Modelling Group
WATER NEW ZEALAND

Modelling Symposium

Modelling in Stream Bank Erosion Management

Presented by
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water
NEW ZEALAND
The New Zealand Water & Wastes Association Waiora Aotearoa

Contents

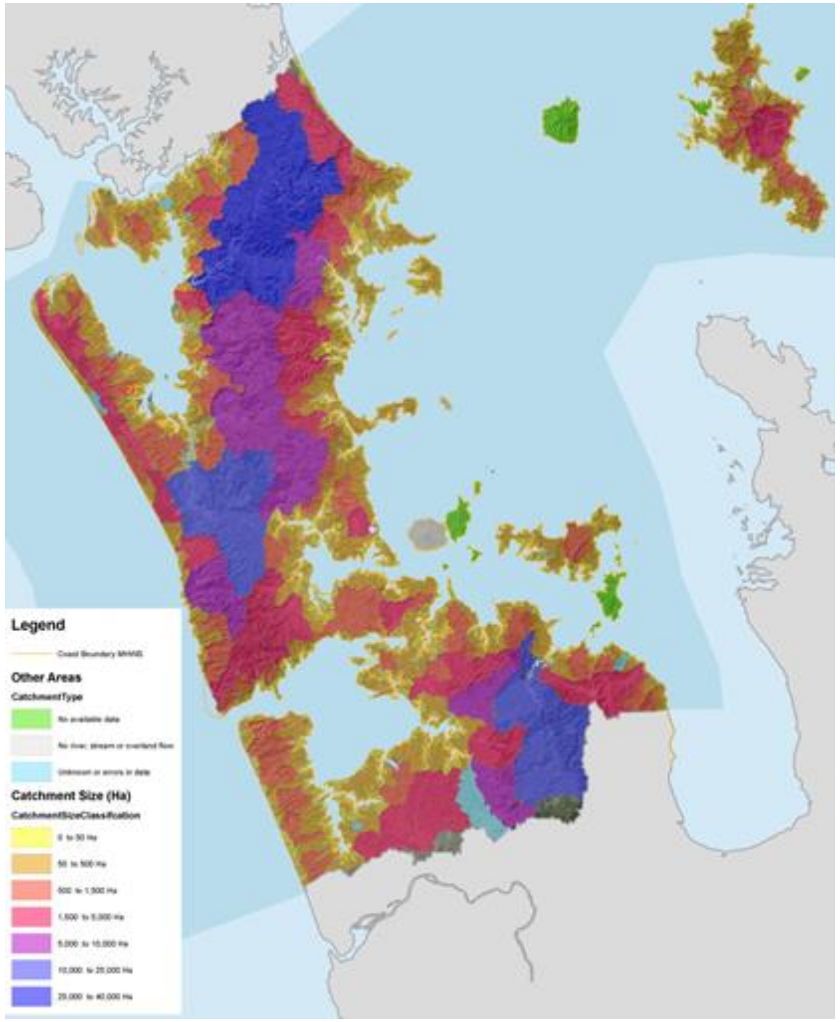
- The problems and challenges
- Our thinking and principles
- Case studies
- Next step - need your support!

Streambank erosion is estimated to contribute at least 50% of sediment

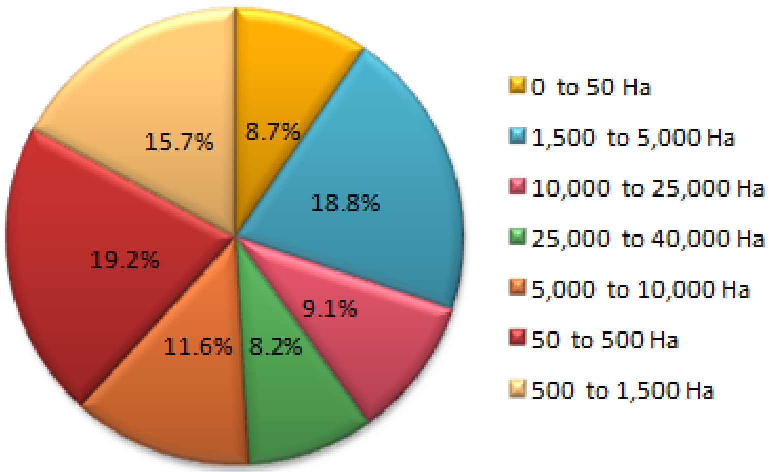

Long Bay – Okura
Marine Reserve


Kaipara Harbour

Our Challenge



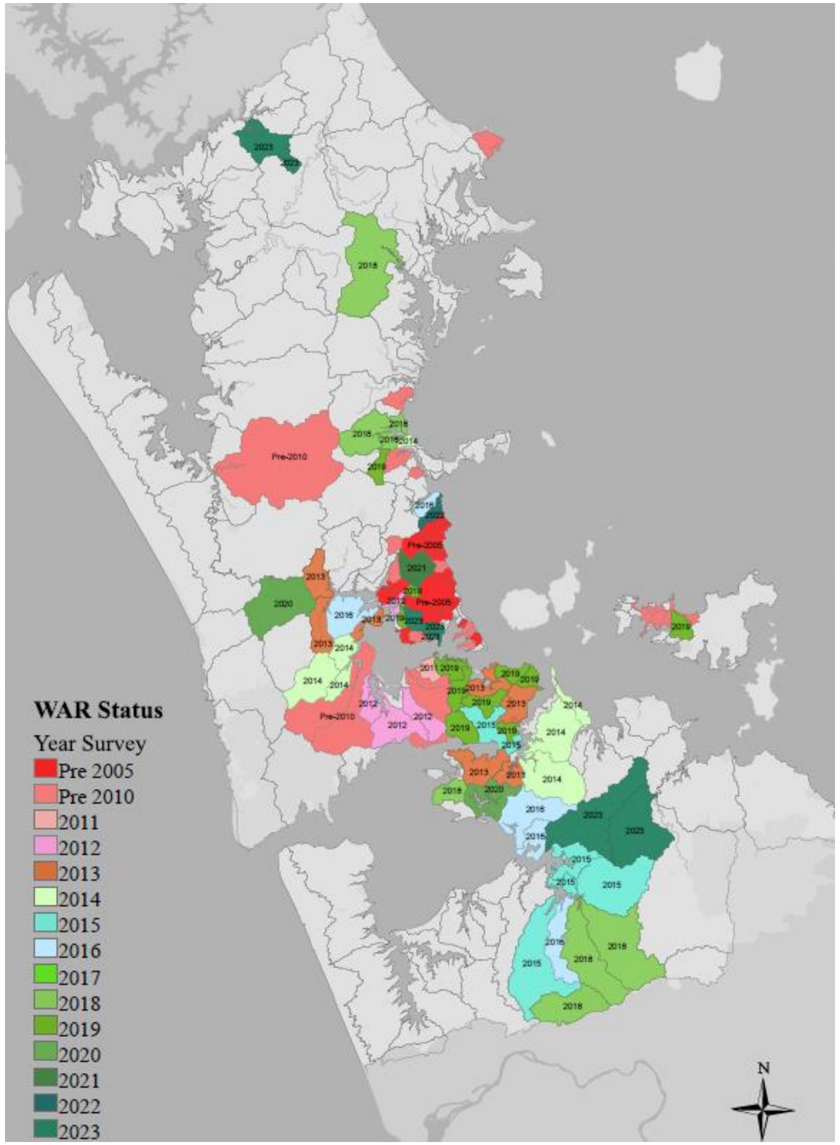
Catchment Size	Total Catchment Area as percentage of Region	Total Catchment Area (Ha)	Number of Catchments
0 to 50 Ha	8.7%	42,831	3,742
50 to 500 Ha	19.2%	94,455	635
500 to 1,500 Ha	15.7%	76,864	91
5,000 to 10,000 Ha	11.6%	56,760	8
1,500 to 5,000 Ha	18.8%	92,228	36
10,000 to 25,000 Ha	9.1%	44,917	2
25,000 to 40,000 Ha	8.2%	40,122	1
Not catchment or errors	8.7%	not calculated	n/a
Grand Total	**100.0%**	**448,177**	**4,515**



- Approx. 16,000km streams across Auckland region of 5,000km2
- Large number of small watersheds < 50 ha

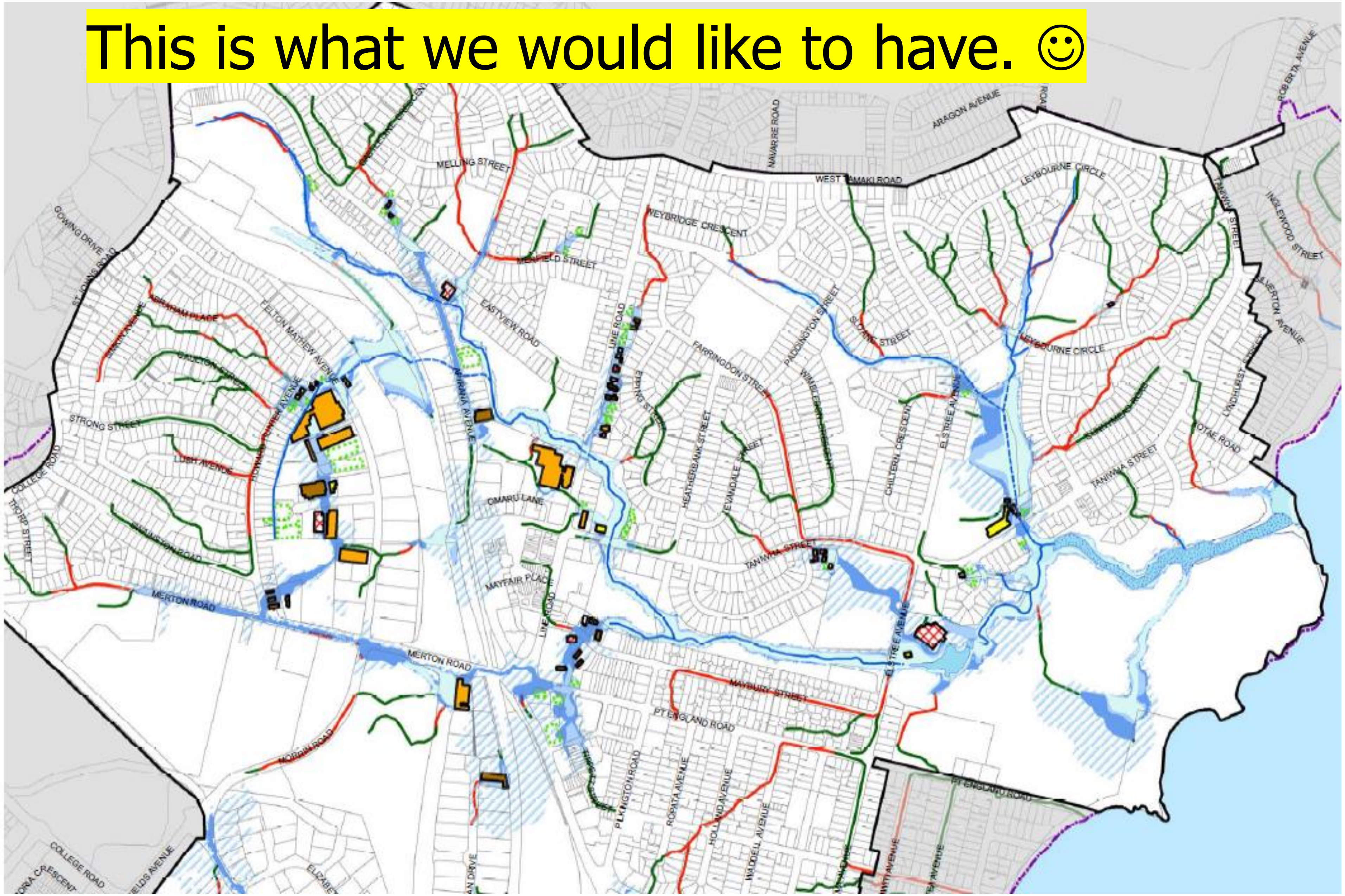
How we manage stream

Attribute	Value
Stream Name	Awaruku Stream
DateCaptured	1/02/2002
Substrate Dominant	Silt/Sand
Bank Erosion R	20-40%
Bank Erosion L	20-40%
Land Slope	Excellent
MassWasting	Fair
DebrisJam	Excellent
BankVegetation	Good
Overall Stability	Good



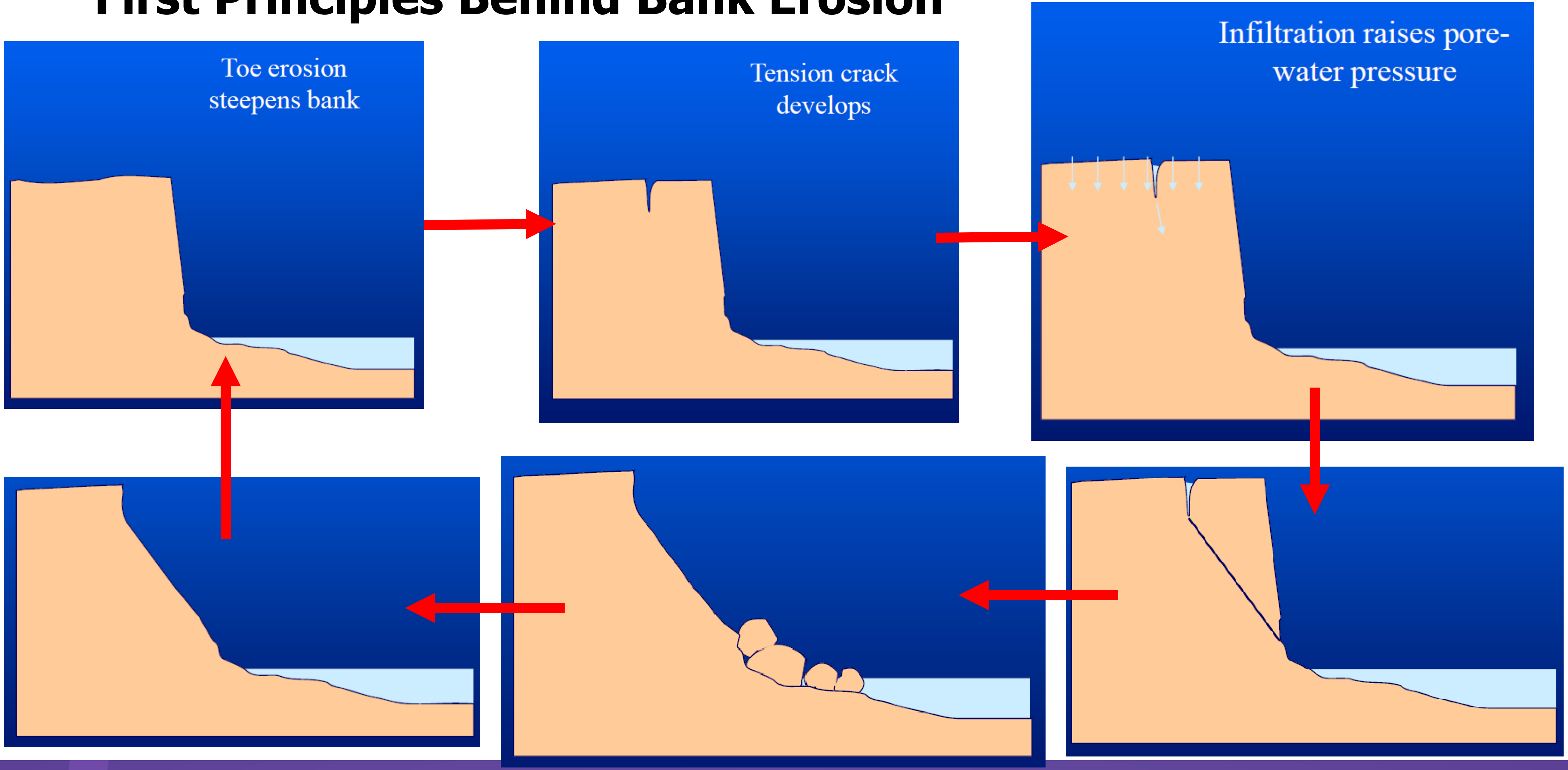
- Watercourse management plans (Stream walk reports) – 1400km walked within 22 years
- 80% in urban and 20% in rural
- Request for services from residents and our ops team (Ad hoc)

This is what we would like to have. ☺

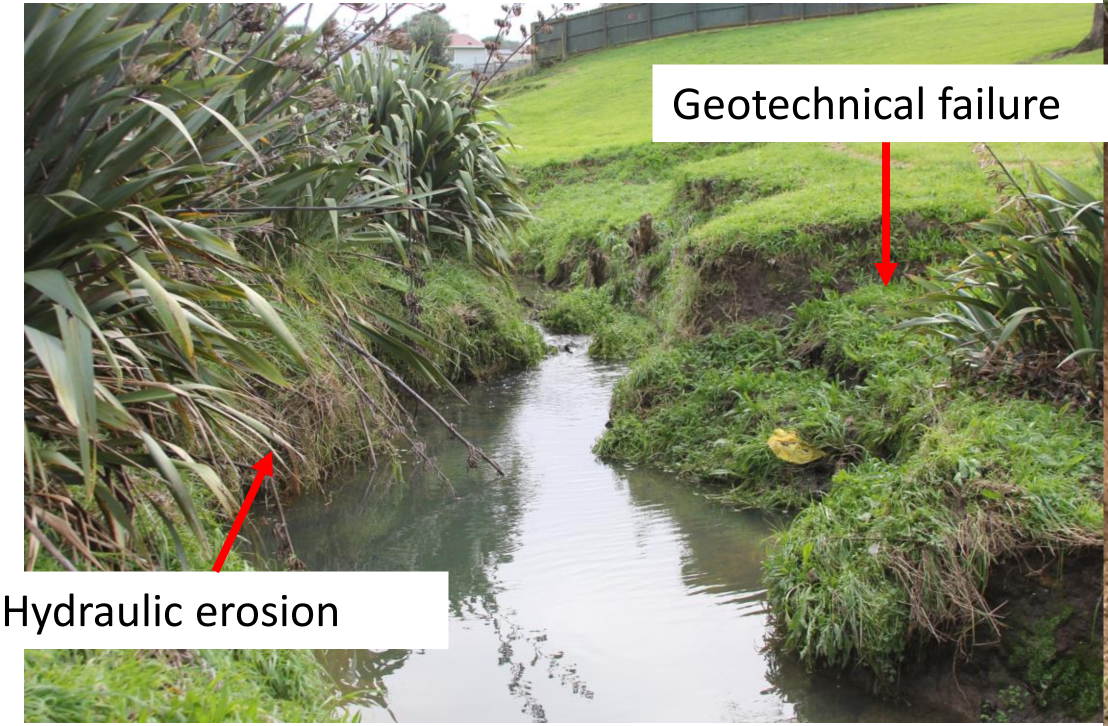


- Overland flow path with flow rates
- Floodplains with depth vs. velocity
- However, we do not have a tool to predict stream bank erosion risk

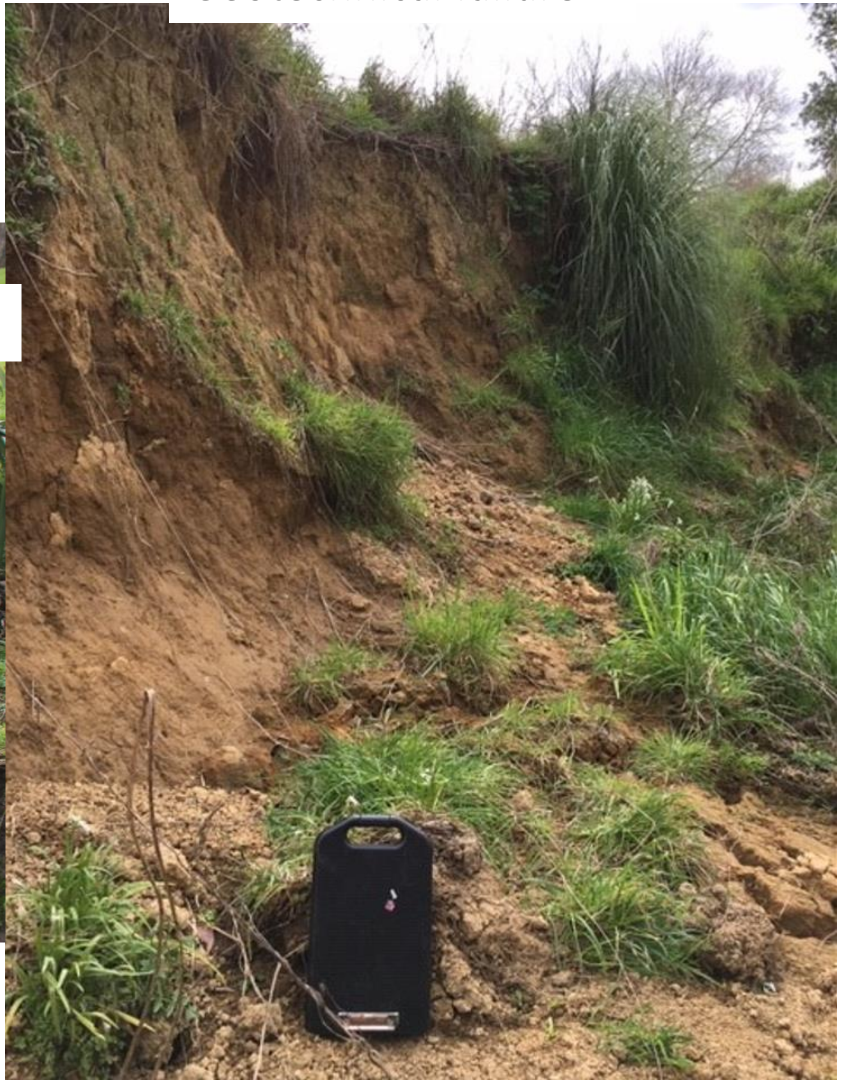
First Principles Behind Bank Erosion



First Principles Behind Bank Stability



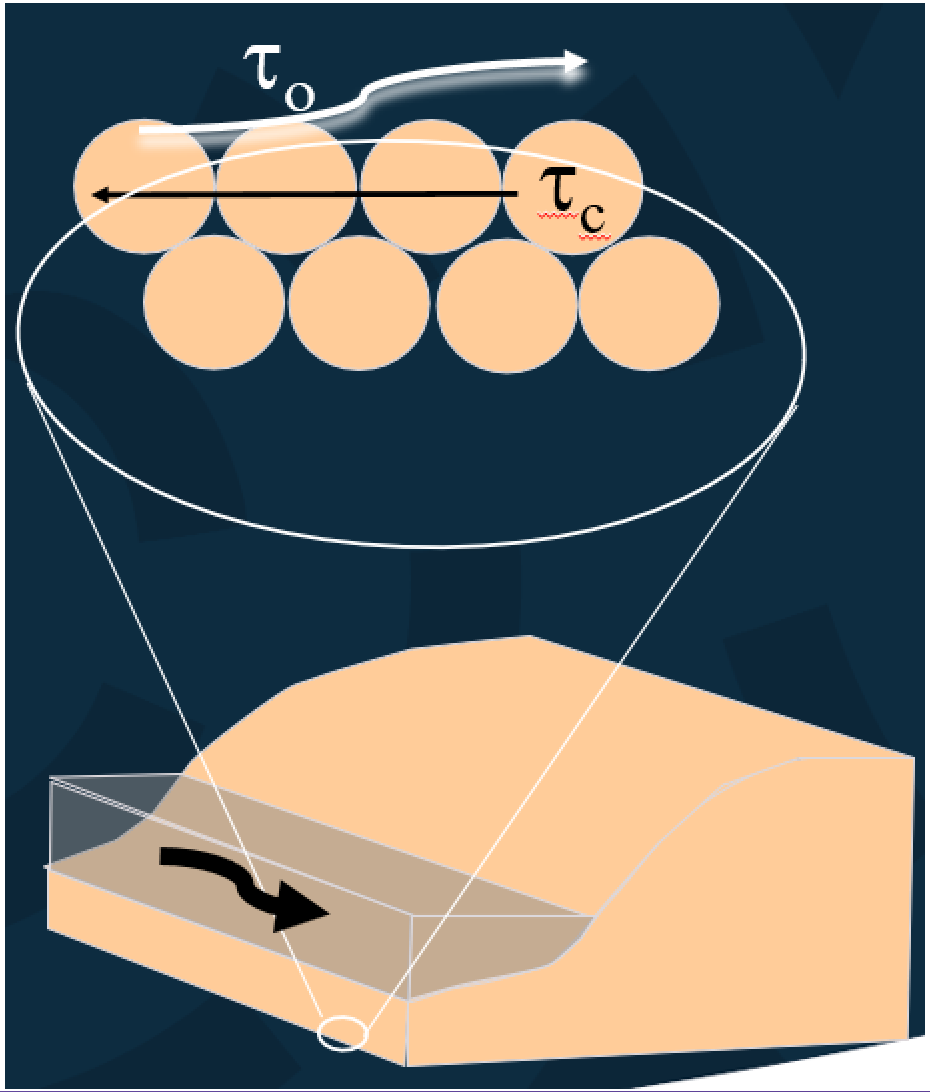
Geotechnical failure



Hydraulic Erosion Processes

Flowing water exerts a shear stress on the toe and bank, τ_o, a function of water surface slope, hydraulic radius and unit weight: $\boldsymbol{\tau_o = \gamma_w R\ S}$

Bed and bank material have resistance due to friction, cohesion and weight. A certain amount of shear stress, τ_c, is required to overcome this (the critical shear stress).



Excess Shear Stress for Erosion Metrics

$$\text{Excess Shear Stress} = \frac{\tau_o}{\tau_c}$$

τ_o = boundary shear stress (Pa)

τ_c = critical shear stress (Pa)

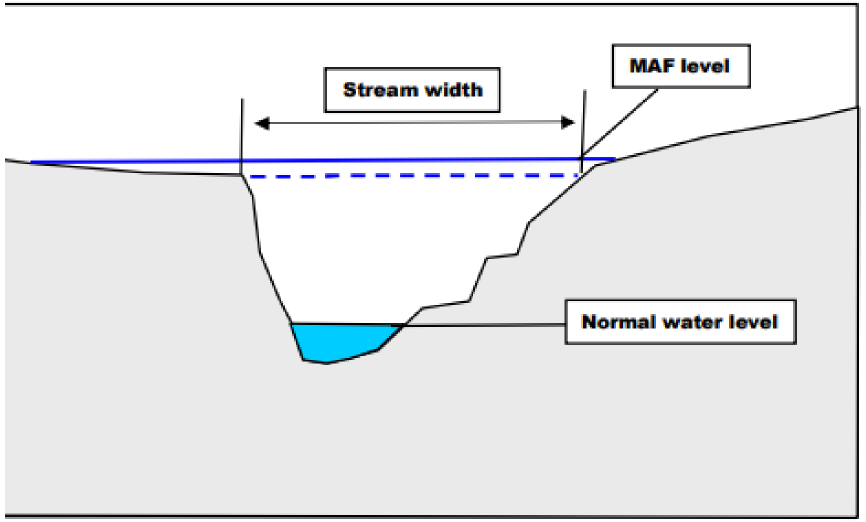
Excess shear is a metric (ratio) representing how much the hydraulic forces applied by the stream flow differs from the resisting forces provided by the channel boundary conditions. The values obtained provide an indication of what flows and to what extent the applied shear stresses within a channel can cause erosion and incision of the stream channel.

Threshold	Excess Shear	Description
Green	<1.0	Indicates no erosion predicted to occur
Yellow	>1.0 <2.0	Indicates the potential for some erosion of the channel
Orange	>2.0 <10.0	Indicates the potential for channel to be mobile, (likely active erosion)
Red	>10.0	Indicates potential rapid rates of erosion and incision of channel

Previous Study to Support Erosion Metrics

- Mean annual flood (***MAF = 2.3 year ARI***) is the most appropriate flow to use as the annual fullest flow – (Stumble, C & Co.,How wide is the stream? Stormwater Conference (2011), Water New Zealand)

- Using ***hydraulic radius and energy slope*** for boundary shear stress – (Irvine, J & Co., Auckland's approach to the stream erosion problem. Stormwater Conference (2019), Water New Zealand)



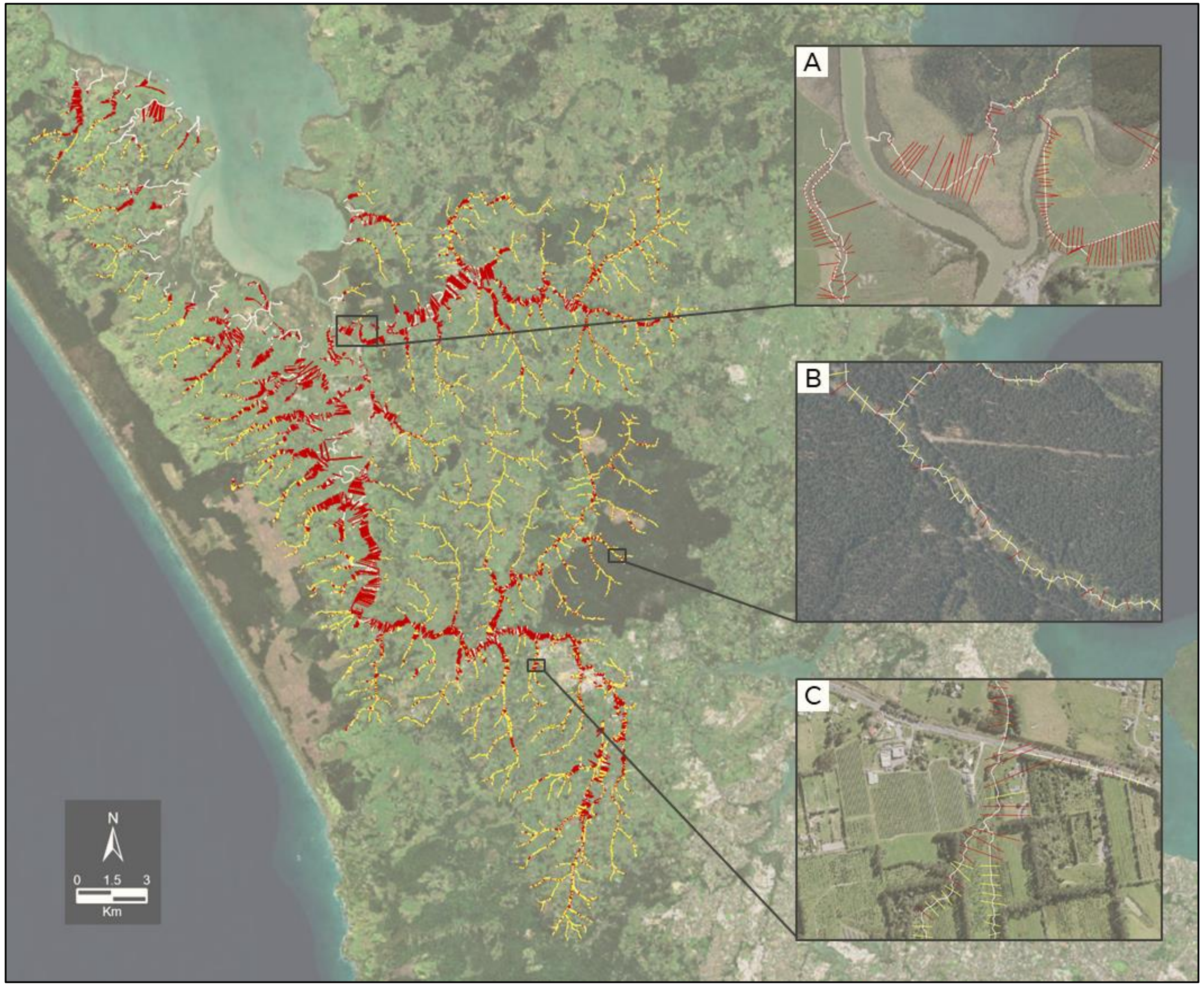
Case Study – South Kaipara Erosion Metrics

Area of Project	$480\ km^2$
Length of Stream (Permanent Stream)	Over 2,000 km

Key Purpose of the Work

- **To calculate hydraulic erosion thresholds and critical bank heights**
- **Prioritise high risk areas for further detailed analysis to save field investigation**

Case Study – South Kaipara Erosion Metrics



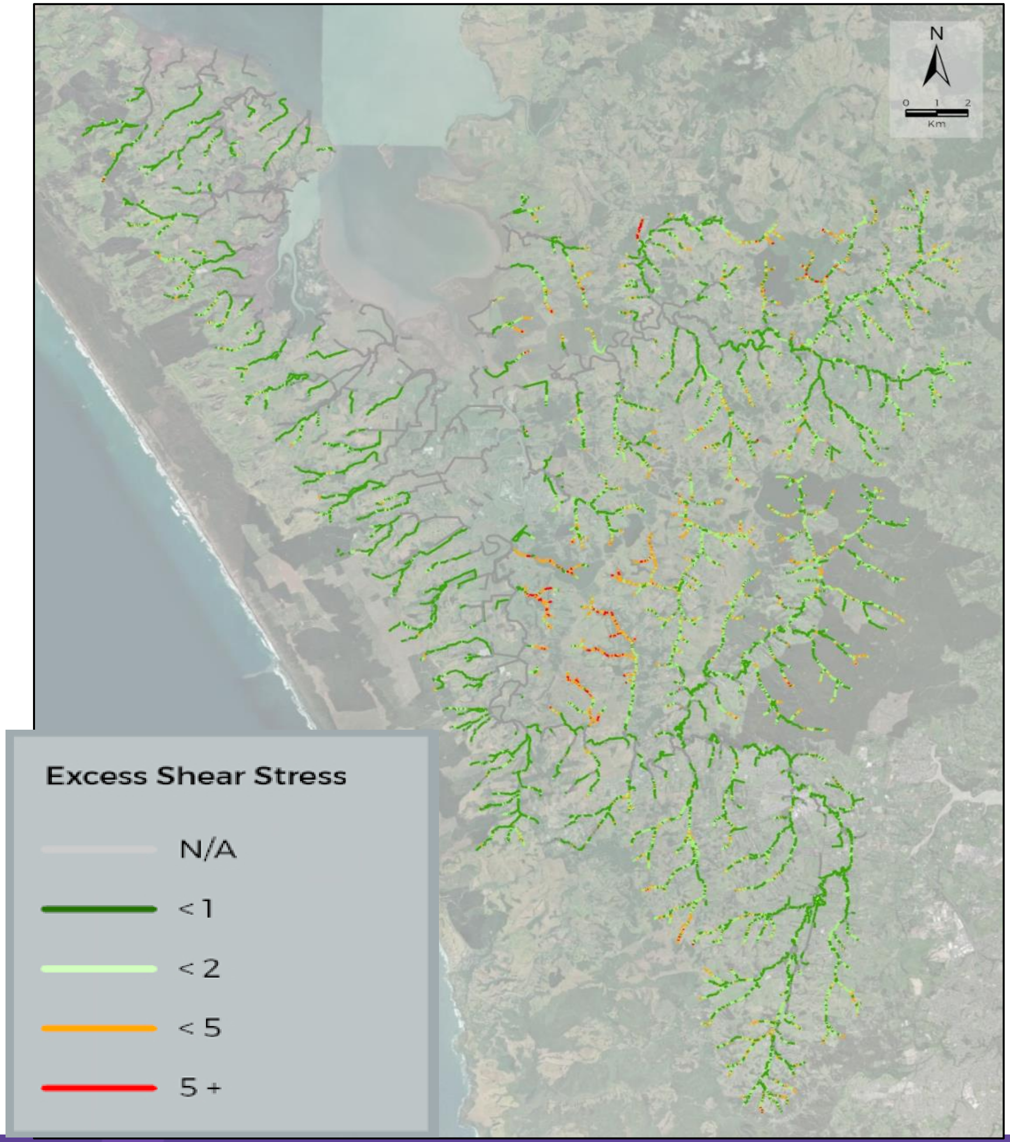
Input Data

<u>Regional flood model (2D model using Tuflow engine)</u>

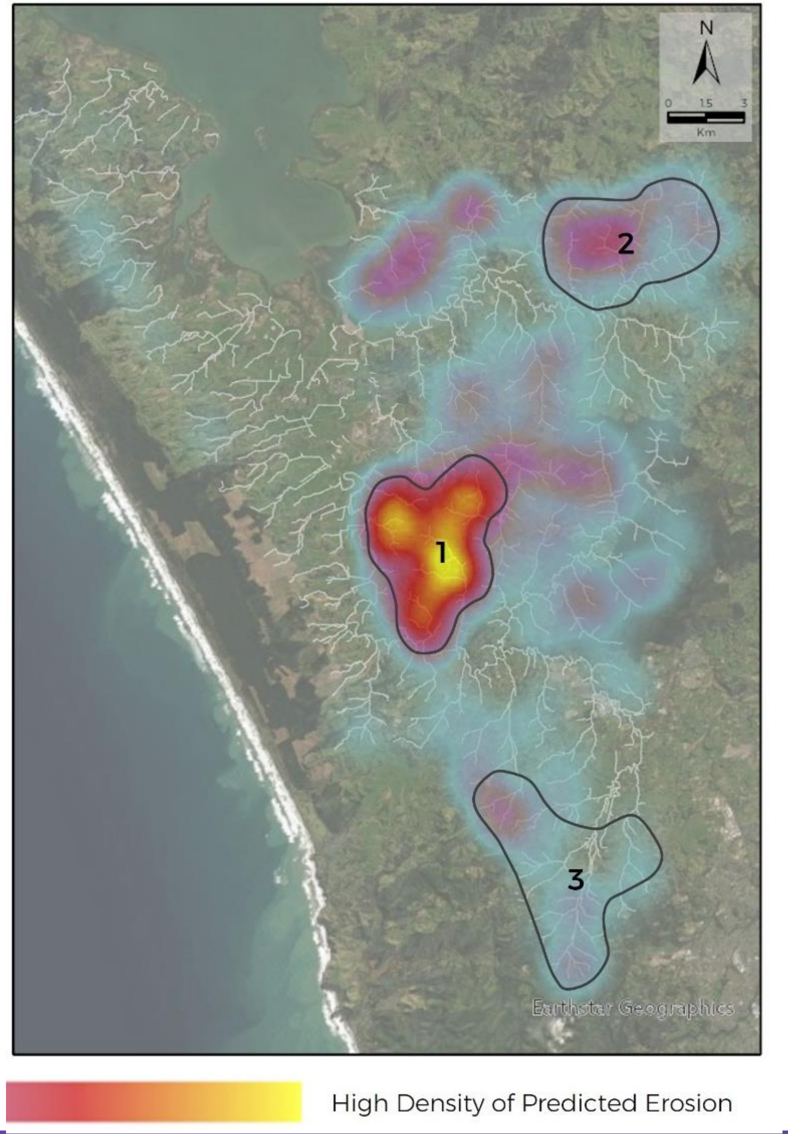
- Over 100,000 cross sections
- 2 year ARI peak flows with climate change 2.1 degree (to calculate hydraulic radius)
- Water level of each cross sections (to estimate energy slope)

<u>Critical shear stress data (20 and 40 pa)</u>

Outcomes

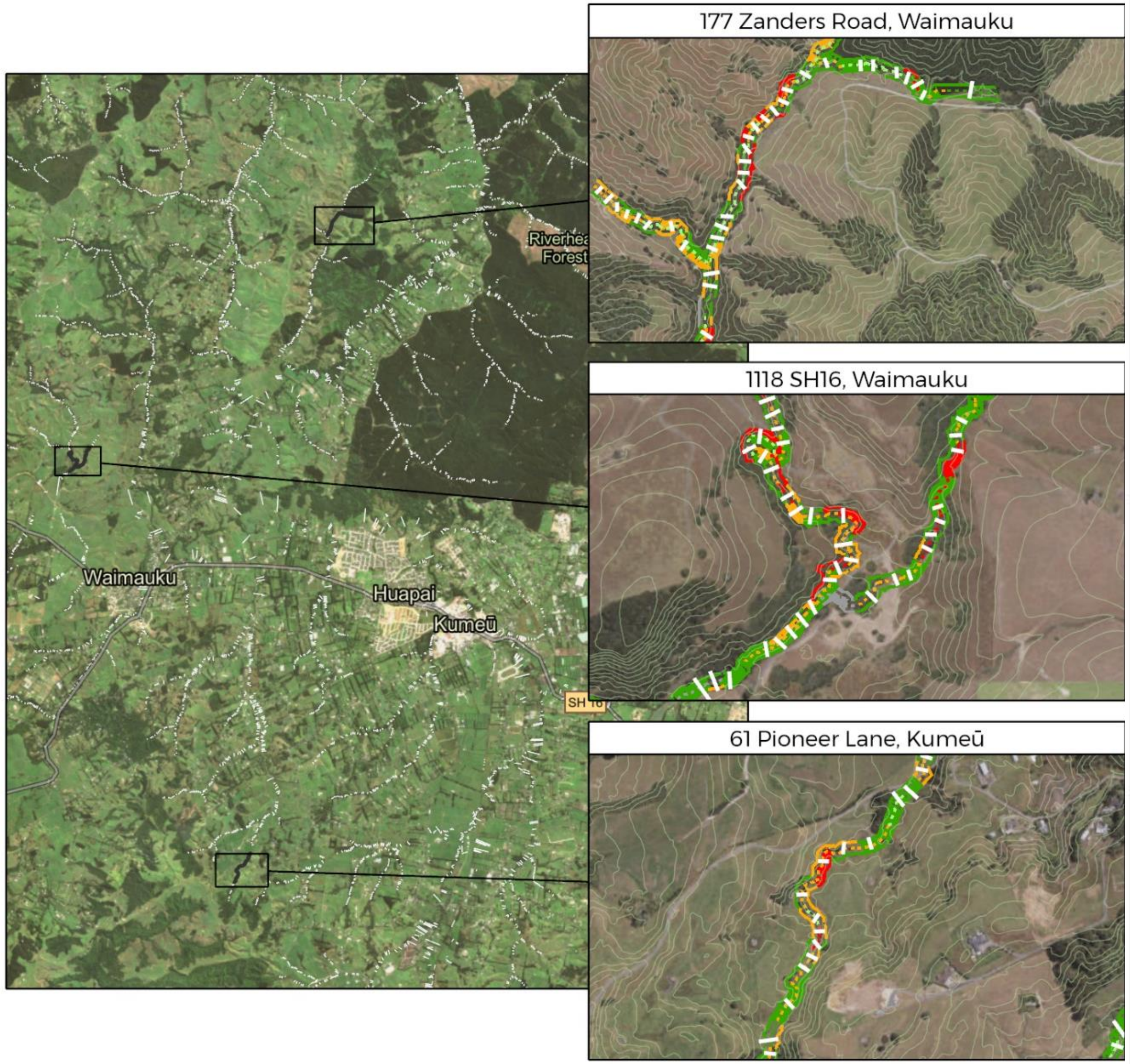


Hydraulic Erosion



- Erosion metrics map
- Heat map for the priority area

Validation



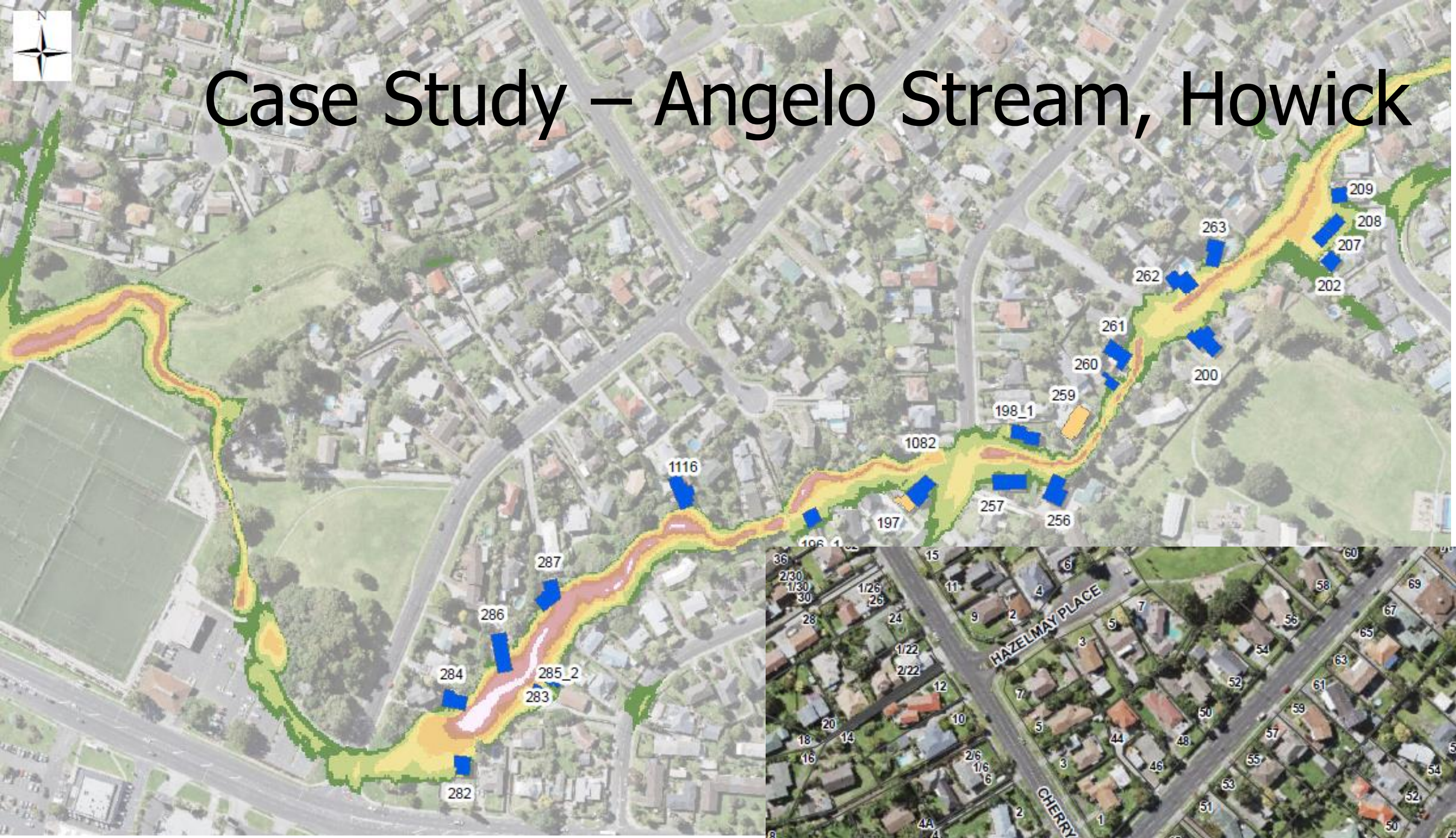
Excess shear		
<1¤	Low·velocity·and·shallow·gradient.¤	
<2¤	Constrained·channel·with·moderate·velocity.¤	
<5¤	Fast·flowing·water·with·significant·gradient·change,·some·evidence·of·cascades.¤	
>5¤	Considerable·gradient·change·with·cascades·and·waterfalls.¤	

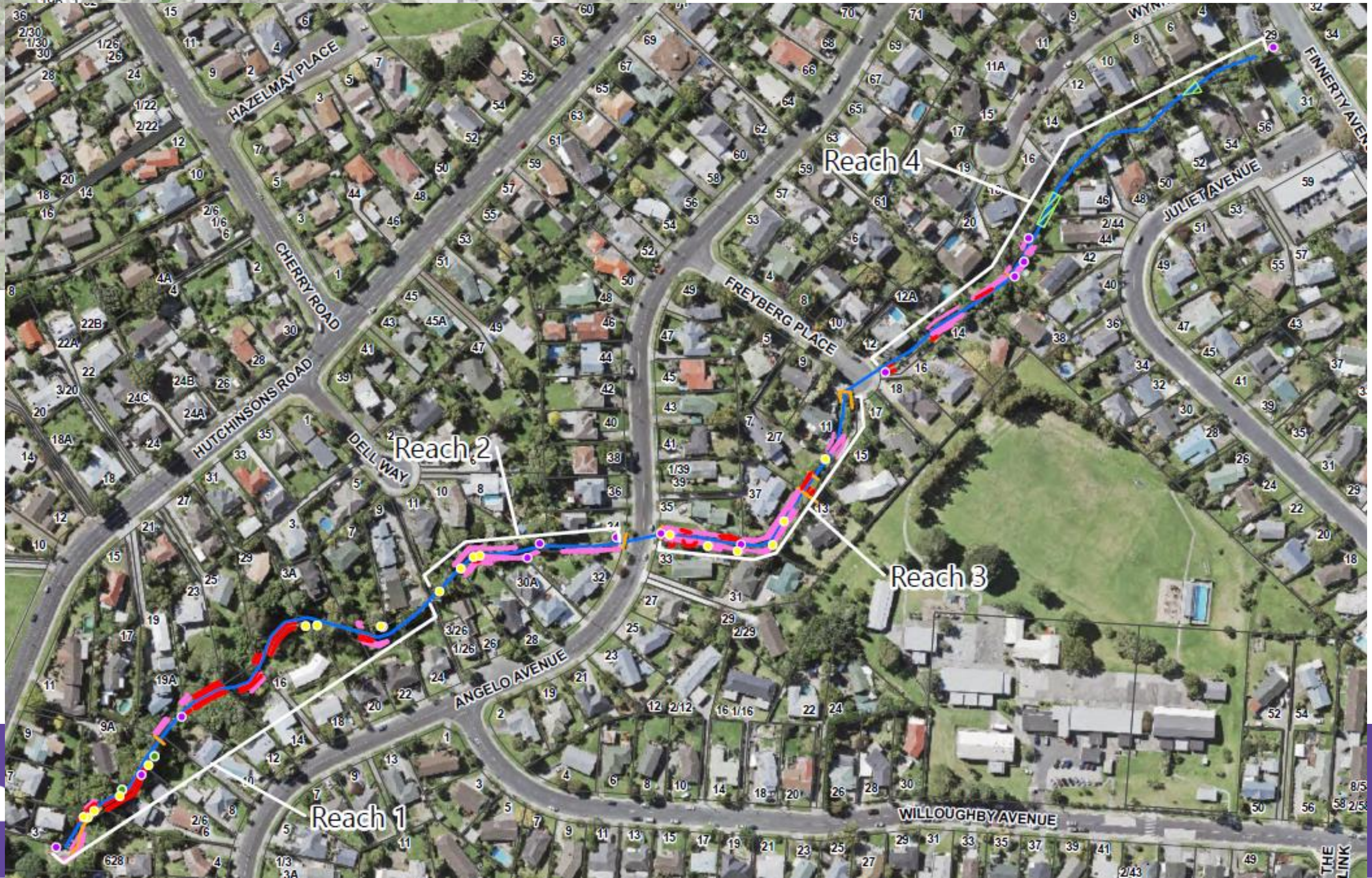
Case Study – Angelo Stream, Howick

Background

- Well known area in South Auckland for flooding to roads and properties
- Stream bank erosion in 800m length of stream
- Poor structures built within the streams by different parties

Case Study – Angelo Stream, Howick





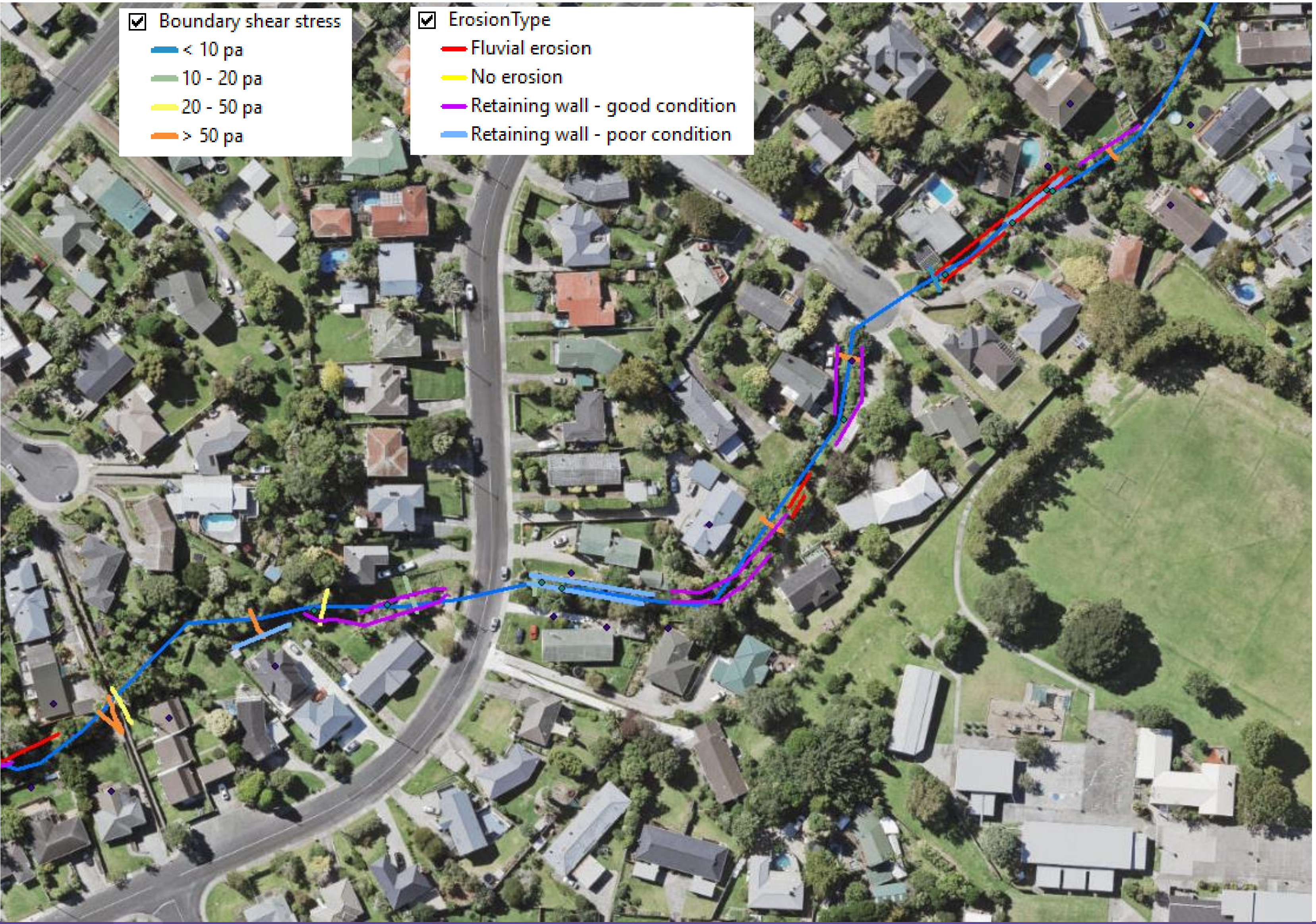
Key Purpose of the Work

- To come out a combined project to address flood risk, as well as stream bank erosion risk

Case Study – Angelo Stream, Howick

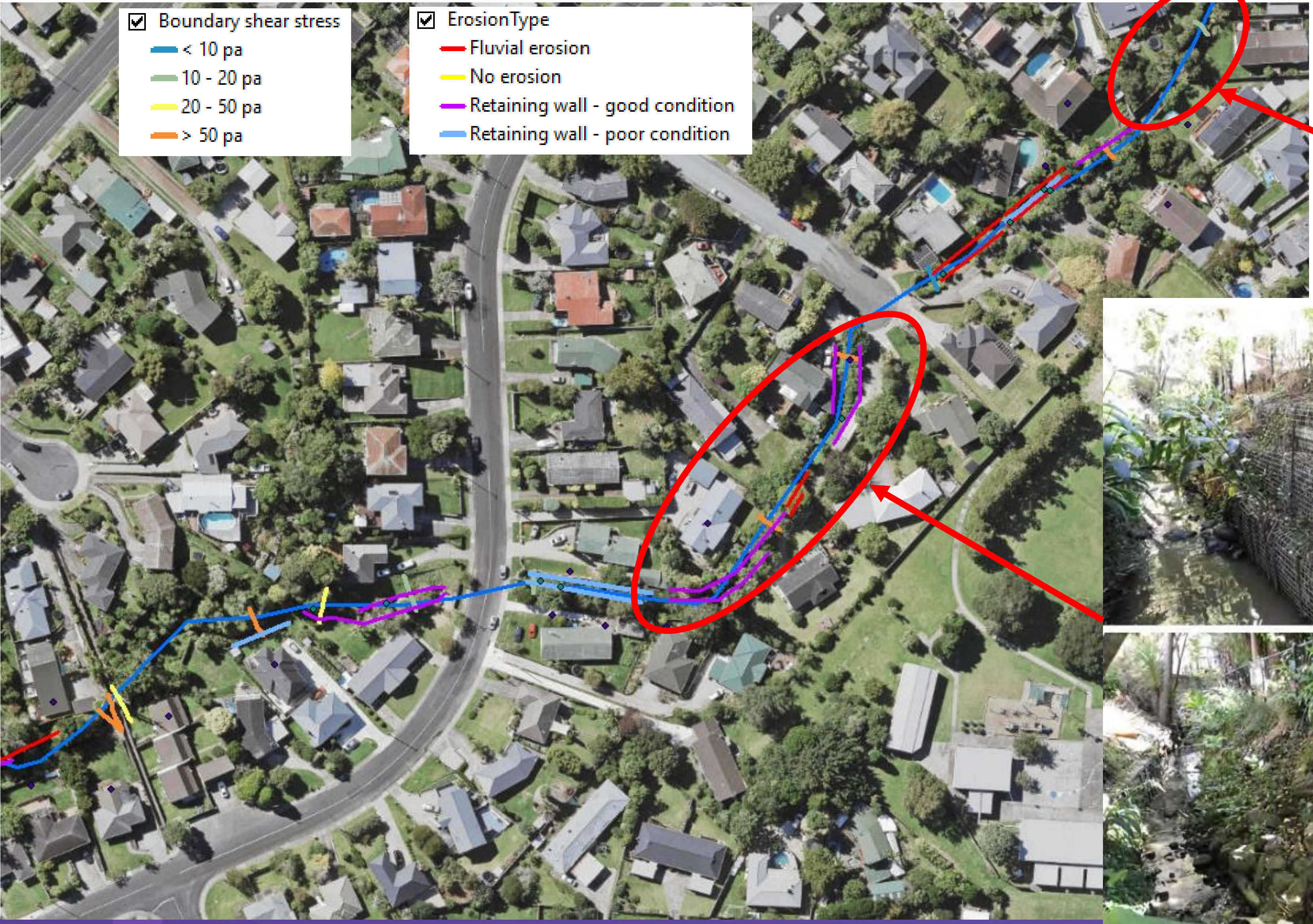
- A 1D-2D coupled model was cropped for flood and erosion assessment
- LiDAR 2016 was used in 2D zone
- Surveyed cross sections were used in river reach to better present the stream

Outcomes



- Boundary shear stress estimated in each cross section for 2 yr with cc
- Boundary shear stress vs. Erosion type from stream walk

Validation



Boundary shear stress
< 10 pa
10 - 20 pa
20 - 50 pa
> 50 pa
ErosionType
Fluvial erosion
No erosion
Retaining wall - good condition
Retaining wall - poor condition

Prelim and detailed design

Next steps

- Ideas from modellers to improve methodology
- Can it be a by-product of hydraulic model?
- Can boundary shear be used in flood hazard assessment?
- Our goal – A regional predicted erosion metrics layer
- Our goal – Hydraulic models should be used in any stream designs (Oakley Creek, Meola Daylighting and more)

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Thank you!
Questions? Patai?

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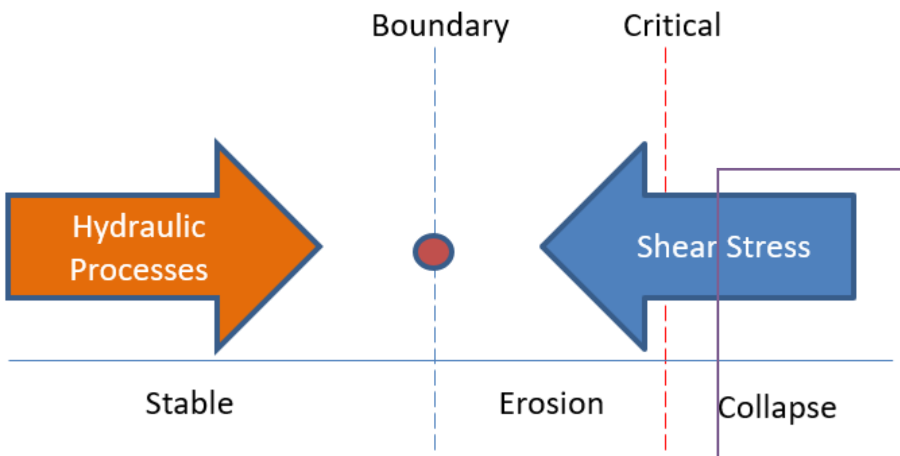
First Principles Behind Bank Stability

Bank toe erodibility (resistance to hydraulic erosion) vs. **Boundary shear** (force of water)



Bank shear strength (resistance to geotechnical failure) vs. **Gravitational forces** (force of weight)