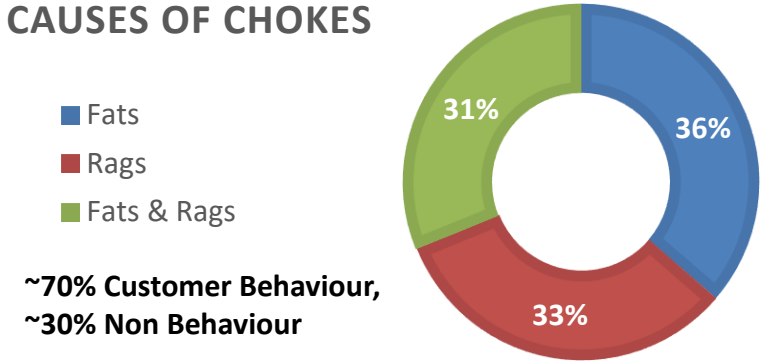


Sewerage (used water)

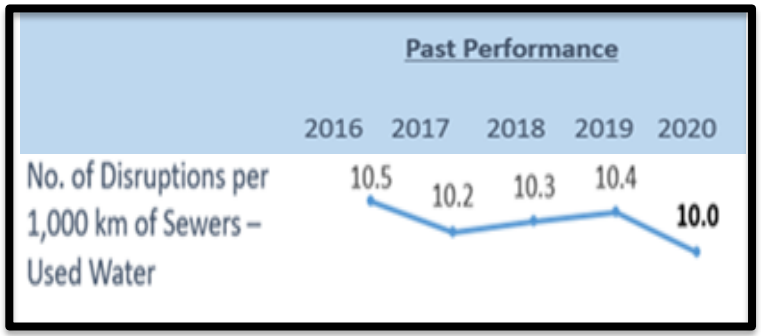
Drainage (rainwater)

Causes of Chokes and their Causes

CAUSES OF CHOKES



~70% Customer Behaviour,
~30% Non Behaviour



$$Service\ Disruption\ Index = \frac{No.\ of\ Service\ Disruptions * a\ month}{1000\ km\ of\ sewers}$$

Hardened Grease

Rags

How are we Tackling Behavioral/ Non- Behavioral Issues

Behavioral

Active Engagement of public through:

Digital Message Boards at Lift Lobbies

Road Shows/ Exhibitions

Engagement at premises

Non - Behavioral

Inspection and sampling at premises

Routine Cleaning

Topic Focus

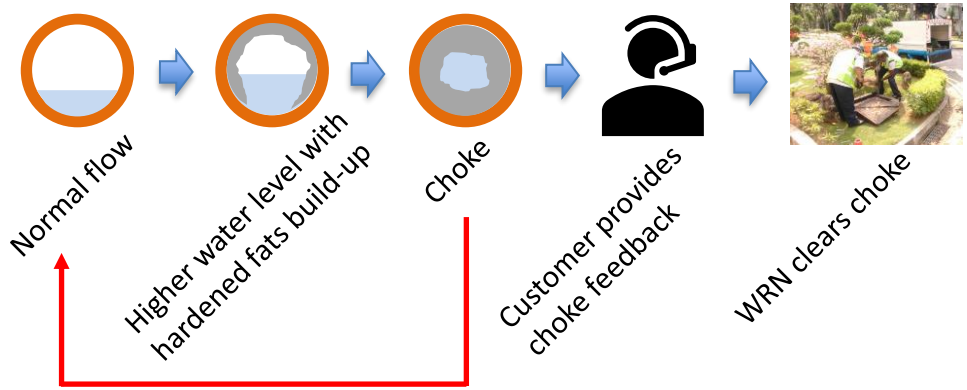
How PUB intends to Improve How We Carry Out Maintenance

Currently:

- Reactive
- Relying on choke feedbacks to identify problematic locations
- Sewers with > 2 chokes / yr will be placed under routine cleaning

Future:

- Proactive
- Flush sewers more frequently
- Flush before choke occurs



★ Flush before choke occurs

PUB
Water for All: Conserve, Value, Enjoy

DHI

Sewer Analytics Management Systems (SAMS)

Reduce Chokes

by monitoring and predicting fats build-up through **3 Pronged Approach**

Primary Approach: Sensors

Reduce chokes by detecting water level buildup in sewers through a network of sensors and taking pre-emptive action

Secondary Approach: Machine Learning

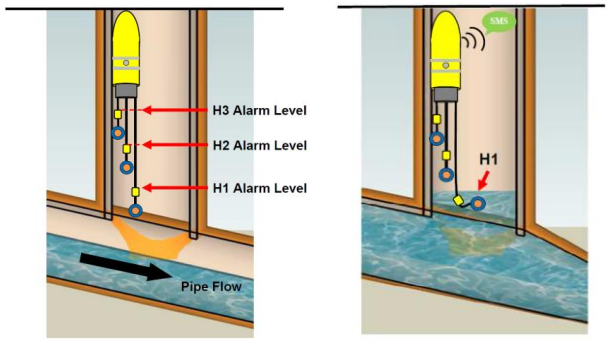
Use ML to predict sewers that are likely to choke and inspect pre-emptively

Tertiary Approach: Cleaning Scheduler

Augment the primary approach by dynamic scheduling of routine sewer cleaning before chokes occur

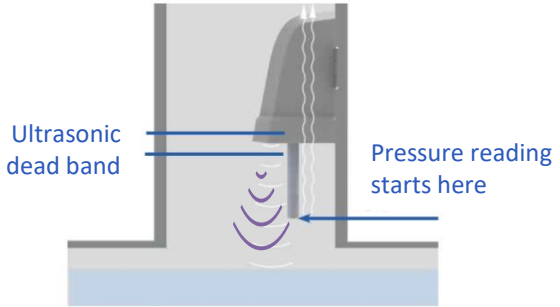
Primary Approach: Ultrasonic-Pressure Hybrid Sensors

Currently in Use:
Float switches



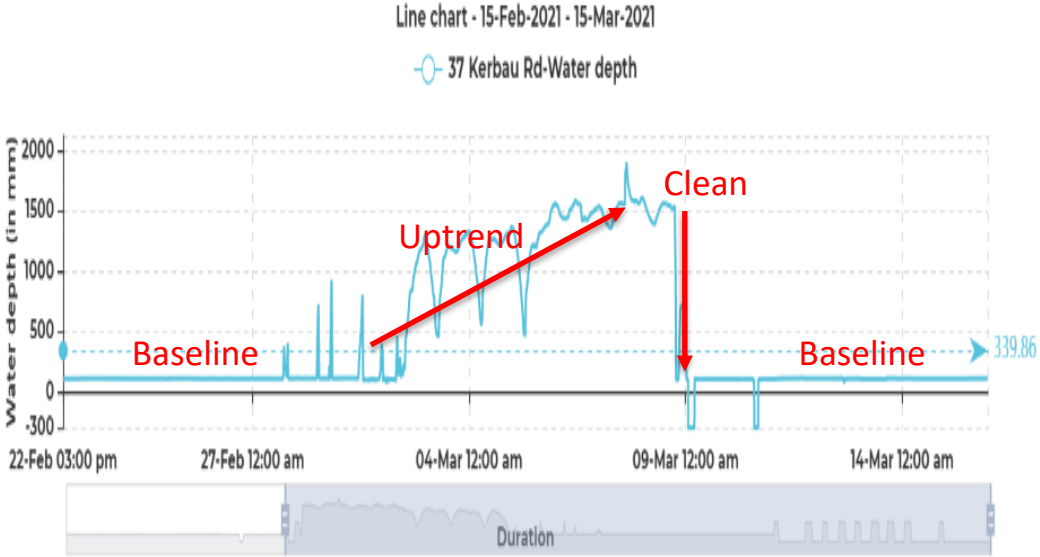
- Discrete levels
- Alerts after water levels exceed the crown of the pipe

Tested :
Ultrasonic – pressure hybrid sensors

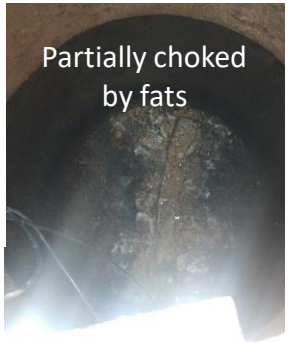


- Continuous data
- Able to show the changes in water level with time

Ultrasonic-Pressure Hybrid Sensors: Use Case

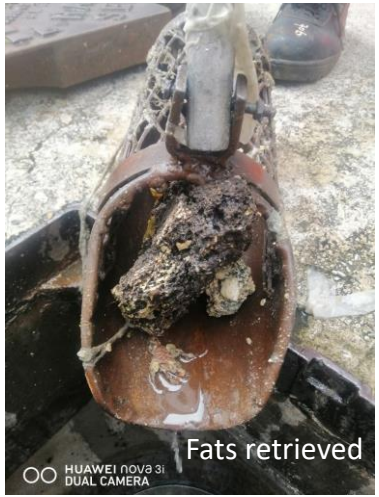


- Detects increases in water level from baseline
- Automated alerts
- Provides high resolution data for analysis



Ultrasonic-Pressure Hybrid Sensors: Chokes Prevented

~10 chokes detected and cleared during 1 year period (20 sensor installed within Proof of Concept zone)



No.	Date	Location
1	10 Dec 2020	67 Kerbau Road
2	8 Mar 2021	37 Kerbau Road
3	8 May 2021	Lor 34 Geylang
4	28 May 2021	268 Geylang Road
5	2 Jun 2021	Campbell Lane
6	4 Aug 2021	Adam Road FC
7	26 Oct 2021	Adam Road FC
8	3 Jan 2022	Adam Road FC
9	7 Jan 2022	37 Kerbau Rd
10	8 Jan 2022	93 Lavender Street

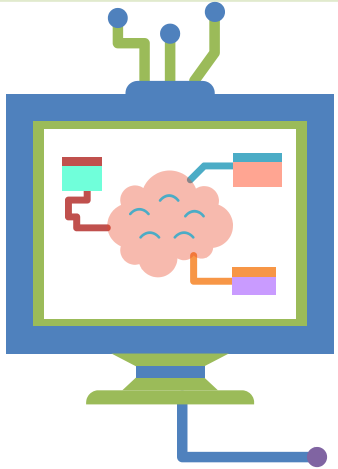
Secondary Approach – Machine Learning

Inputs

- Rainfall
- Cleaning records
- Float switch sensors
- Water consumption
- Choke records

Data-driven predictions

- Use past years of data train ML model to predict chokes
- Constant retraining with new data
- Monthly choke prediction list
  - Prioritised for inspection & maintenance



Inspection Priority (update: 16/03/2022)

Search

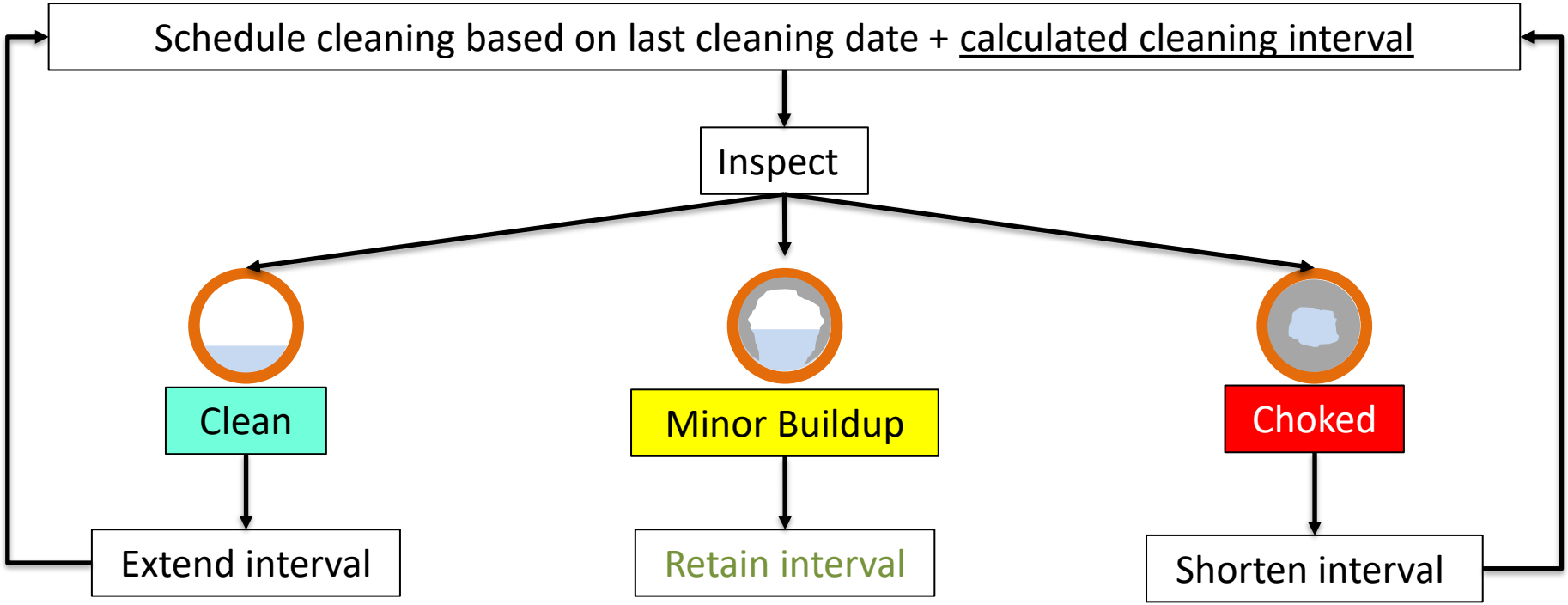
Subcatchment	SID	Area	RENE	Inspection Priority	Postal Code	Address
KC-TN87	3410850	KC	Yes	1	207713	SYED ALWI ROAD
KC-TN108	169819	KC	Yes	1	321106	JALAN RAJAH
KC-TN87	148647	KC	Yes	1	207710	SYED ALWI ROAD
KC-TN87	148648	KC	Yes	1	207278	VERDUN ROAD
KC-TN87	148869	KC	Yes	1	207713	SYED ALWI ROAD
KC-TN87	3405245	KC	Yes	1	207721	SYED ALWI ROAD
KC-TN87	3409078	KC	Yes	1	207713	SYED ALWI ROAD
KC-TN108	169814	KC	Yes	1	320107	JALAN RAJAH

Output

- **Choke prediction**

Tertiary Approach - Dynamic Cleaning Scheduler

Adjusts routine maintenance schedule according to choke & cleaning data



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Thank You

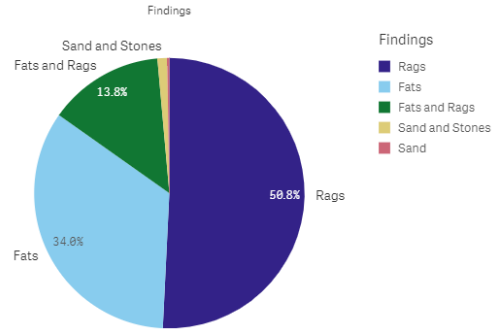
SAMS Machine Learning

Veradej Phipatanasuphorn
2022-03-14

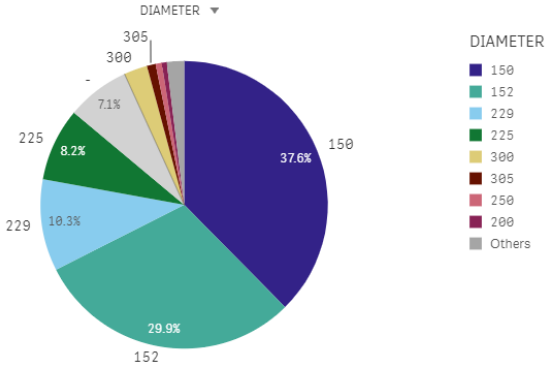
Machine Learning Problem Statement

- Predict Potential Choke Locations in Advance
  - Extreme event forecasting – happened only at the same pipe a few times in a year or many years)
  - Choke process is not always deterministic – Rags, Fat, Sands, etc.

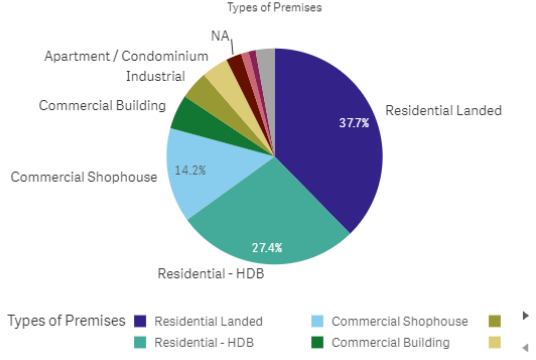
Findings



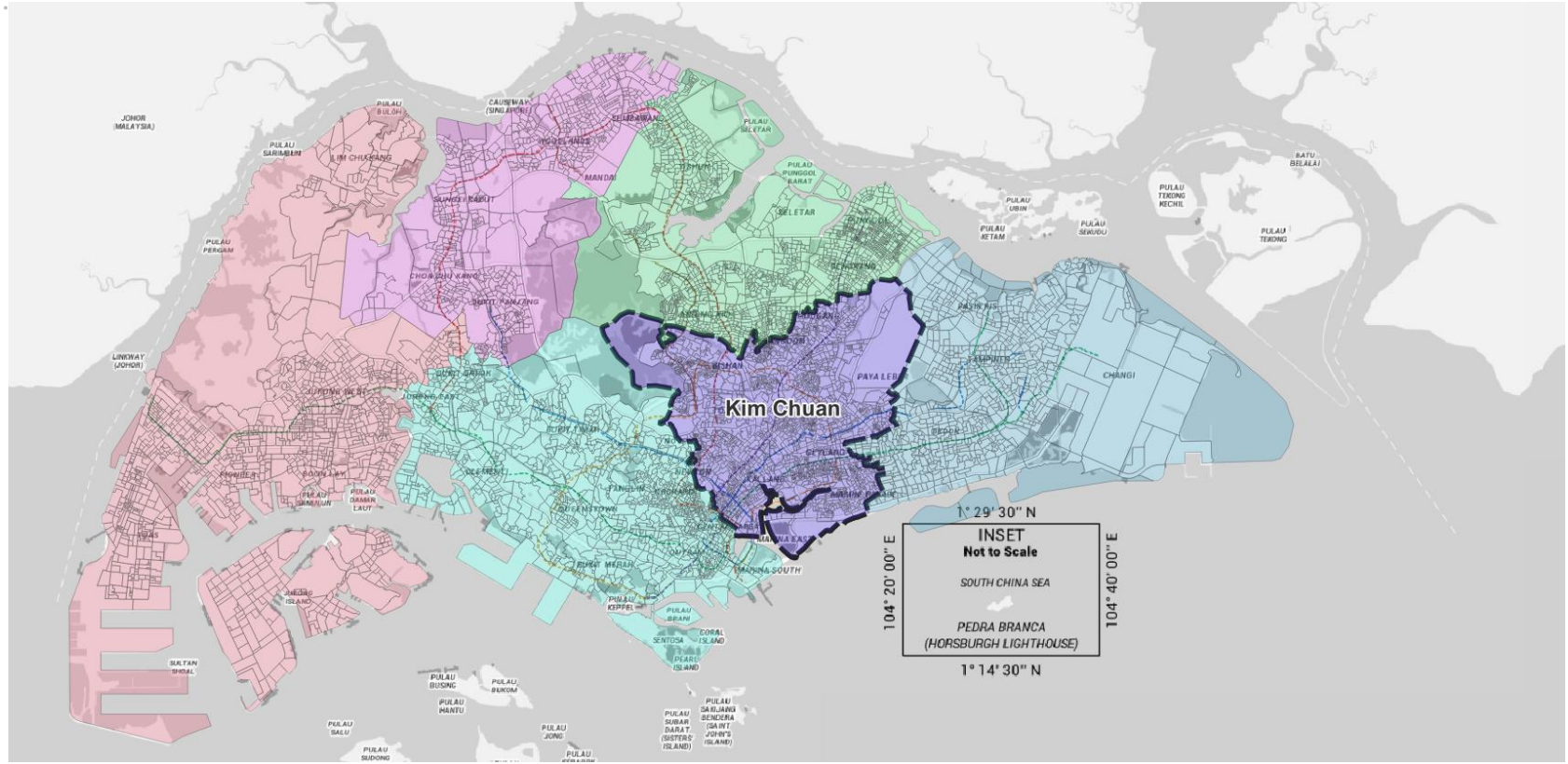
Diameter



Types of Premises

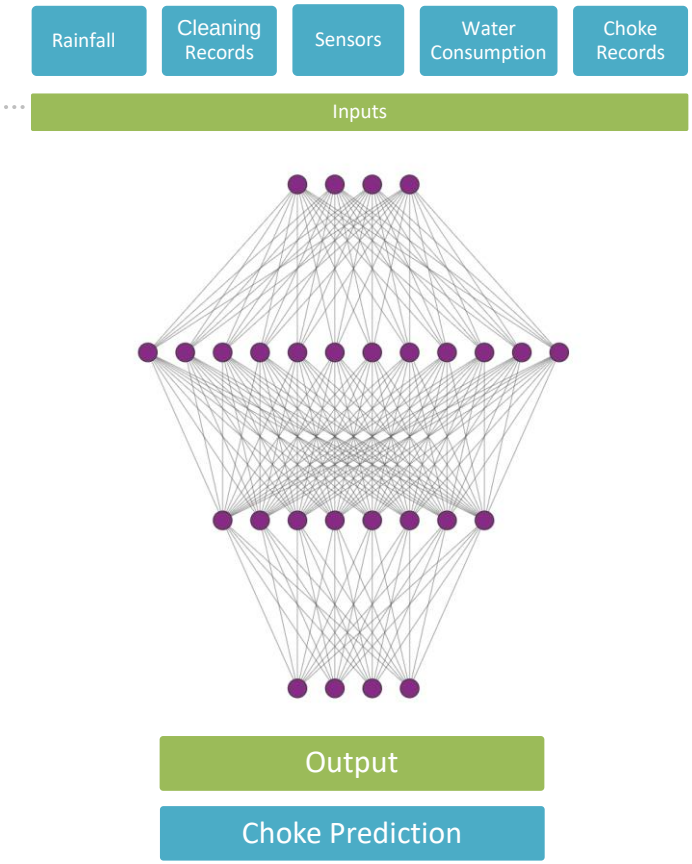


Machine Learning – Proof of Concept Area (Kim Chuan Catchment)

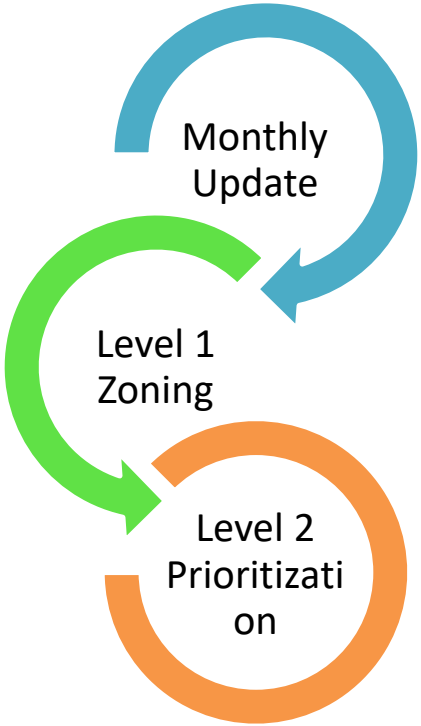


Machine Learning Methodology

- Identify key features that influence the choke incidents
- Select best model to key features with the choke incidents
  - Train, Test and Verify
- Make use of data from 2017 – present
- Prediction outcome is used to prioritize inspection & maintenance of pipes



Machine Learning (Neural Network)



Update Data

Cleaning records, choke cases, rainfall, ReNe (level sensors), water consumption

Sub-catchment level Prediction (LSTM-Long/Short term memory)

To identify area of attention at sub-catchment level (more information)

Pipe level Prediction (LSTM- Long/Short Term memory)

To identify pipes for high-priority pipes within sub-catchment

Machine Learning outcome in Kim Chuan Catchment (Hit Rate)

ML ranks its predictions into 7 priority levels
Priority 1 has the highest likelihood to choke
Only 1-4 are checked with the available resources

Hit Rate

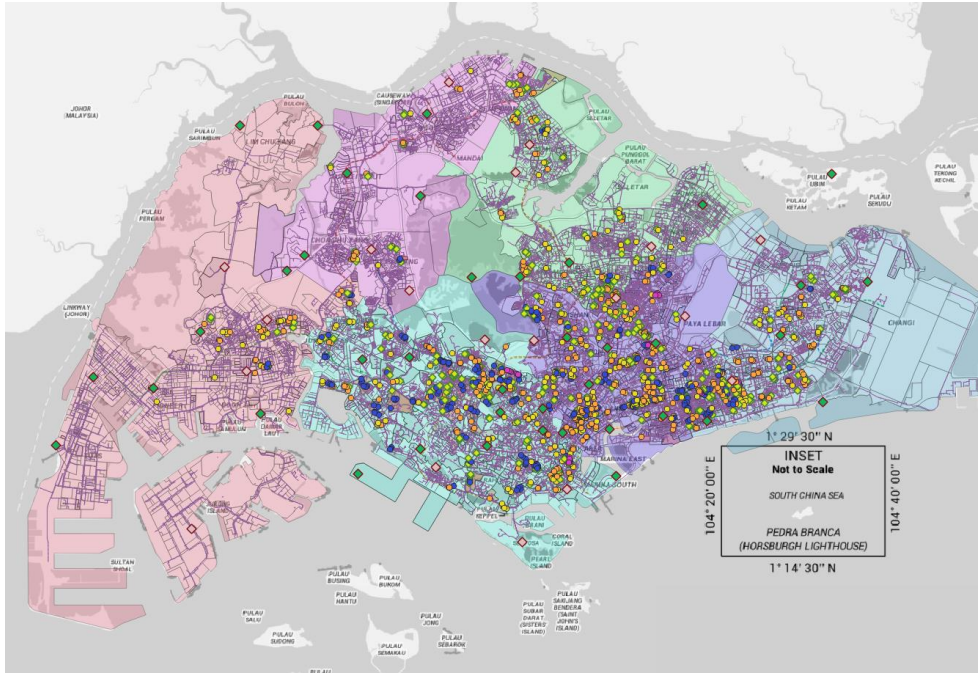
Month	**Predictions** (Total no. of predictions from ML)	**Checks** (Priority 1-4 out of 7 only)	**Chokes** (full and partial)	**Hit rate** $\frac{\text{Chokes}}{\text{Checks}}$
Aug 2021	420	65	3	5%
Sep 2021	422	11	3	27%
Oct 2021	421	31	0	0%
Nov 2021	460	24	3	13%
Dec 2021	433	21	2	10%
Jan 2022	467	44	7	16%
Feb 2022	539	22	1	5%
Mar 2022	491	23	9	39%

Similar ML study for Sydney Water has accuracy of 10 - 40% with 13 years of training data (2001 – 2014).

Machine Learning Challenges and Future Plan

- Key Challenges for ML model
  - Need lots of data
  - Produced balanced training data for rare events

- Future Plan
  - Deploy sensors for entire Singapore
    (Currently only for Kim Chuan Catchment)
    Expand ML prediction for entire SG
  - Improved ML prediction with targeted type of choke and better sensor data → Further optimized pre-emptive Cleaning



Thank you