GHD Digital

→ **Jane Hancock**
Water, Digital, Innovation

Consequence Assessment of Catastrophic Watermain Failures

Welcome

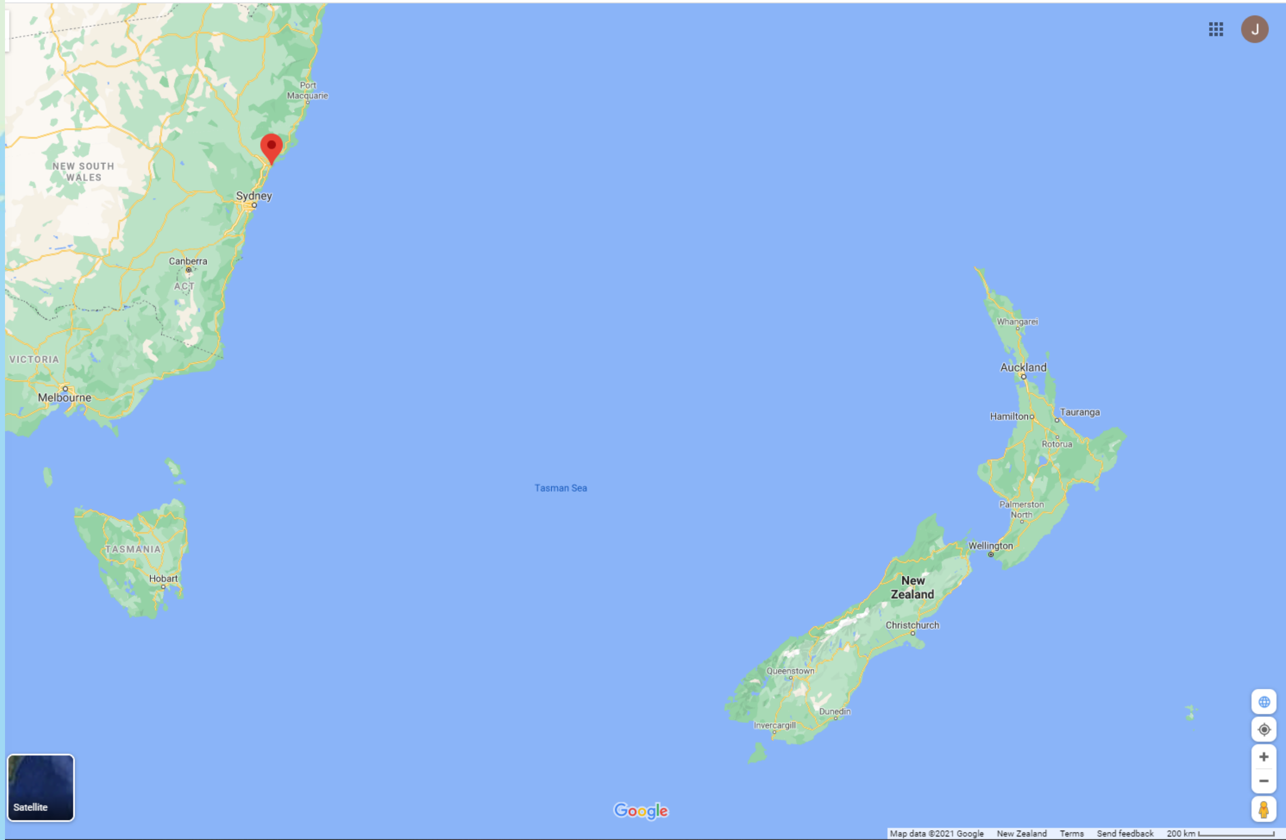
Contents

Introduction

→ How it all started

Hunter Water

- Newcastle area of NSW
- 600,000 customers
- > 5,000 km of water pipes



The Problem

Image: Newcastle Herald

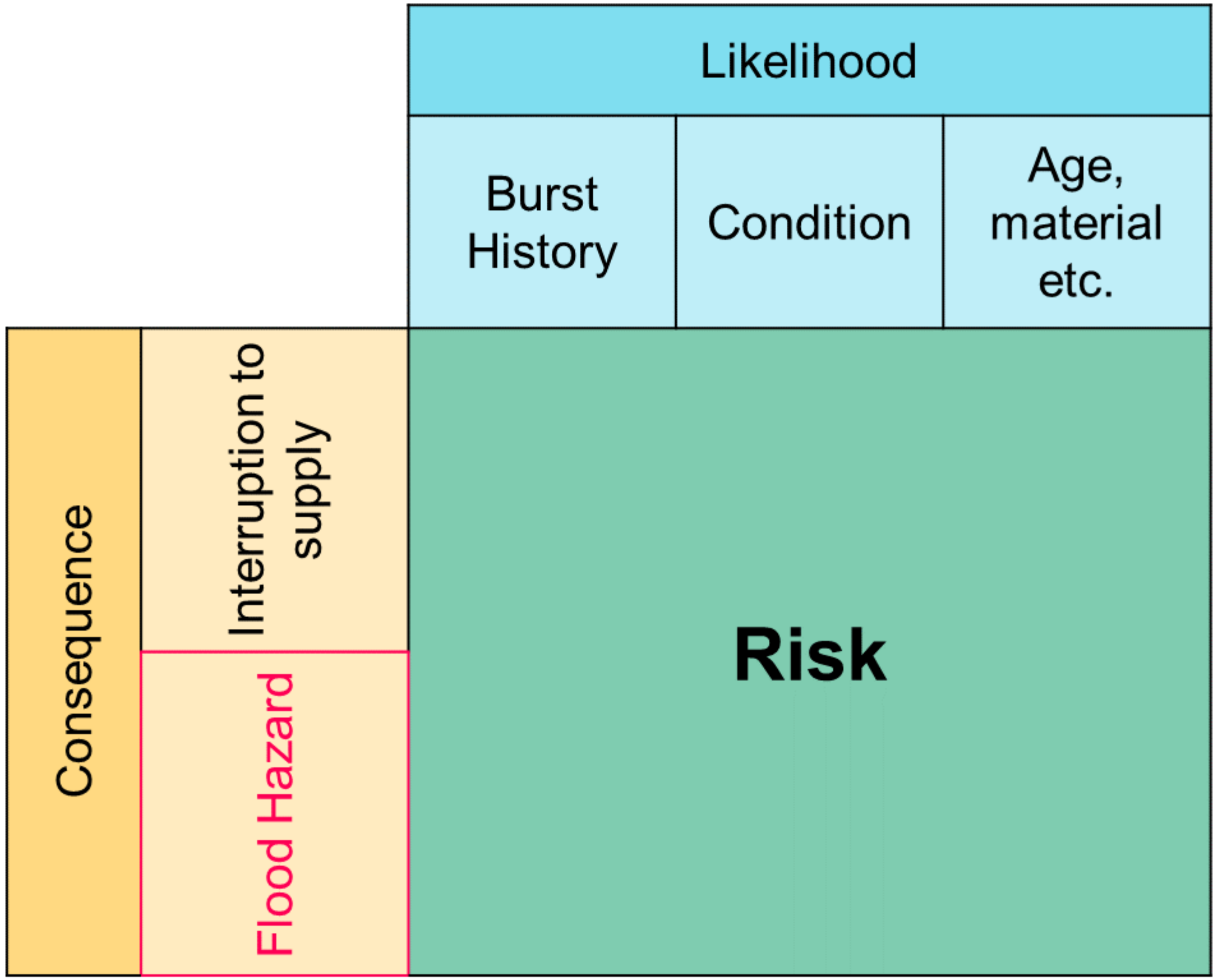
“Water main bursts, flooding homes at Elermore Vale”

– Newcastle Herald, September 2017


Image: Newcastle Herald

“Carpets have been pulled out and one woman was taken hospital… after burst water main”

– Newcastle Herald, March 2018



Flood hazard:

- Damage to property and other infrastructure
- Community safety risks due to overland flow
- Traffic disruption

Client Requirement

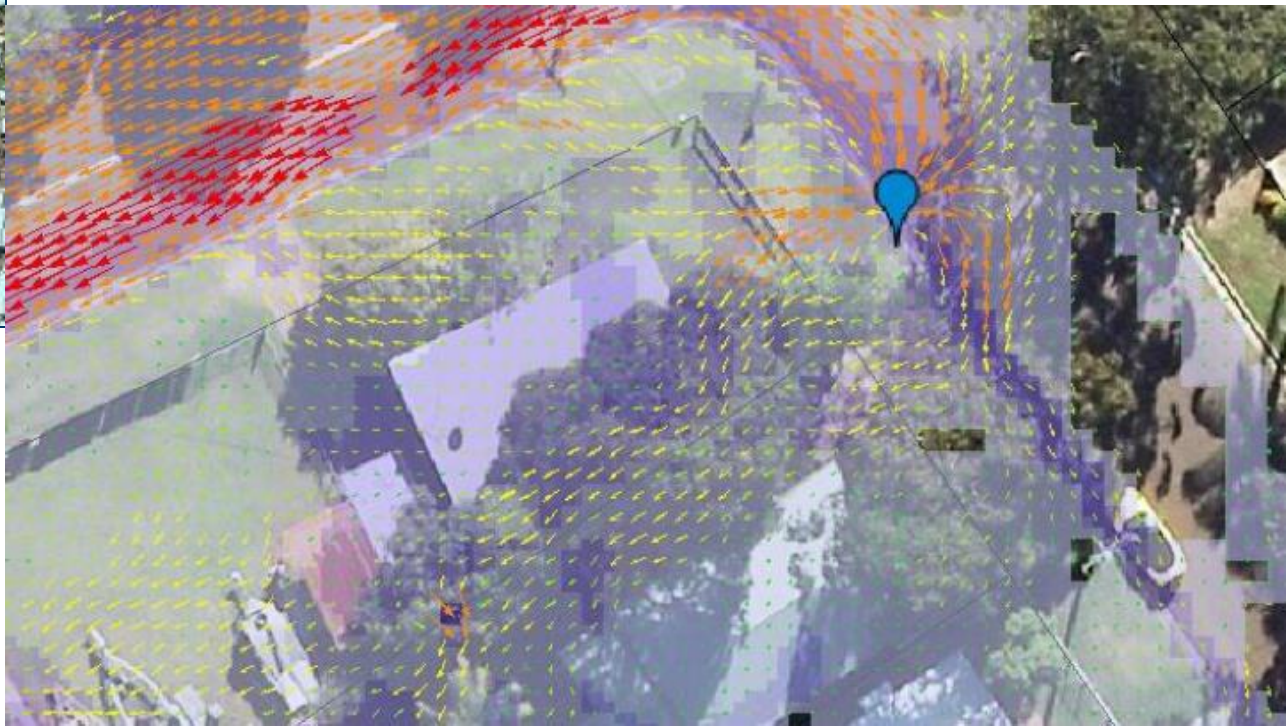
- An understanding of the consequence of watermain bursts in terms of flood hazards
- An ability to identify high risk assets in order to prioritise maintenance and renewals funding

Image: stuff.co.nz

The Solution in a Nutshell

Build > 57,000 models using TUFLOW to simulate the flood hazard caused by watermain bursts every 5 m. Use GIS processing, Python scripting and machine learning to automate model build and analysis of results.

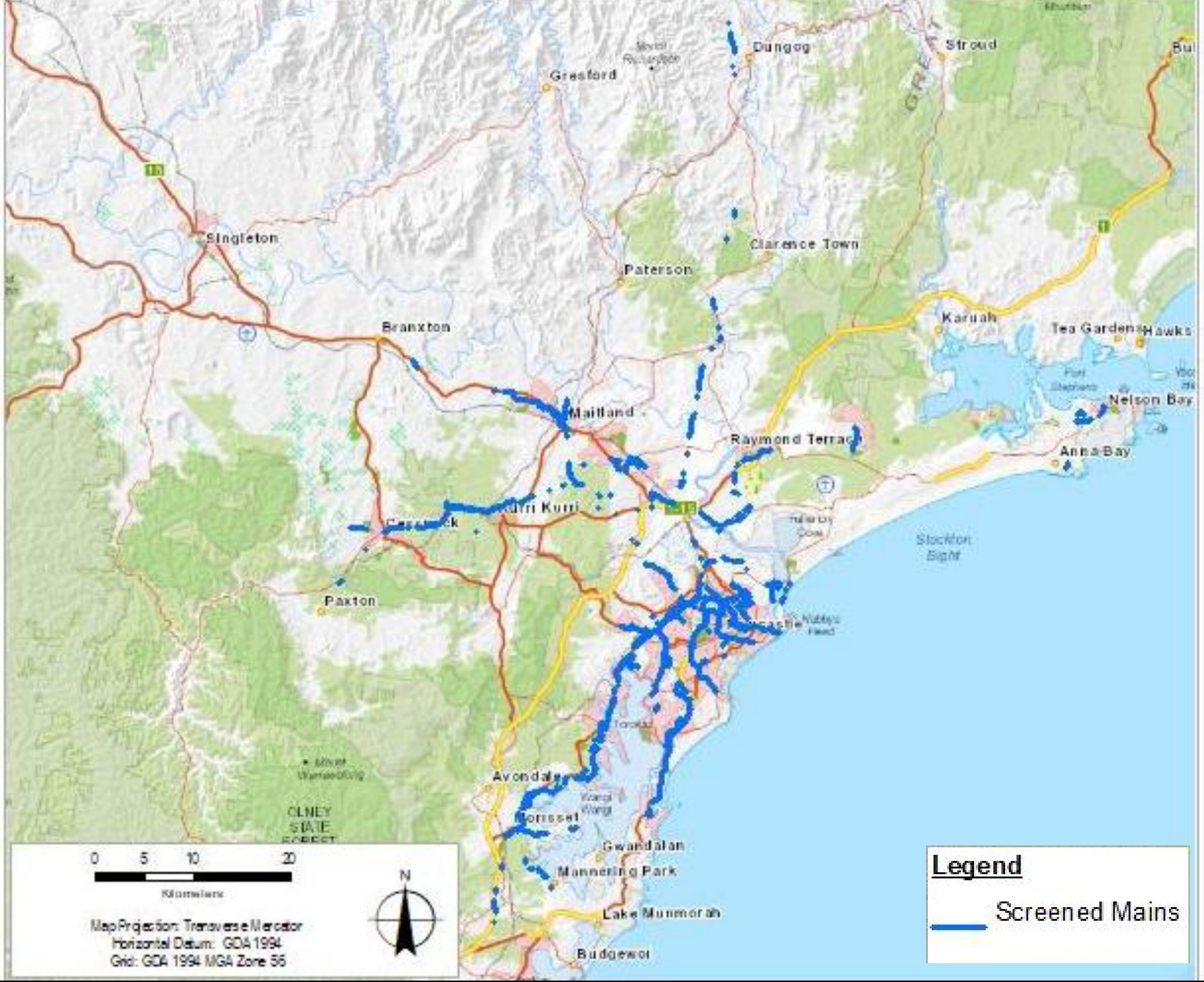
- Quantify flood hazard
- Consequence score for each section of main
- Combined with likelihood to give risk rating
- Identify areas of high risk



Methodology

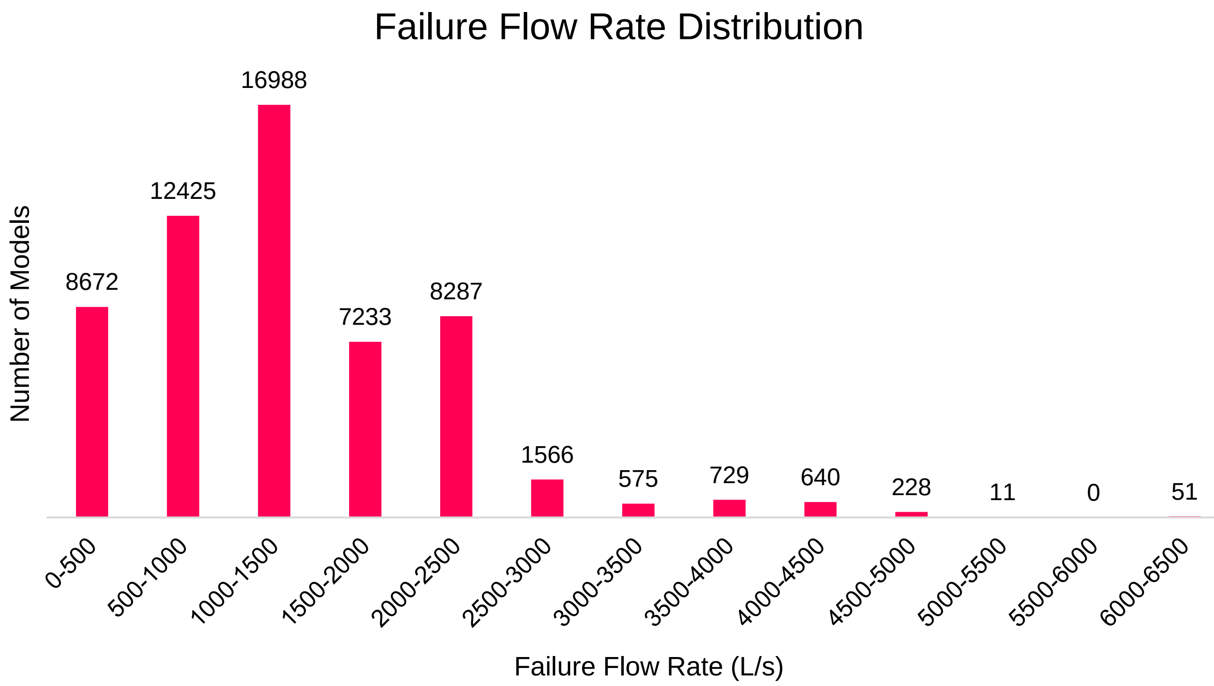
→ What we did

Initial Screening & Failure Flow Rates



Initial Screening

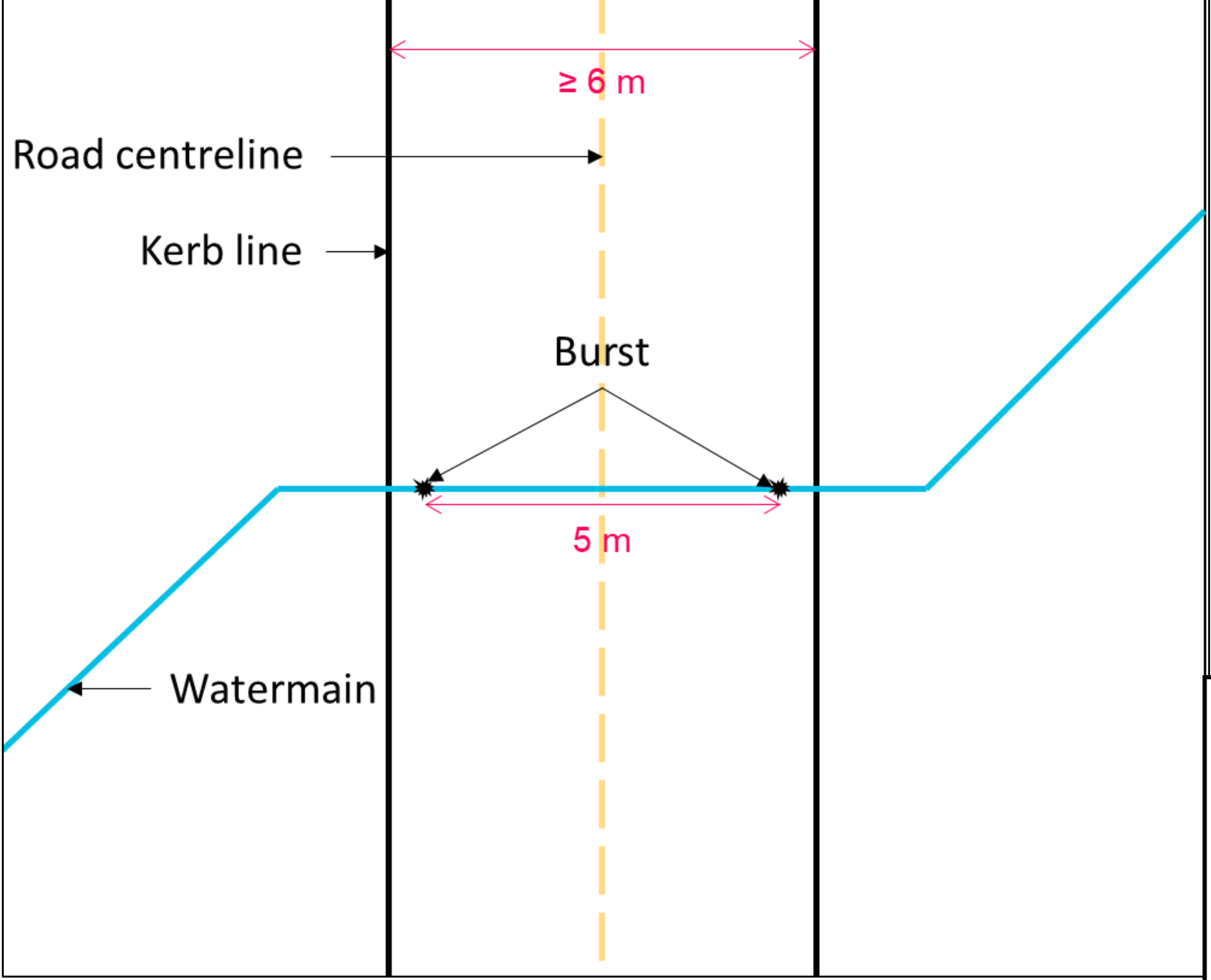
- Pipe capacity check: 5041 km > 640 km
- Proximity to buildings check: 640 km > 271 km
- Buildings downstream check: visual audit



Failure Flow Rates

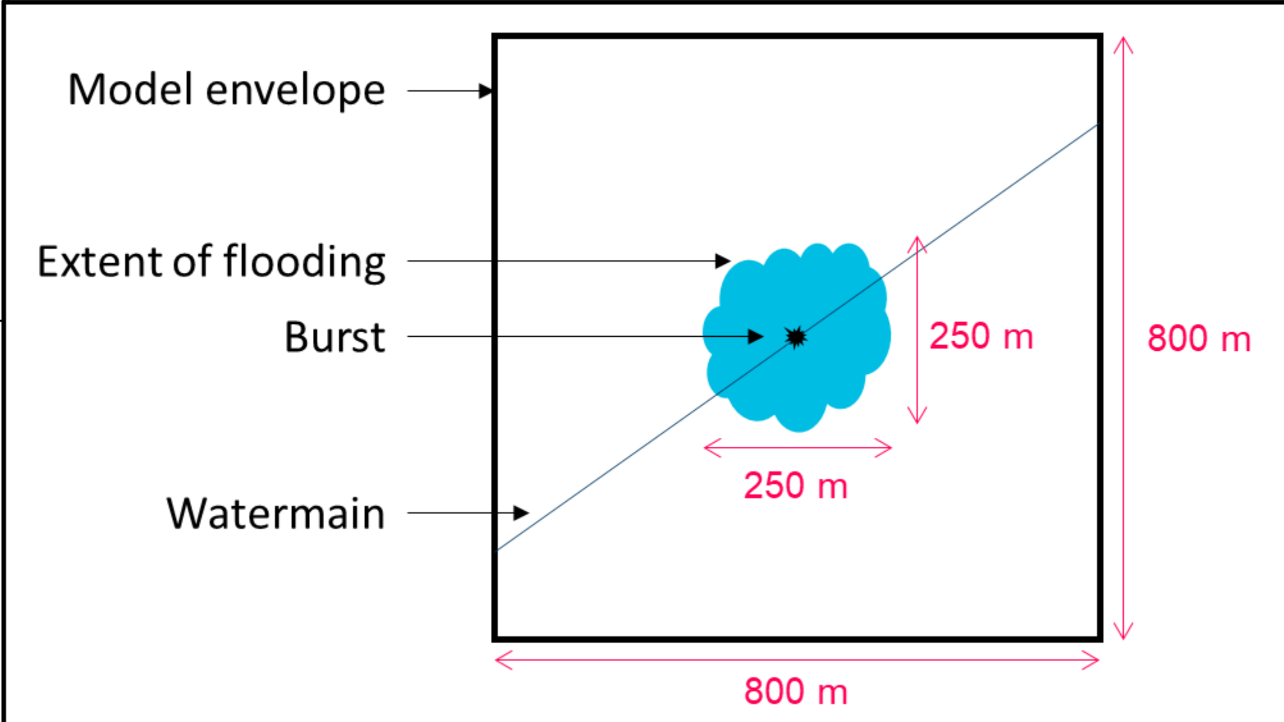
- Discharge coefficients of breaks estimated and calibrated
- Flow rates based on modelled operating pressures

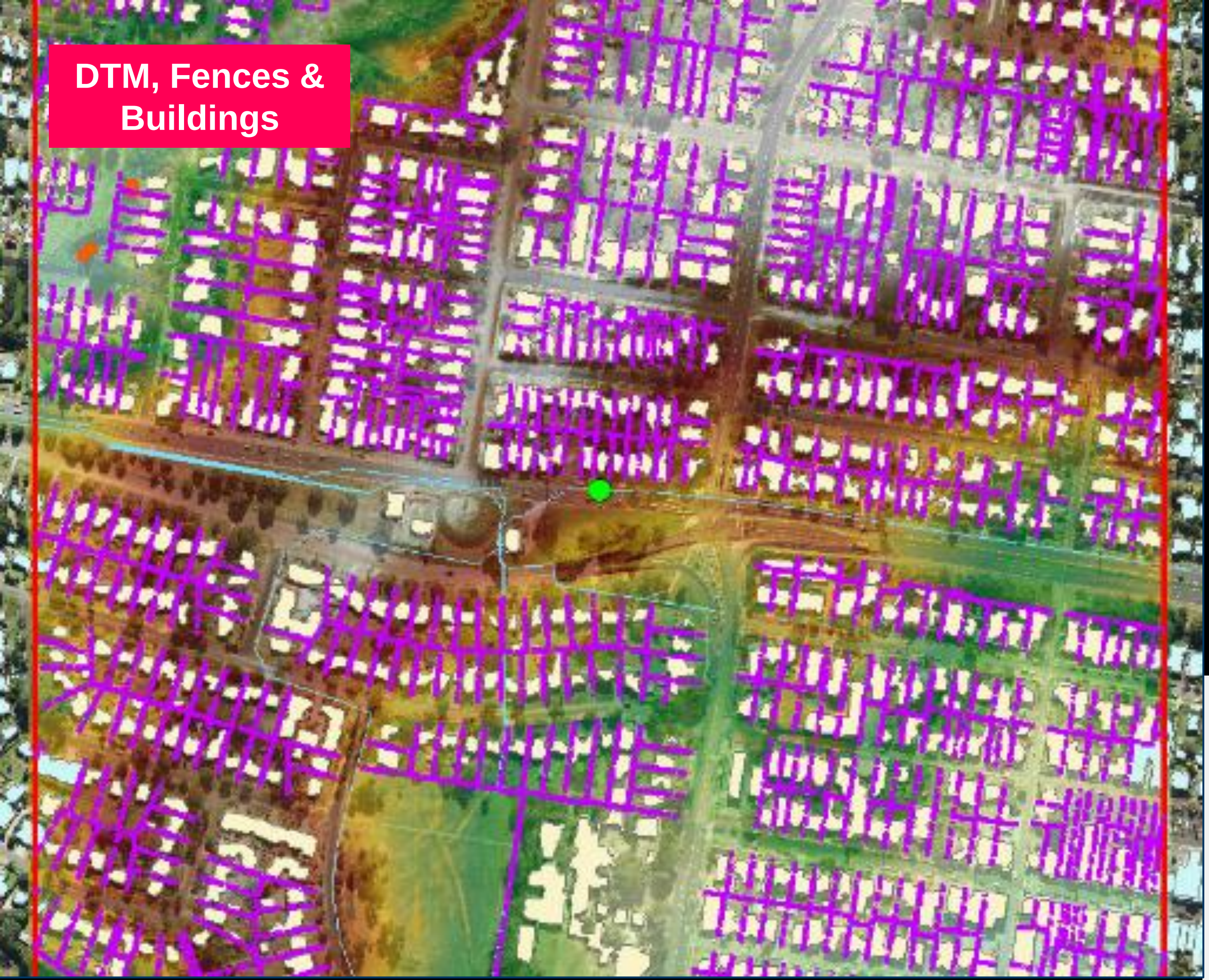
Model Selection & Parameterisation



– Modelling software: TUFLOW
– Burst spacing of 5 m selected: 271 km > 57,405 models

Model envelope: 800 m by 800 m





Surface Elevation

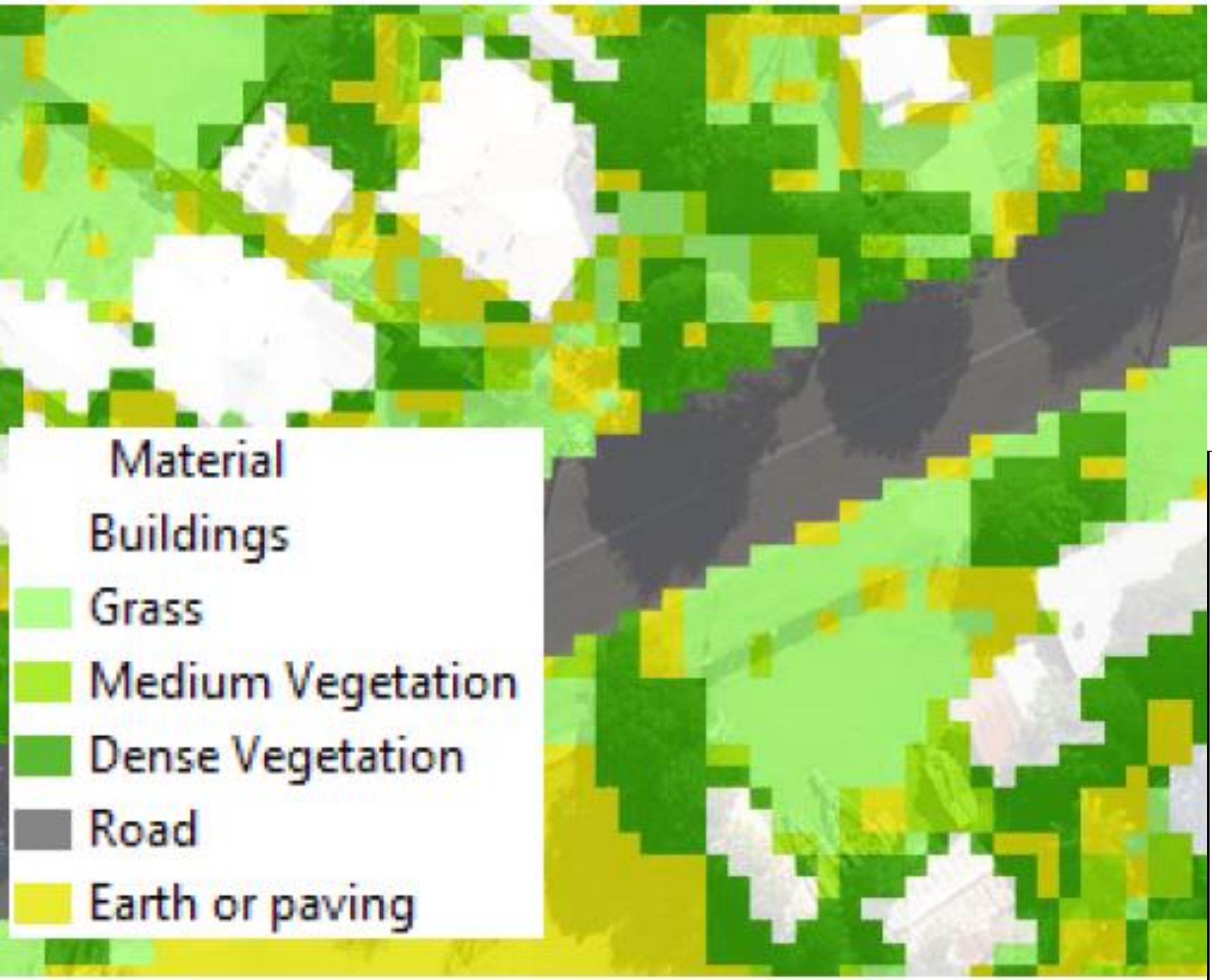
Waterways & Drainage

- 1D stormwater network: excluded
- Streams: represented in DTM
- Culverts & bridges > 0.8 m: normal depth boundaries

Topography

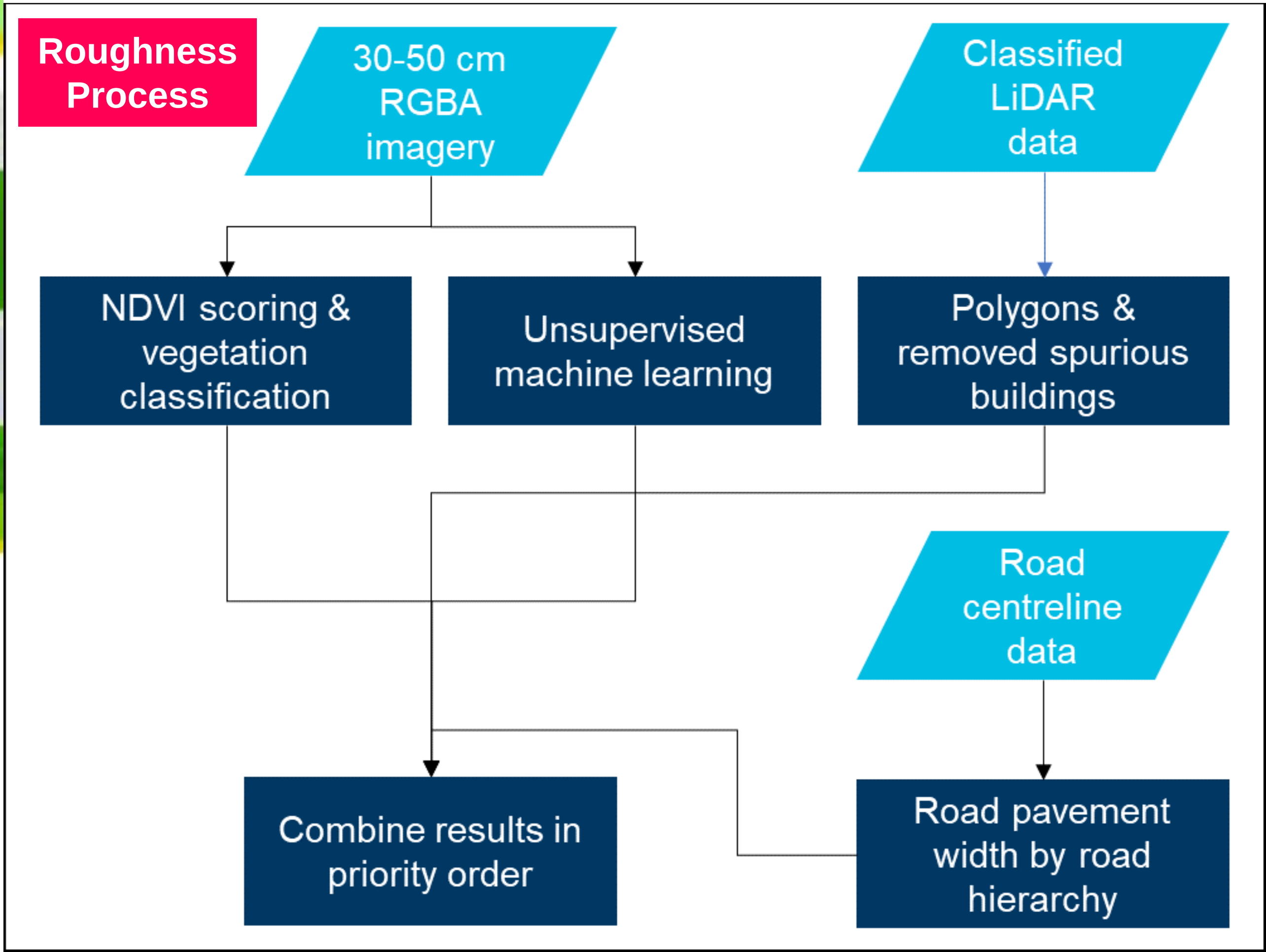
- Digital terrain model: 1.5 m x 1.5 m
- LiDAR: 1.6 strikes per square metre

Image of DTM showing surface features e.g.
Open channels



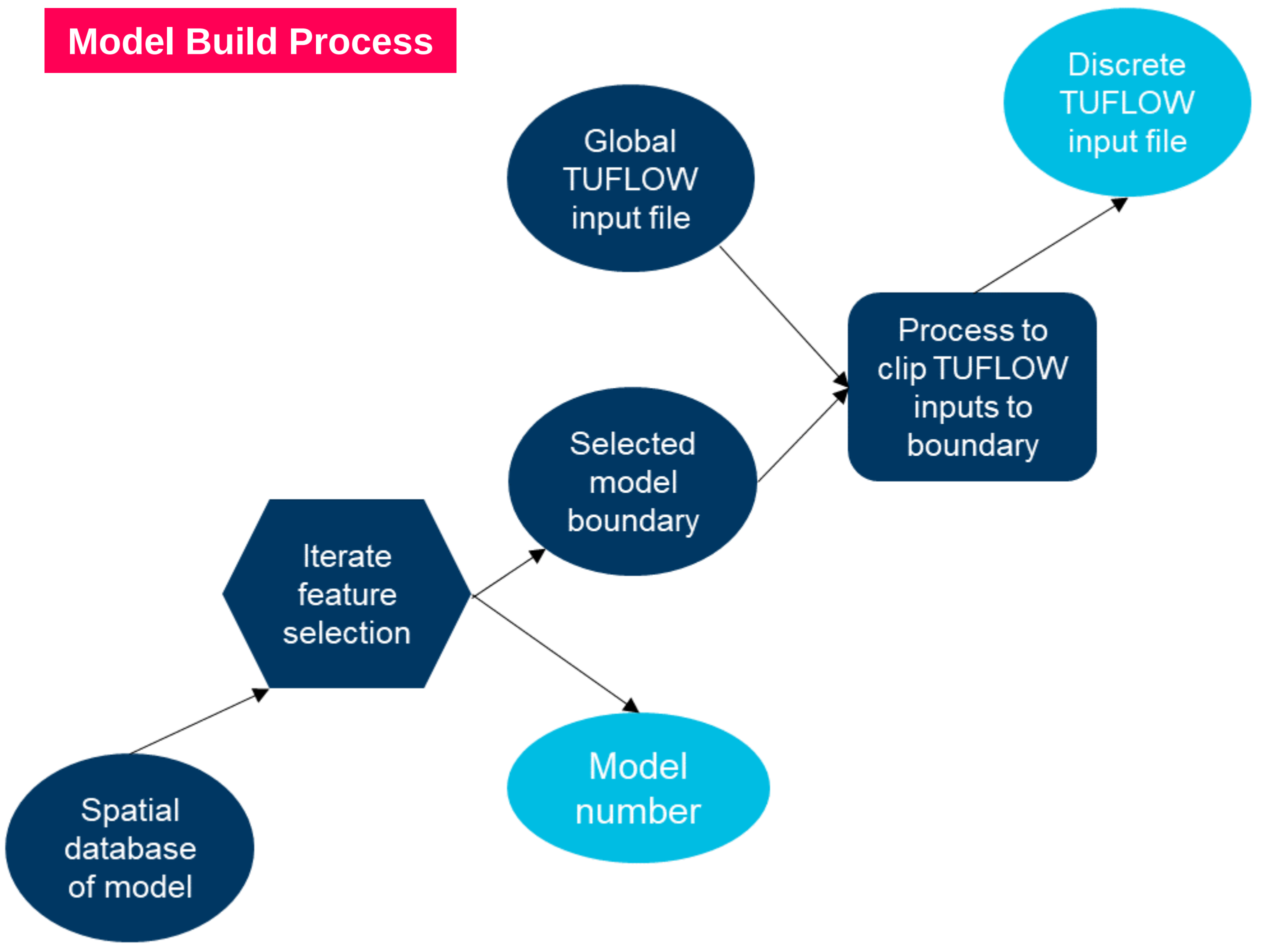
Surface Roughness & Features

– Surface roughness: determined using process below



– Buildings: included as raised ground level and assigned occupancy data
– Front fences: excluded
– Side & back fences: modelled as 50% blockage, max height 1.8 m

Model Build & Simulation



Model Build

– Study-wide TUFLOW input databases clipped to each model boundary envelope
– Normal depth boundary applied

Model Simulation

– 3 hours of burst flow for each model
– 57,405 models
– 3 weeks computer processing

Example simulation

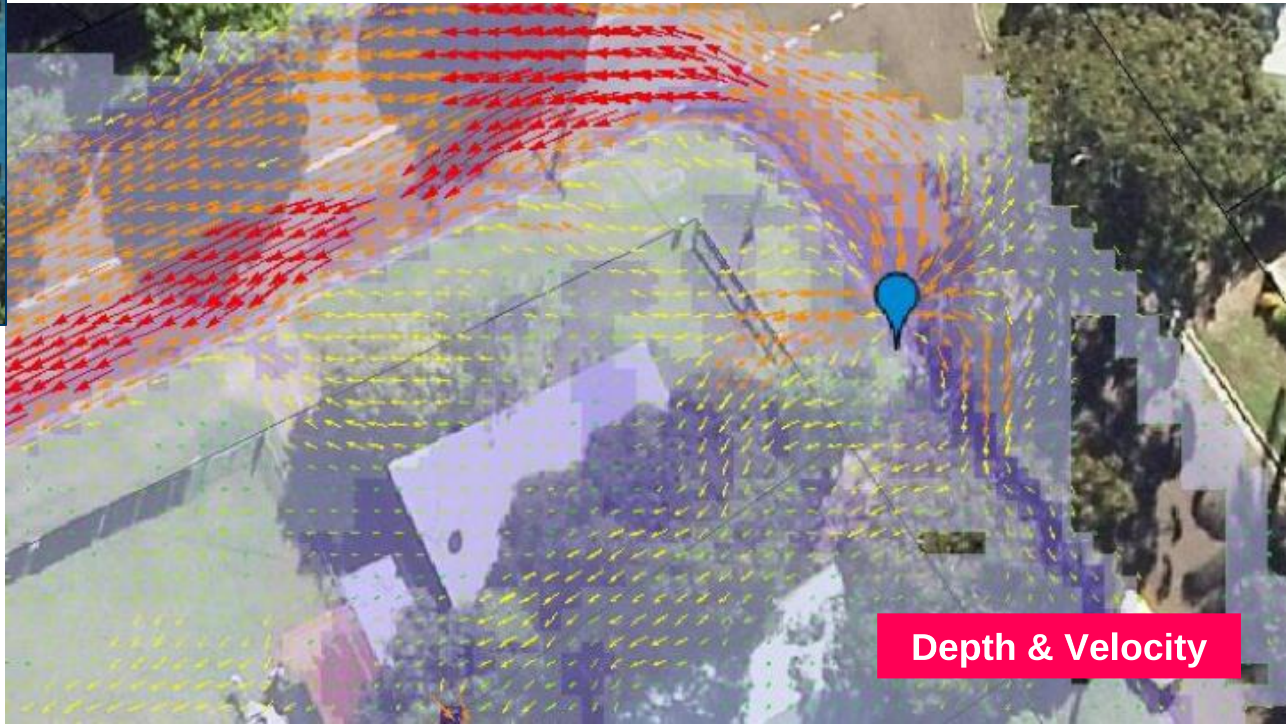
Results

→ What we found

Results Processing

Model Outputs

- Maximum depth
- Maximum velocity
- Maximum hazard



Results Processing

- > 40 billion individual results
- Processed using Python scripting and GIS processes

Results Verification

Anomalies

- Data outliers checked: ≈ 500
- Models discounted: 225 (0.4%)
- Reasons:
  - Instability
  - Input file errors
  - Software & hardware errors

Image from field verification

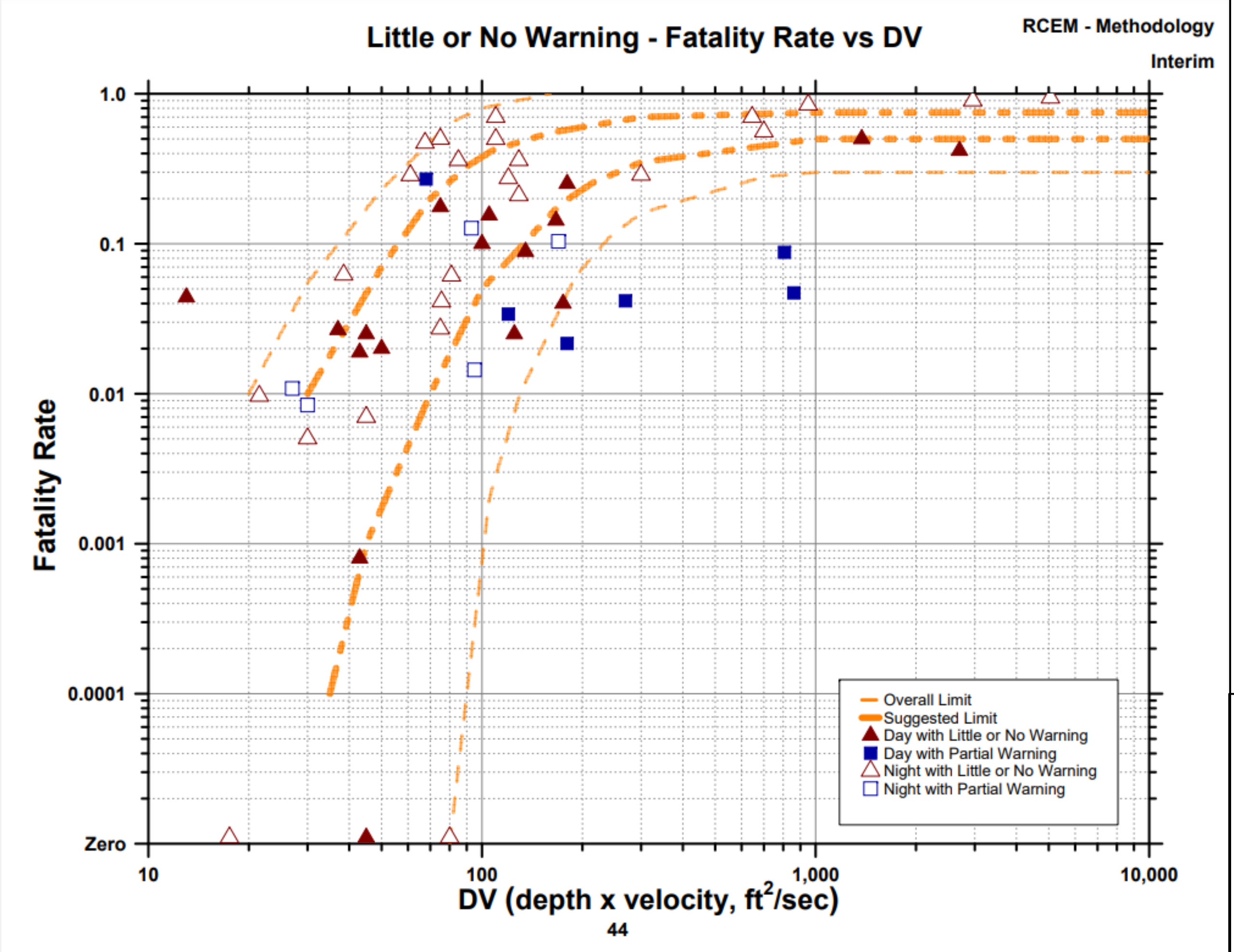
Verification

- Field verification: 20 models
  - 10 randomly selected
  - 10 with high PAR values
- Break flow modelling: 5 sites with high flood hazard

Verification Results

- Field verification: reasonable with minor over-predictions at some locations
- Break flow modelling:
  - Conservative to over-conservative
  - Average overestimation 46%

Results: PAR & PLL



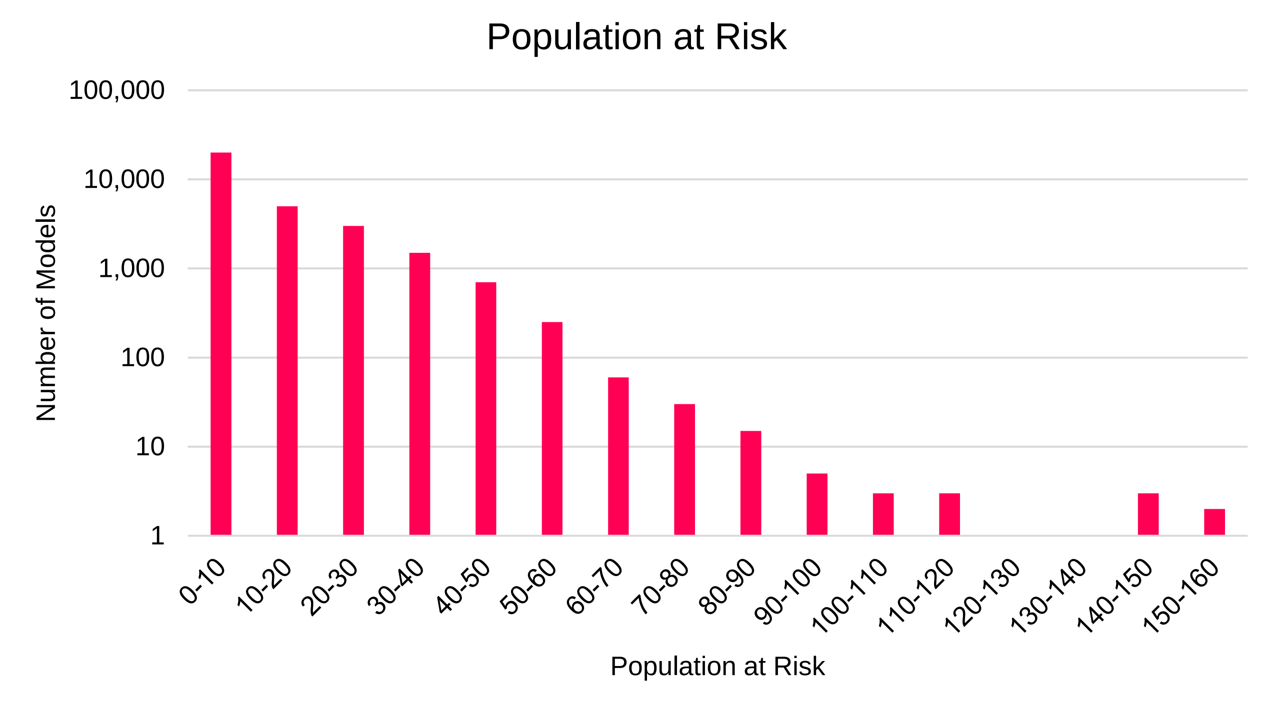
Population at Risk (PAR)

Residential buildings within flood hazard

X

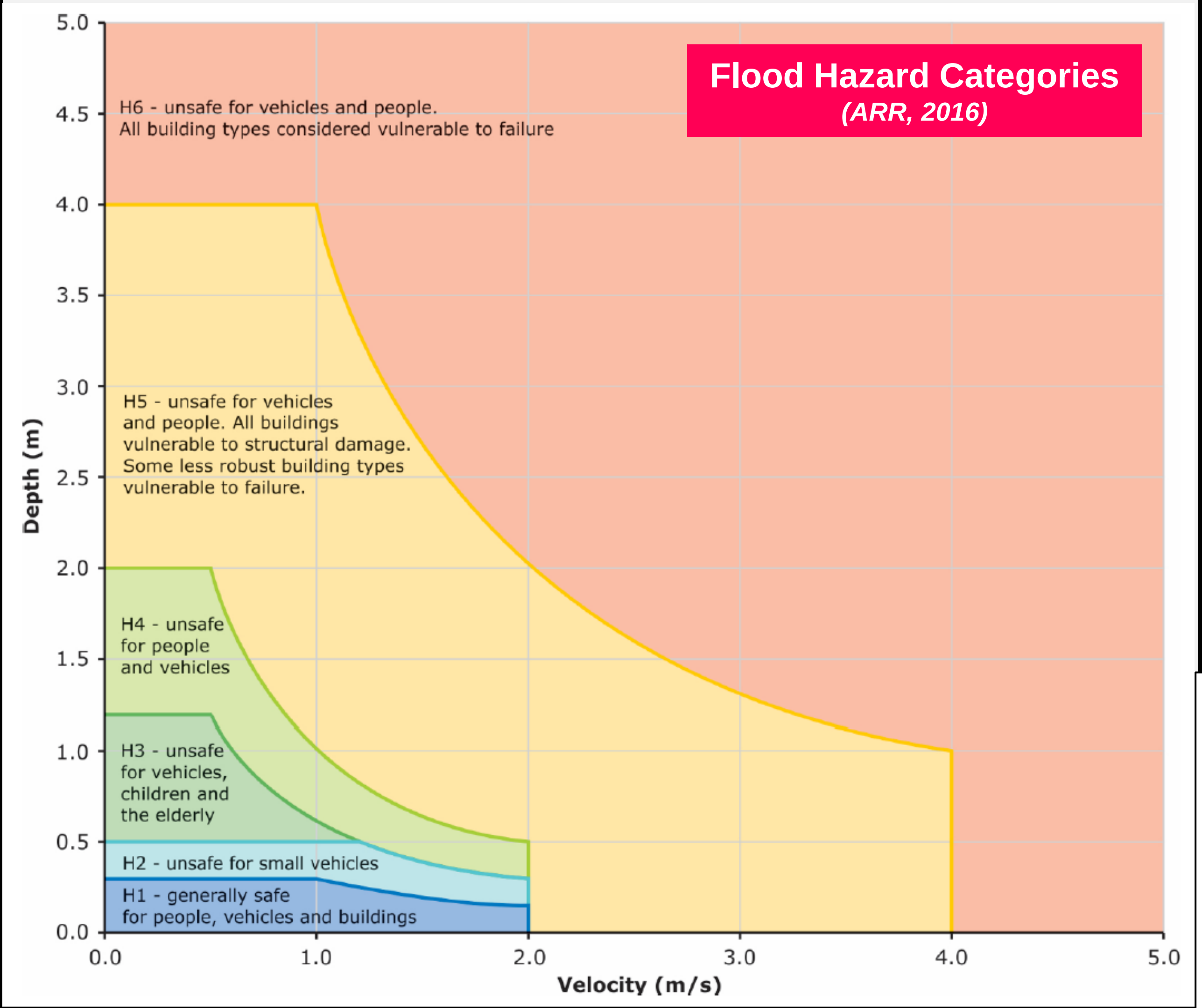
Occupancy rate

Average: 5.2; Peak: 156



Probable Loss of Life (PLL)

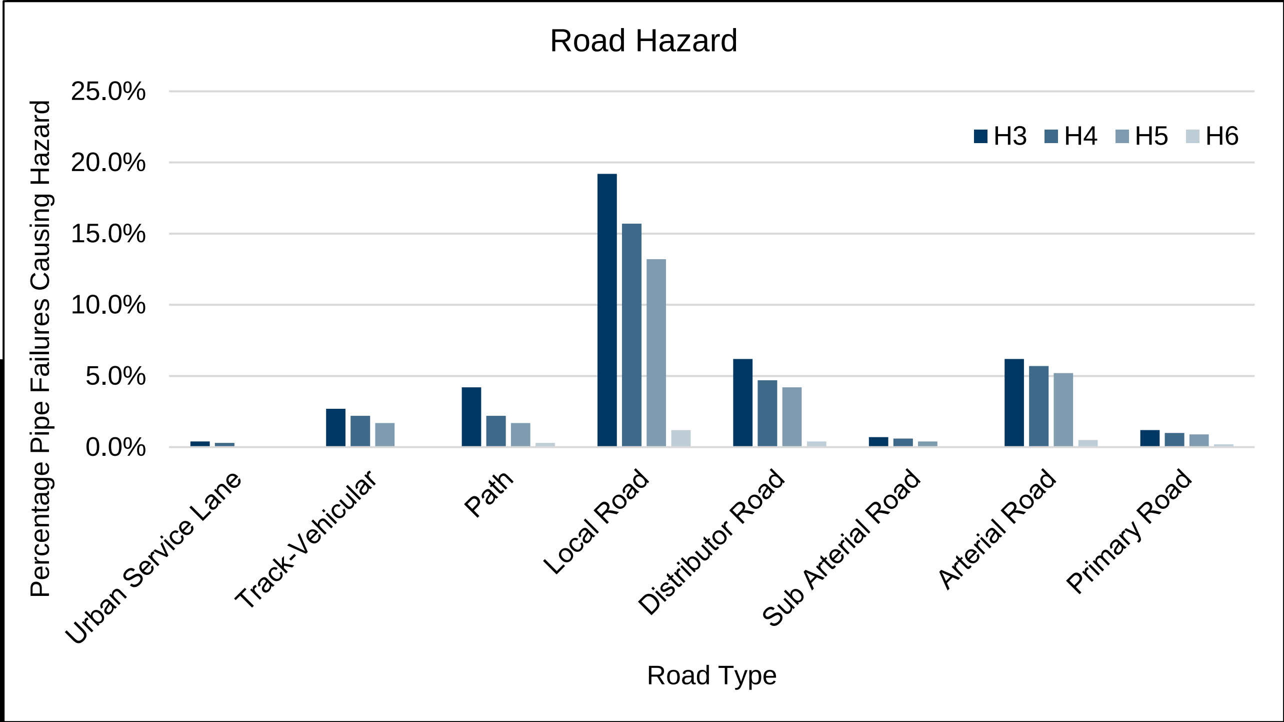
- Based on DV value
- Results conservative



Results: Structural & Road Hazard

Structural Hazard

- Buildings vulnerable to structural damage: 2,384
- Buildings vulnerable to structural failure: 219
- Buildings at risk of over floor flooding: 13.6%



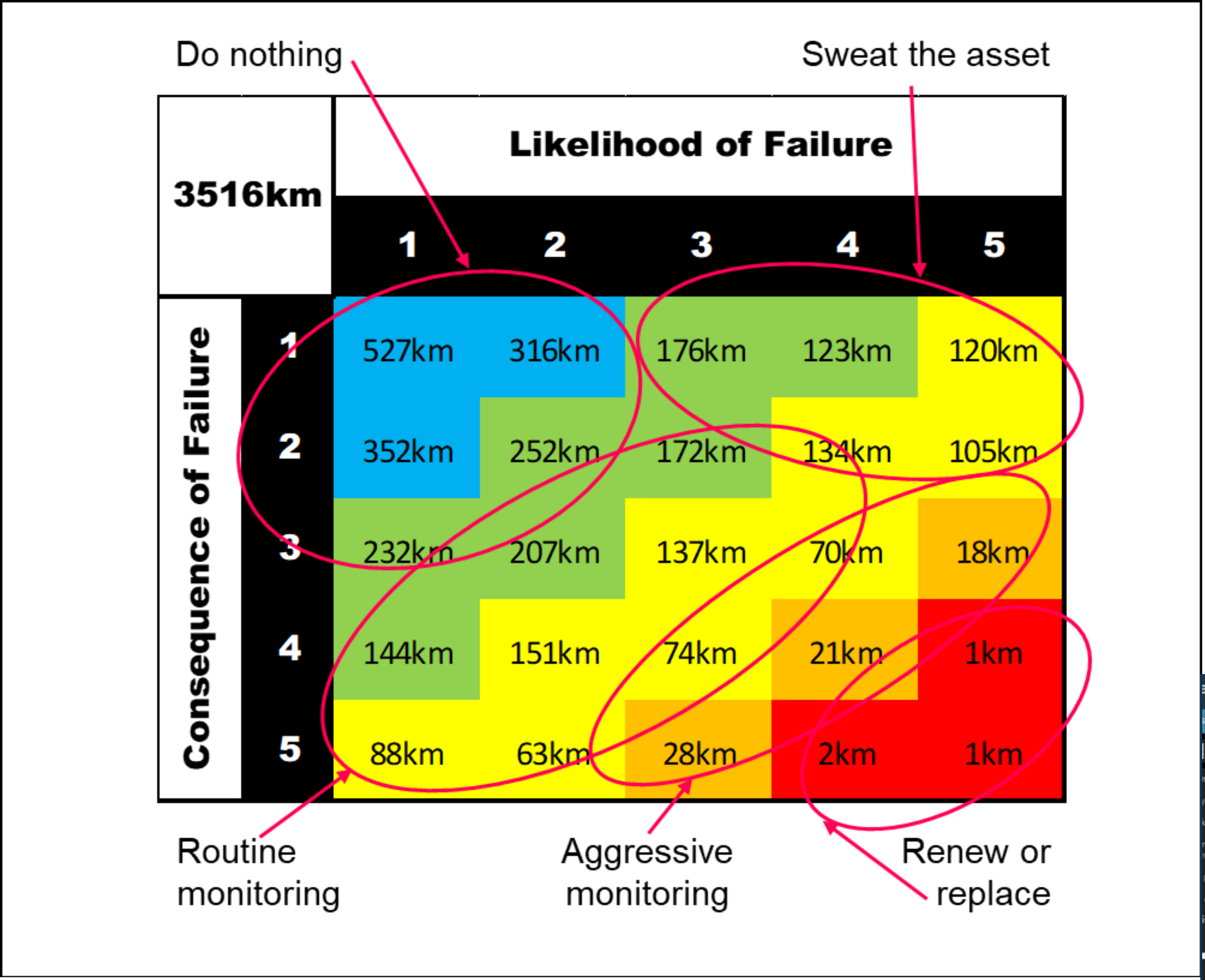
Road Hazard

- Pipe failures causing local road disruption: 82%
- Pipe failures causing main road disruption: 21%

Summary

→ **What were the outcomes and where else can this be used**

Outcomes & Benefits

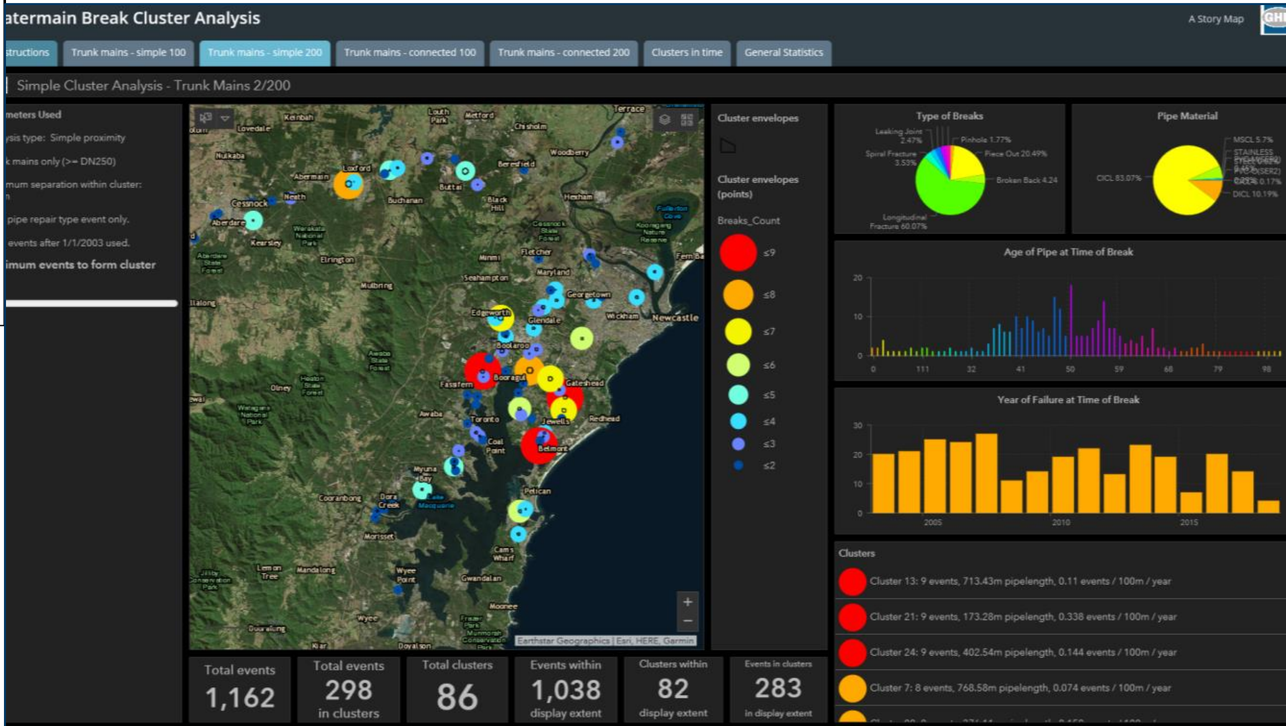


Combined with Likelihood to provide risk score

- Understand high risk assets
- Identify where money is better spent
- Use to justify need to additional spend

GIS dashboard to display information visually

- Location of high risk assets
- Populations at risk
- Compare to historic burst history



Relevance & Other Applications

Image: NZ Herald

– Aro Valley, Wellington: 28 January 2021
– Huia Road, West Auckland: 29 October 2020
– Toitū Settlers Museum, Dunedin: 26 March 2020

Other Applications

– Scour flow paths from reservoirs
– Wastewater rising main bursts
– Embankment breaches

Image: stuff.co.nz

Summary

The Problem

Hunter Water wanted to understand the community safety risks of watermain bursts following a number of bursts.

The Solution

GHD made use of new technology and computing power to develop > 57,000 models to quantify the risks of bursts. This demonstrated that bursts location was a bigger factor in hazard than burst flow rate.

The Outcome

Hunter Water could prioritise funding to high risk assets, diverting funding from assets with low consequence, using data to obtain more money from the regulator for renewals.

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*Thank You

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