CONTINUOUS SIMULATION MODELLING TO SUPPORT HEALTHY WATERWAYS

Josh Irvine and Jahangir Islam

wsp | OPUS AECOM

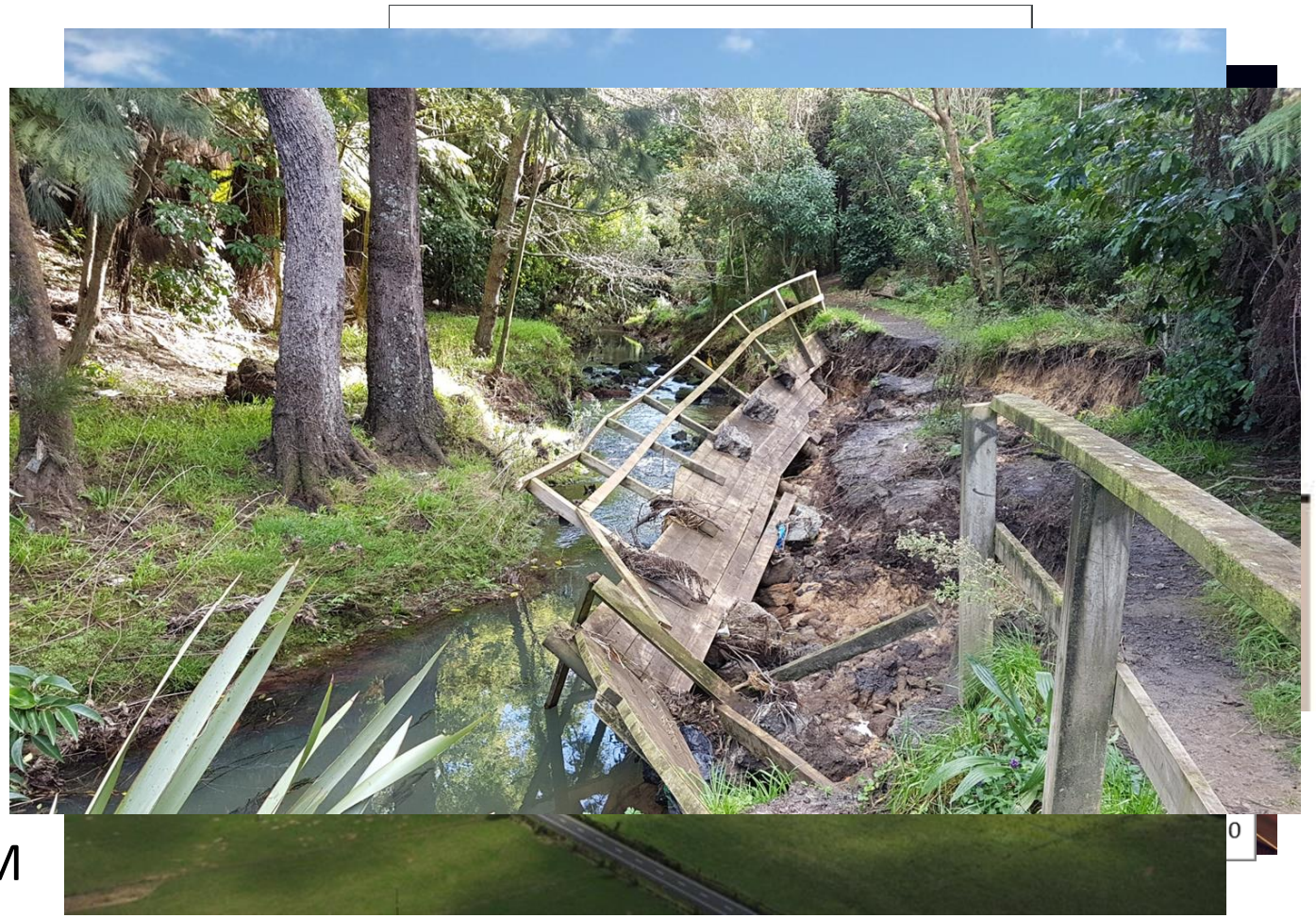
Content

- Introduction
- Modelling Approach
- Modelling Results and Discussion
- Limitations and Uncertainties
- Further Work
- Conclusions

Introduction

Drivers

- Existing stream erosion
- Huge growth and associated effects
  - 50% of NZ's population increase
  - 50% increase in population in the region
- 70% of the total sediment is from stream banks
- Sediment is key 'matter' in the NPSFM

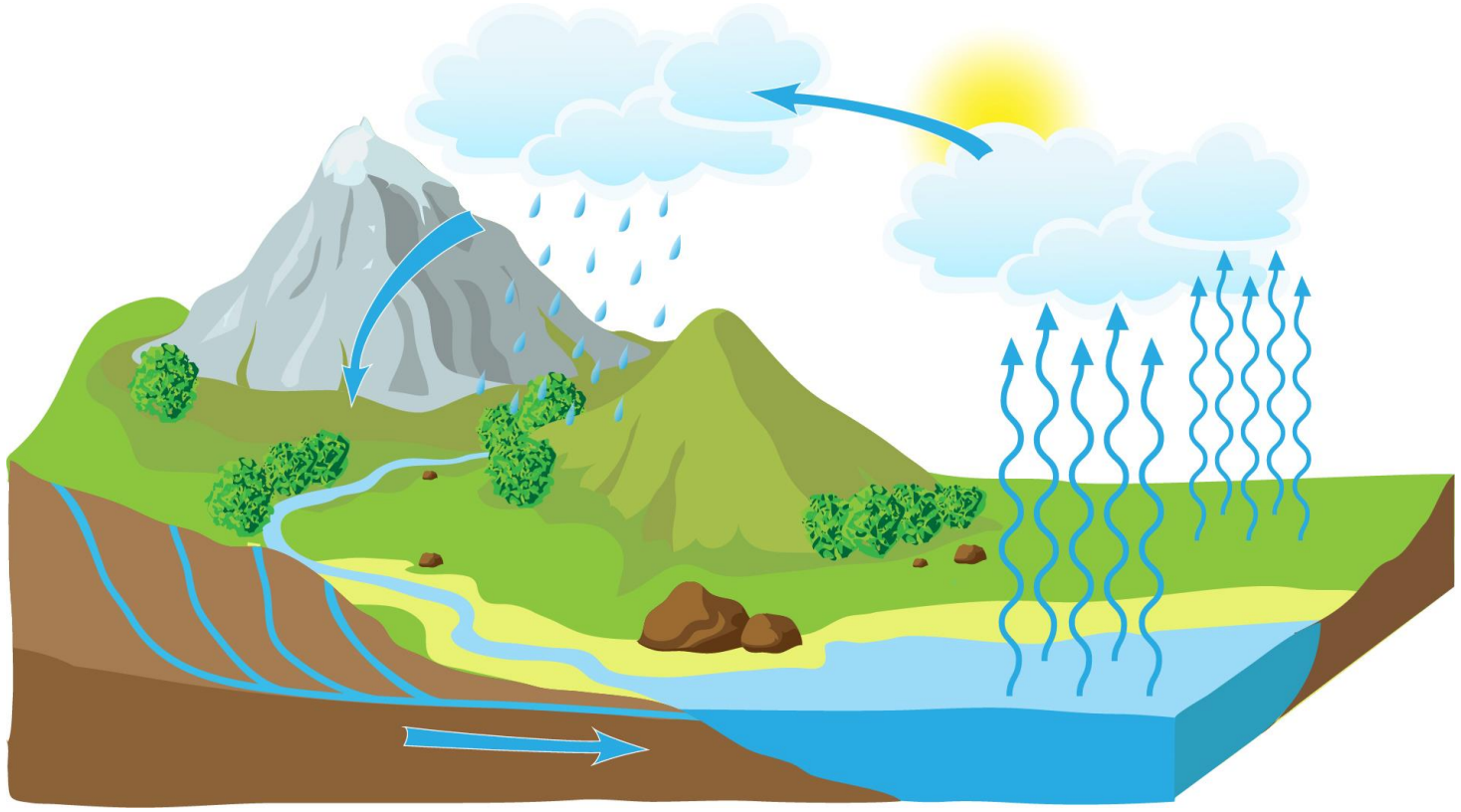


Introduction

- Traditional approaches not appropriate
- Limited no. of flow gauges
- Continuous simulation modelling approach
- Calibrate to gauged cachments
- Apply parameters to ungauged catchments

Modelling Approach

- Simple lumped catchment
- Rainfall data (2007-2011)
- Evapotranspiration data



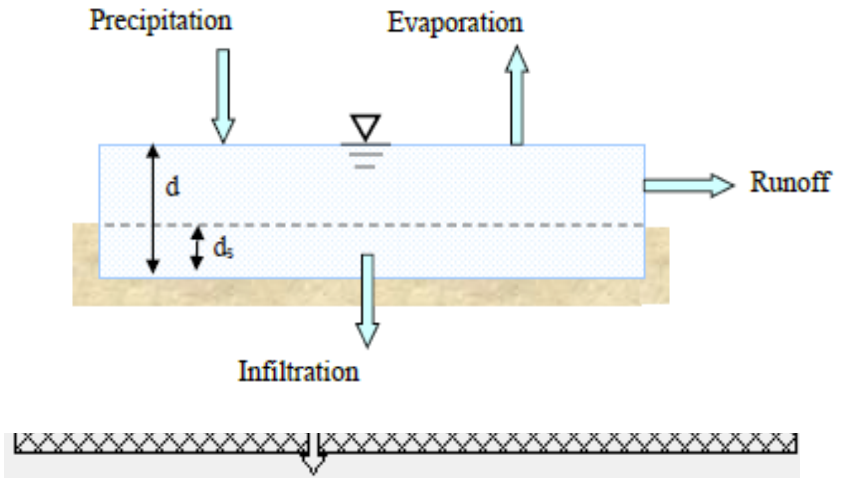
Model Calibration Approach

- No one event calibrated perfectly
- Calibration methods
  - Hydrograph
  - Nash-Sutcliffe
  - Flow duration curves
  - Peak flow frequency
- Better overall calibration

$$E = 1 - \frac{\sum_{t=1}^{T} \left(Q_0^t - Q_m^t \right)^2}{\sum_{t=1}^{T} \left(Q_0^t - \overline{Q_0} \right)^2}$$

Hydrological Model

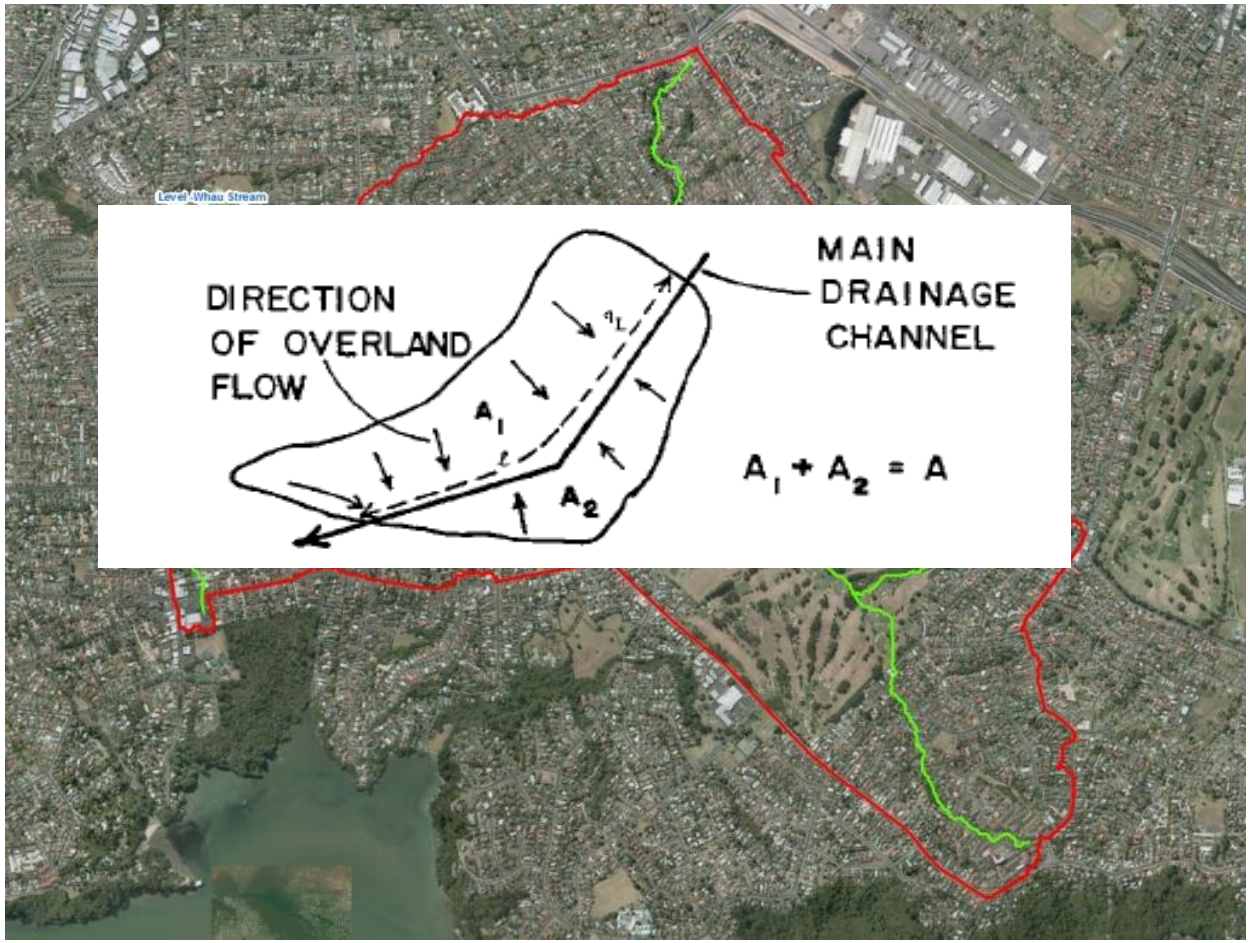
- EPA-SWMM modelling software
- Non-linear reservoir rainfall-runoff routing model
- Curve Number (CN), Horton and Green-Ampt
- Groundwater



Gauge Catchment Characteristics

- 3 urban and 2 rural gauge catchments
- Depression storage & surface roughness
- Catchment slopes
- Catchment widths

  $W = L + 2L(1-Z)$ where $Z = A_m/A$



Gauge Catchment Characteristics

Gauge Catchment Name	Lucas	Chartwell	Whau	Hoteo	West Hoe
Urban/Rural	Urban	Urban	Urban	Rural	Rural
Area (ha)	614	138	467	26,780	52.8
Imperviousness	29.8%	51.8%	43.1%	0.1%	0.0%
Mean Annual Flood (m^3/s)	19.7	13.4	12.1	163.8	1.7
Location of Rainfall Gauge	1.1km from Catchment Boundary	0.65km from Catchment Boundary	Within the Catchment	Within the Catchment	3km from Catchment Boundary

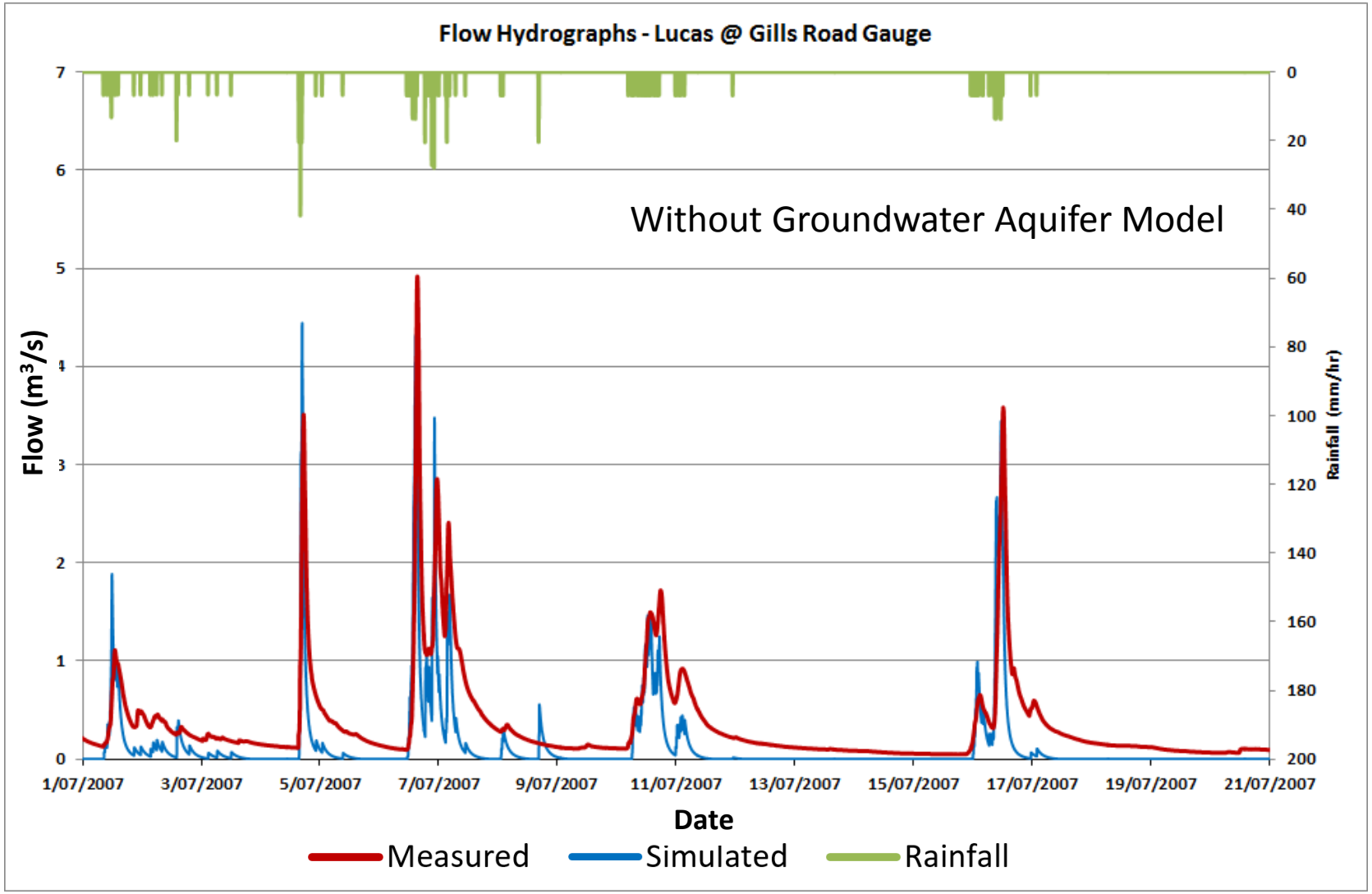
Infiltration Model Parameter Values

Gauge Catchment Name	Lucas	Chartwell	Whau	Hoteo	West Hoe
Horton's Infiltration Model Calibrated Parameter Values					
Max. Infiltration Rate (mm/hr)	85	61	71	61	51
Min. Infiltration Rate (mm/hr)	4.0	3.0	4.0	3.0	0.5
Drying Time (day)	8.5	9.3	9.0	9.3	9.7
Green-Ampt Model Calibrated Parameter Values					
Suction Head (mm)	195	205	195	205	220
Saturated Hydraulic Conductivity (mm/hr)	4.0	3.0	4.0	3.0	1.5
Initial Deficit (fraction)	0.18	0.17	0.18	0.15	0.15

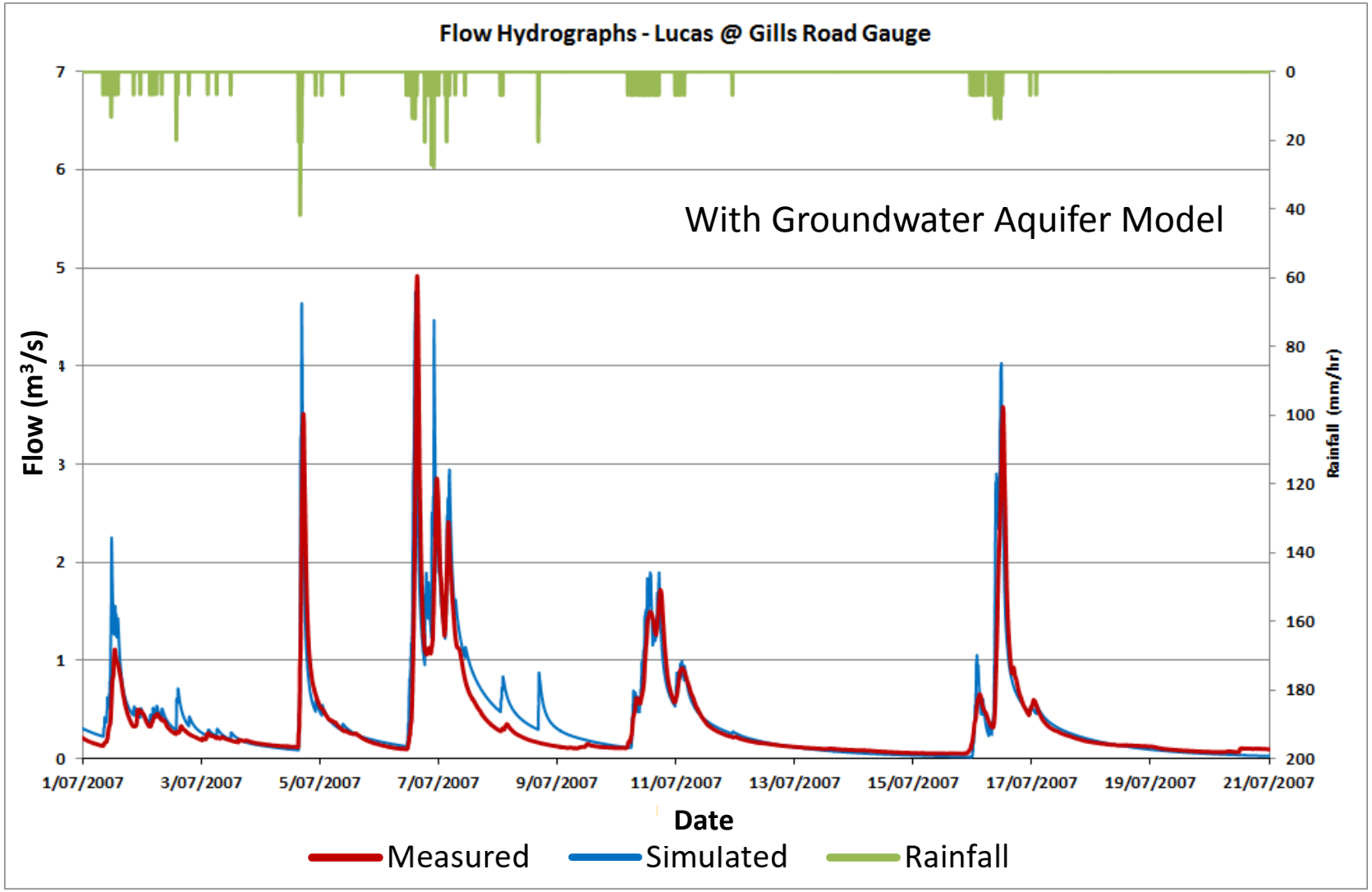
Groundwater Parameter Values

Gauge Catchment Name	Lucas	Chartwell	Whau	Hoteo	West Hoe
Porosity (m^3/m^3)	0.45	0.43	0.45	0.43	0.40
Conductivity (mm/hr)	4.0	3.0	4.0	3.0	1.5
Conductivity Slope	5	10	10	10	10
Tension Slope (mm)	350	350	350	350	350
Lower GW Loss Rate (mm/hr)	1.0	0.1	1.0	0.1	0.1
Groundwater Depth (m)	1.0	2.0	2.0	2.0	2.0
Groundwater Flow Coefficient (A1)	0.10	0.01	0.01	0.03	0.03

Modelling Results – Groundwater Effects



Modelling Results – Groundwater Effects



Modelling Results - NSE

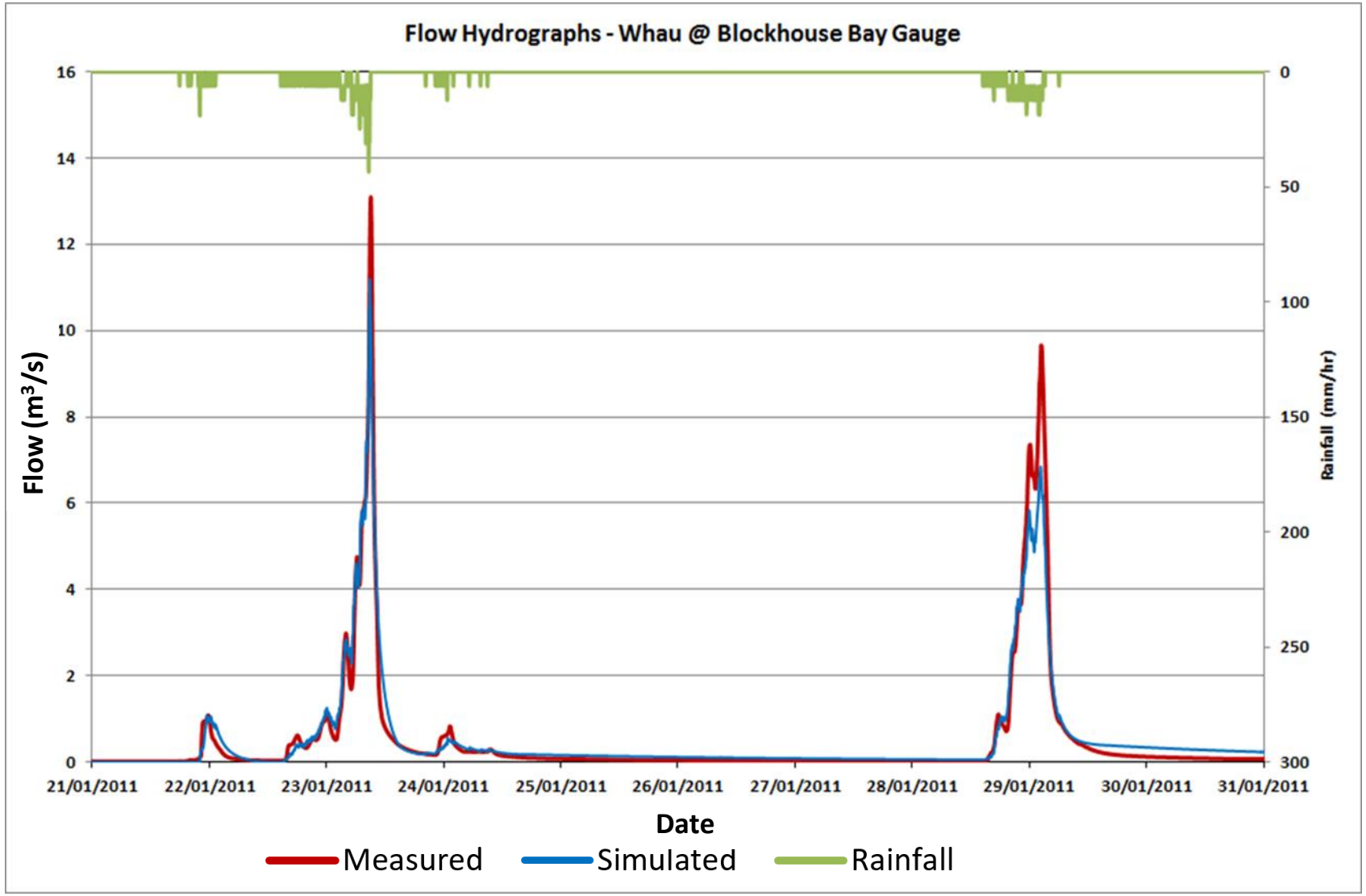
Gauge Catchment Name	Lucas	Chartwell	Whau	Hoteo	West Hoe
	NSE result for 2007-2011				
Horton method	0.69	0.48	0.75	0.73	0.47
Green Ampt method	0.68	0.60	0.77	0.72	0.43

NSE > 0.5 satisfactory

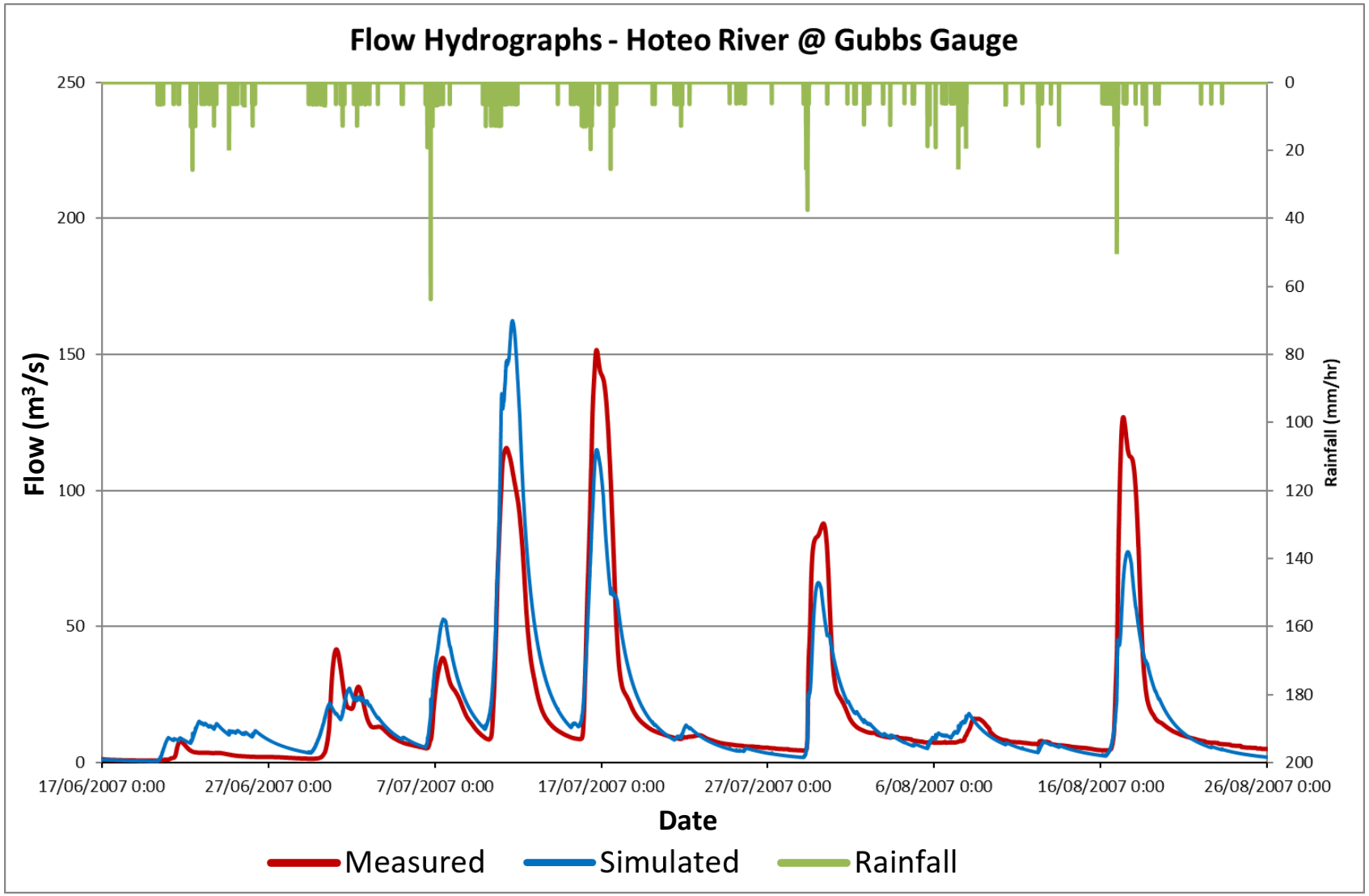
> 0.65 good

>0.75 very good

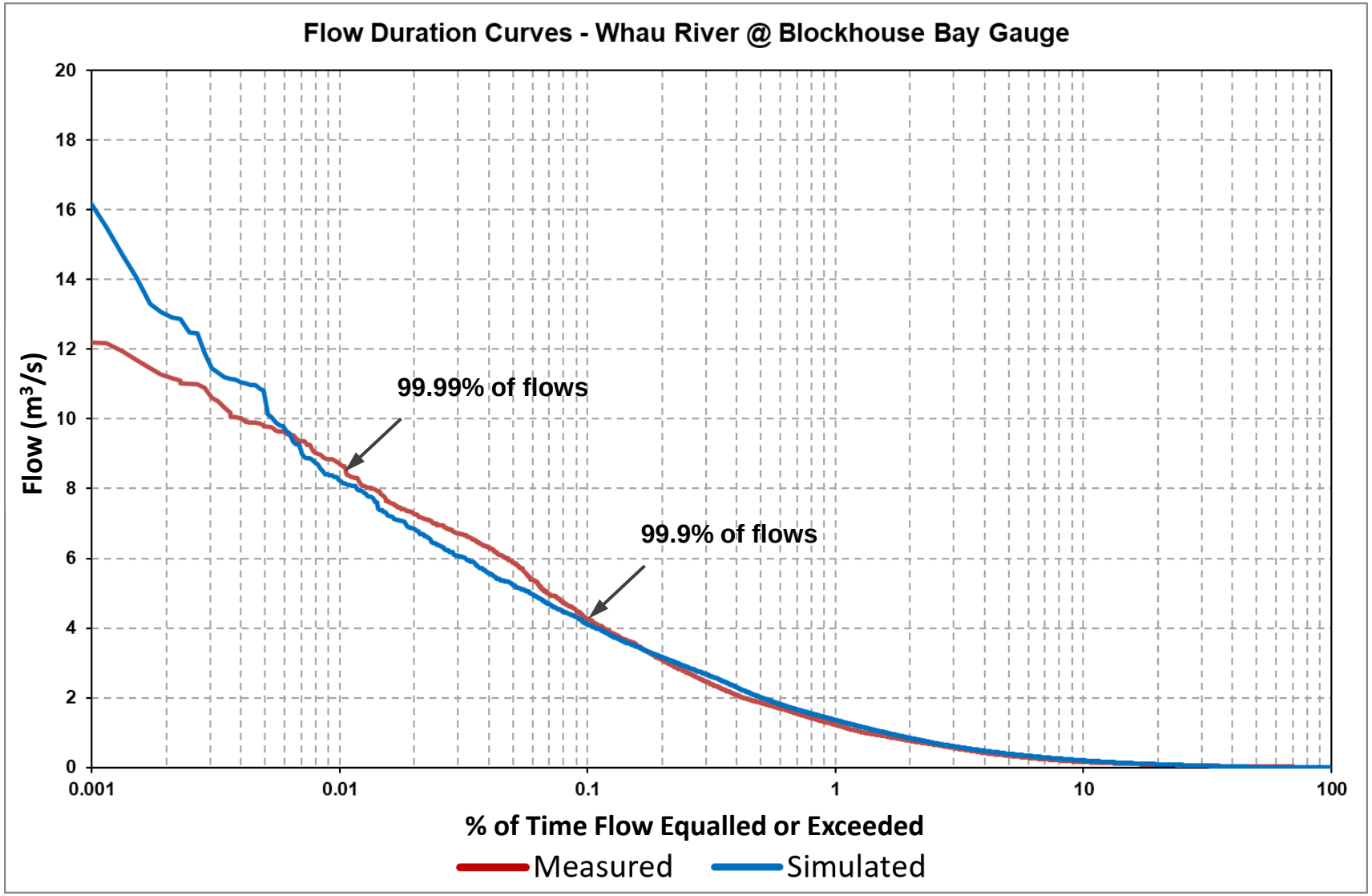
Modelling Results - Hydrographs



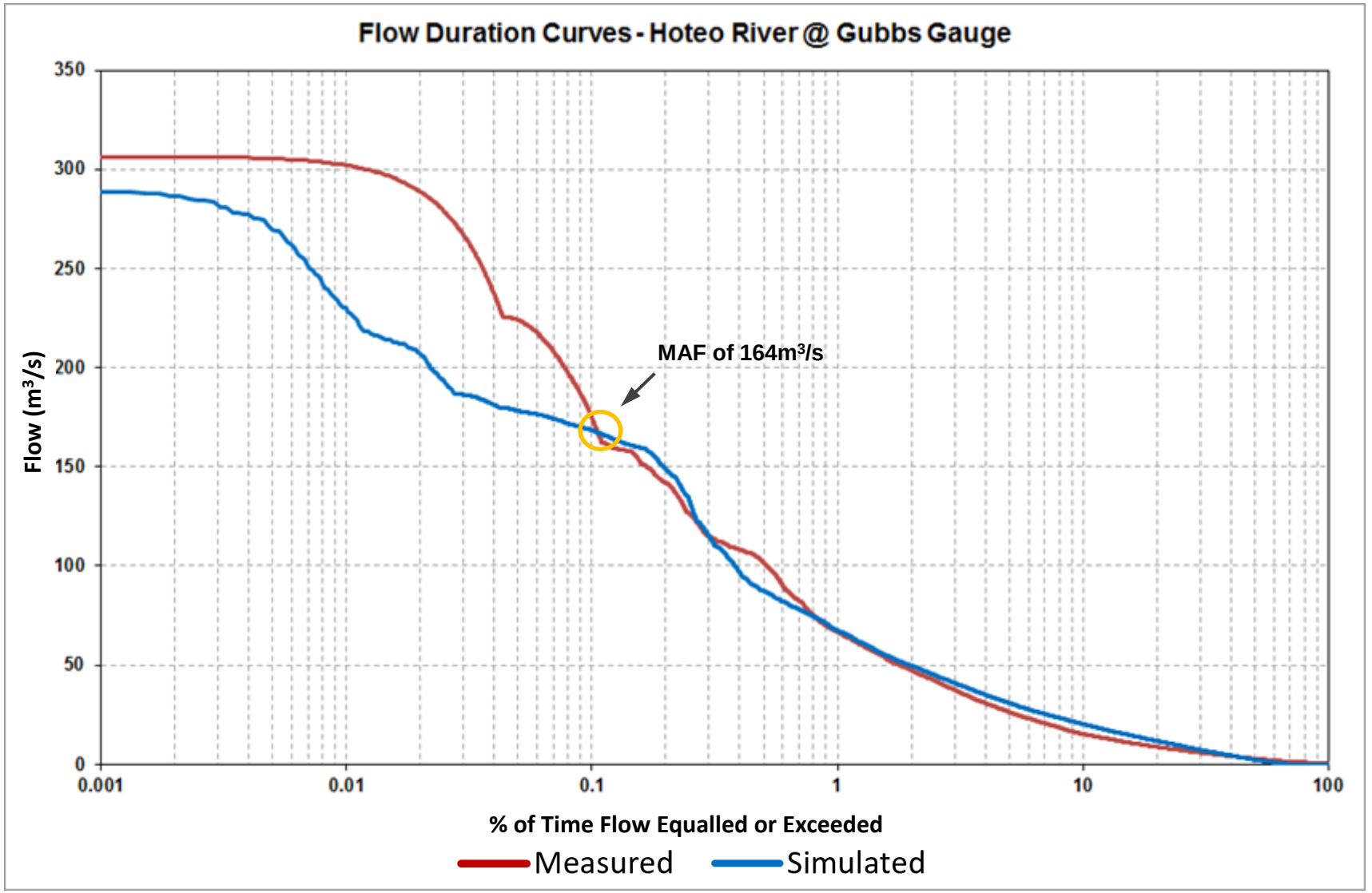
Modelling Results - Hydrographs



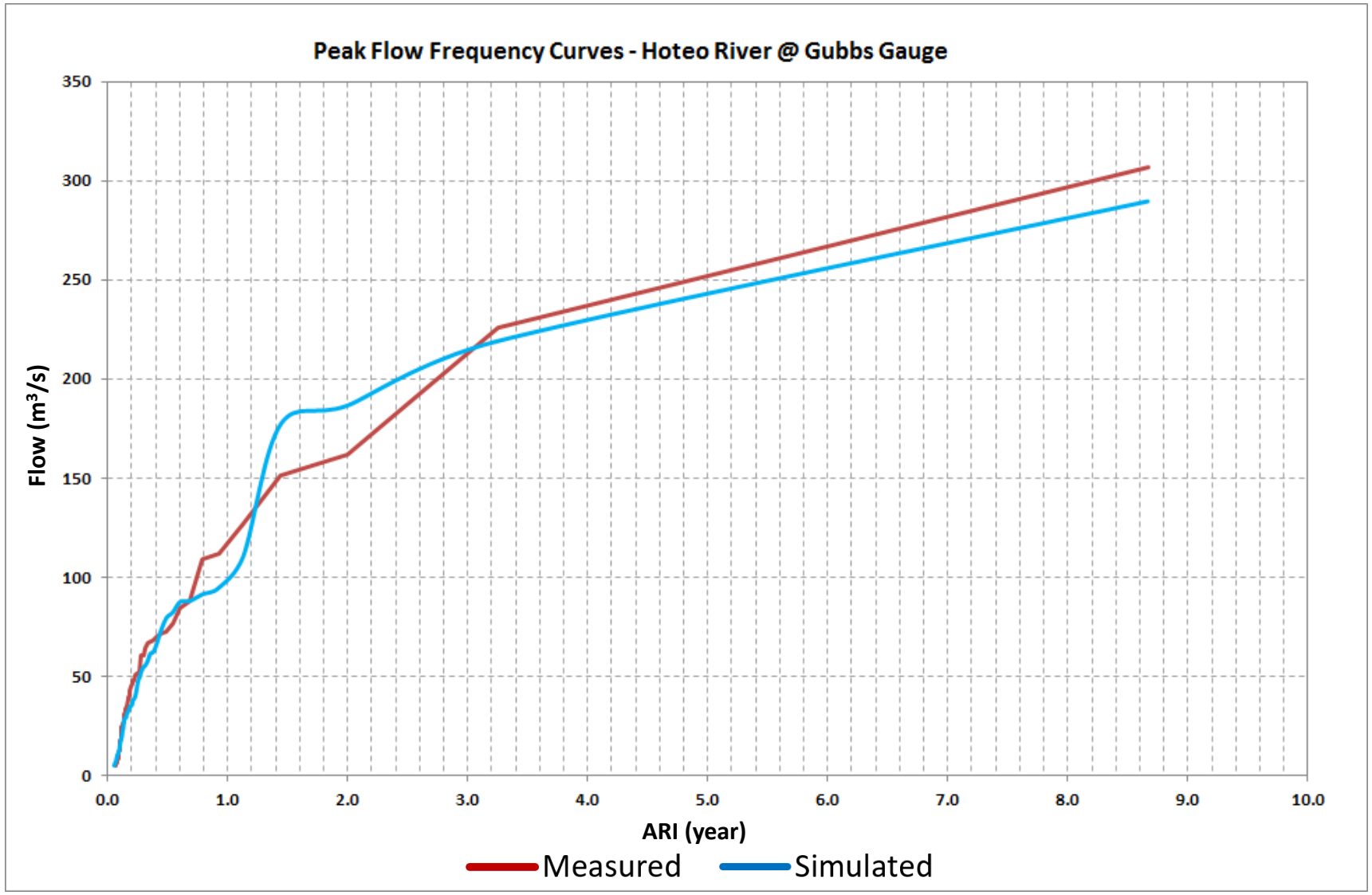
Modelling Results – Flow Duration Curves



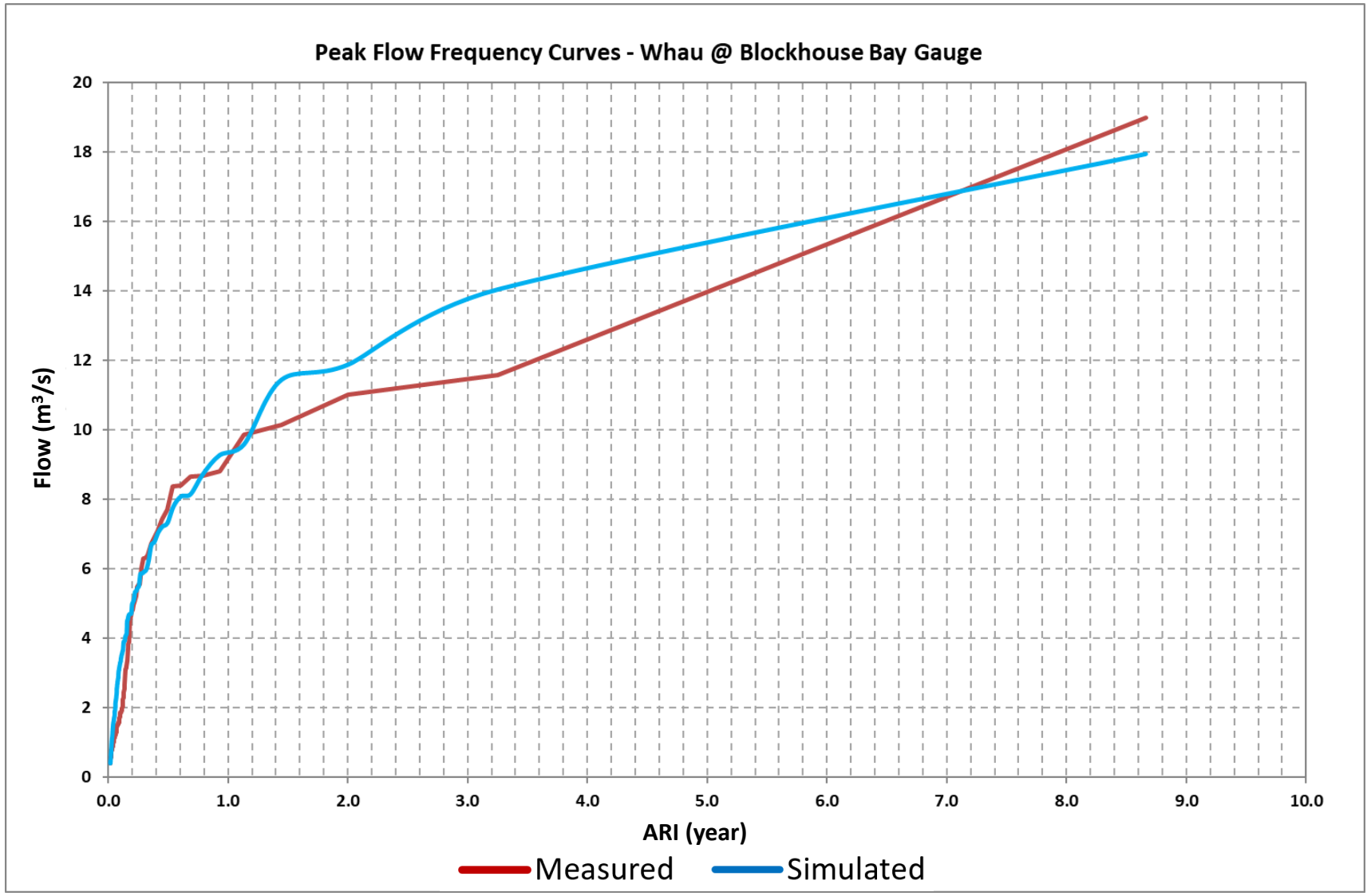
Modelling Results – Flow Duration Curves



Modelling Results – Flow Frequency Curves



Modelling Results – Flow Frequency Curves

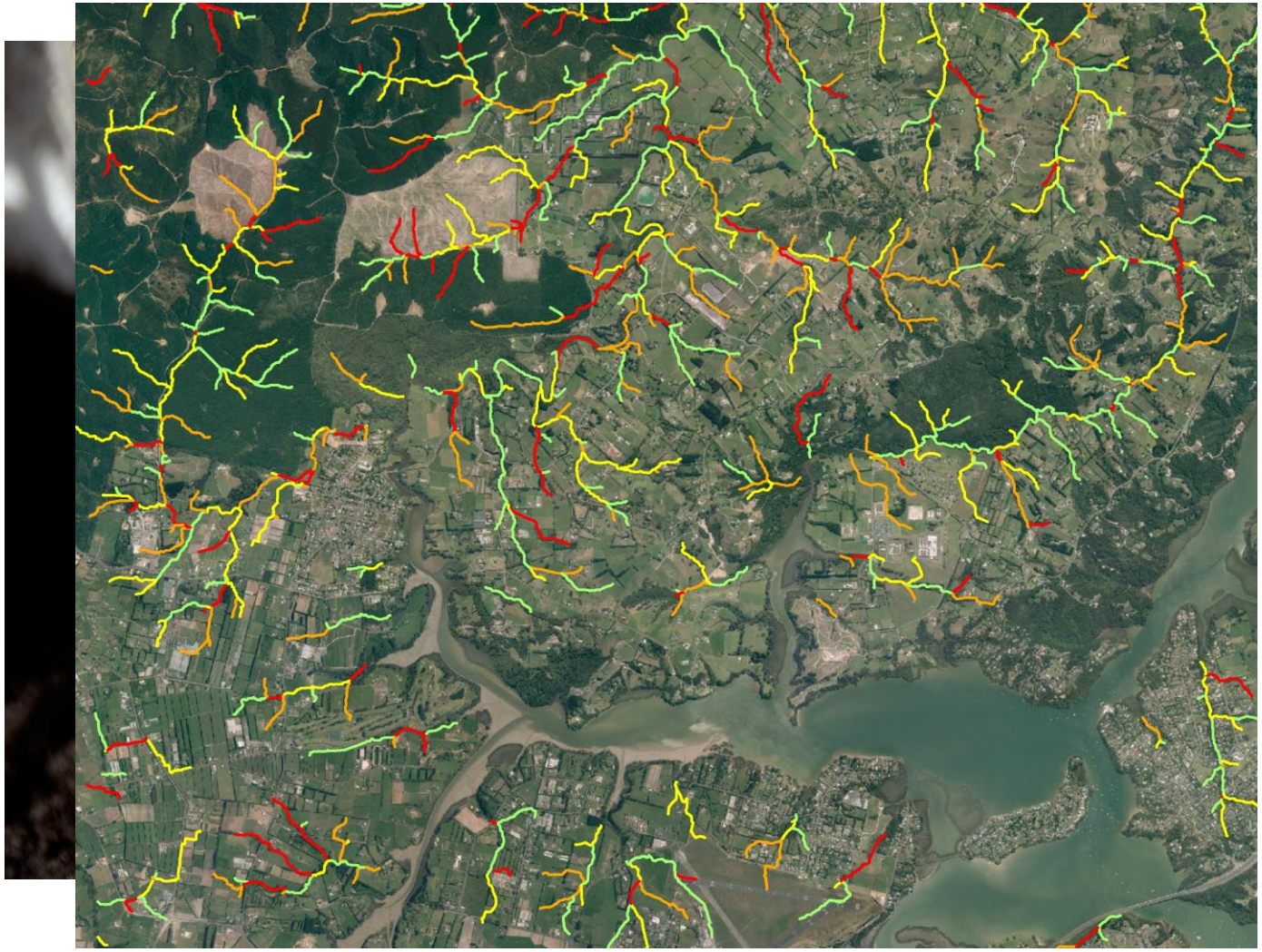


Limitations and Uncertainties

- Location of the rainfall gauge
- Flow gauging issues/uncertainties
- Simple, lumped catchments
- Lack of catchment specific groundwater/aquifer information
- Sub-catchment width parameter

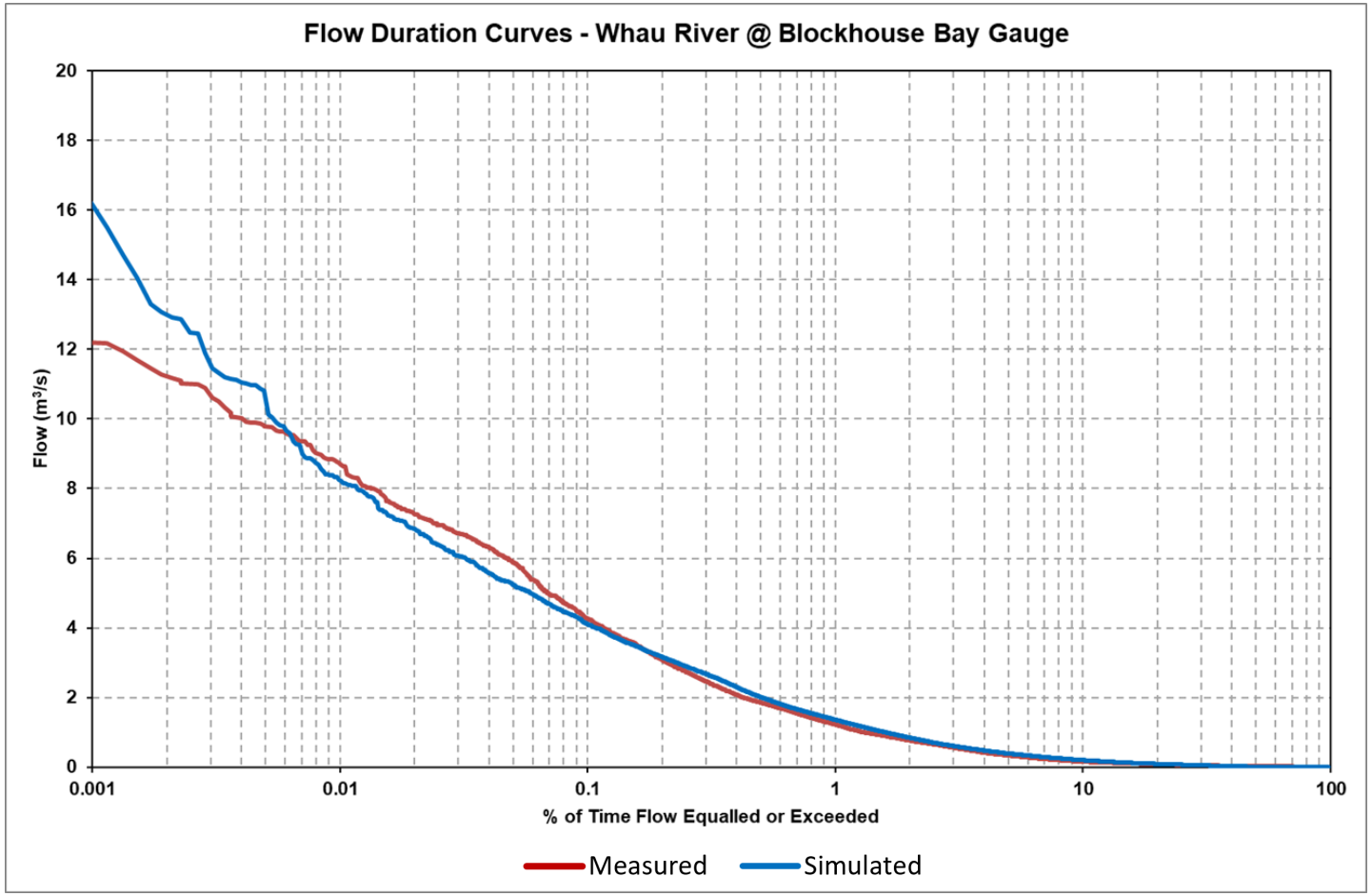
Future work

- Investigate other soil types
- Semi-distributed hydrology
- Implementation into HEC-RAS BSTEM model
- Regional GIS assessment
- Predict what streams will erode



Conclusions

- Continuous simulation modelling
- Calibration methods
- Calibration results
- Horton and Green Ampt provided similar results
- SCS/CN method in SWMM



Conclusions

- Spatial variability of rainfall
- Uncertainty still remains with some parameters
  - Groundwater depth
  - Groundwater A1 coefficient
  - Sub-catchment width
- Future work will help further improve uncertainty and model calibration
- Work will:
  - Identify a consistent set of parameters to predict flows in ungauged catchments
  - Predict what streams might erode and to assess the performance of mitigation strategies


THANK YOU
Josh Irvine and Jahangir Islam
WSP | OPUS
AECOM