THE BENEFITS OF CONTINUOUS STORMWATER QUALITY MODELLING IN CHRISTCHURCH

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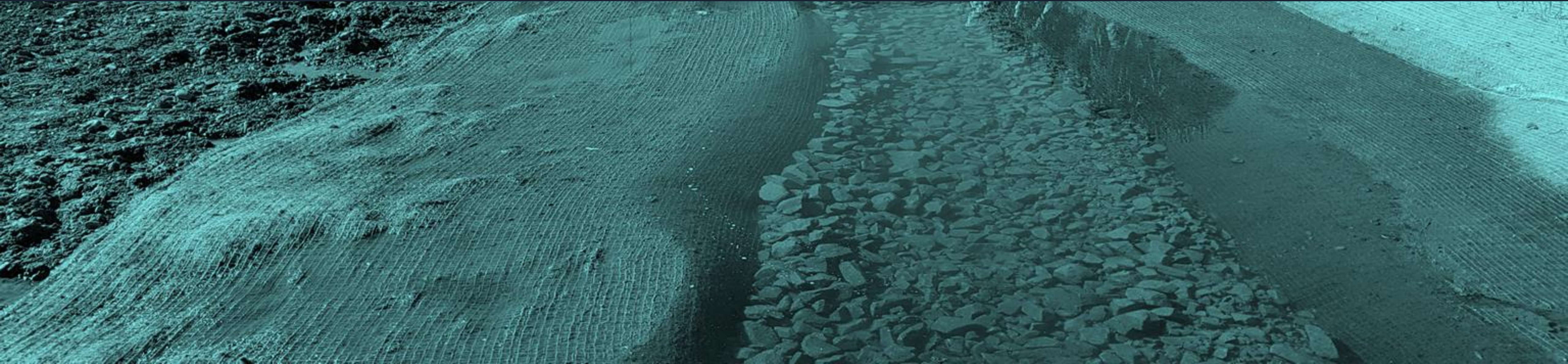


Introduction

- What is continuous stormwater modelling?
- How was it undertaken?
- Model calibration and results
- Project examples

EVENT BASED VERSUS CONTINOUS MODELLING

Event based modelling

- Standard approach using Christchurch City Council's Waterway, Wetlands and Drainage Guide and other National Guidelines
- Works well for individual stormwater devices

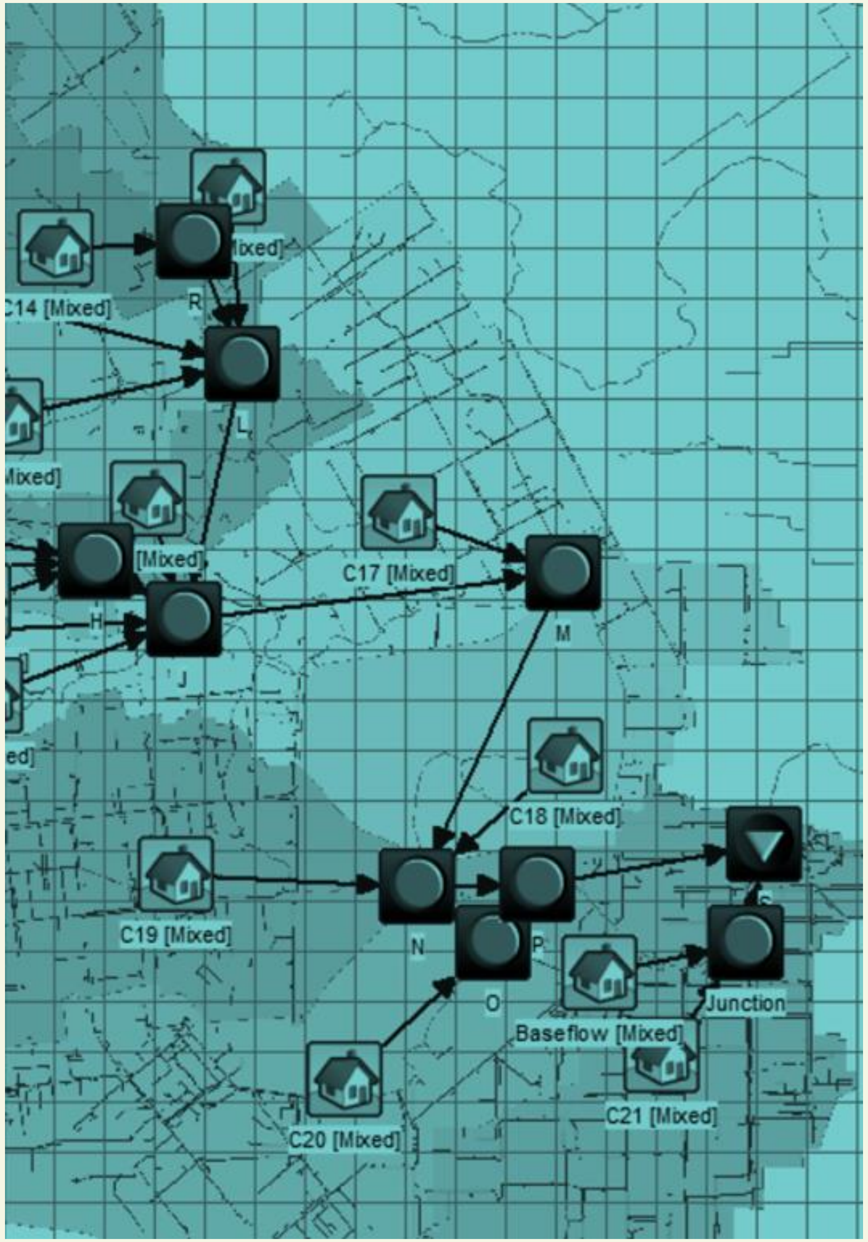
Continuous modelling

- Uses long term historical rainfall records and evapotranspiration data
- Considers groundwater interaction and varying rainfall patterns
- Allows for a number of devices to be modelled in a treatment train configuration

WHAT IS MUSIC

Model for Urban Stormwater Improvement Conceptualisation (MUSIC)

- Water quality modelling tool developed by eWater
- Implemented extensively throughout Australia
- Consists of source nodes, routing links, treatment nodes and receiving nodes
- Uses event mean concentration to generate contaminate runoff loads for various pollutants
- Can be used to size various treatment devices
- Allows for catchment contaminant load modelling
- Can be used to assess non-standard treatment device efficiency



WHAT CONTAMINANTS CAN MUSIC MODEL

1. Total Suspended Solids (TSS)
2. Total Phosphorus (TP)
3. Total Nitrogen (TN)
4. Total Copper (TC)
5. Biological Oxygen Demand (BOD)
6. Gross pollutants
7. Other heavy metals using MUSIC's swap pollutant function and specified removal efficiencies

CATCHMENT WIDE STORMWATER QUALITY MODELLING

Benefits

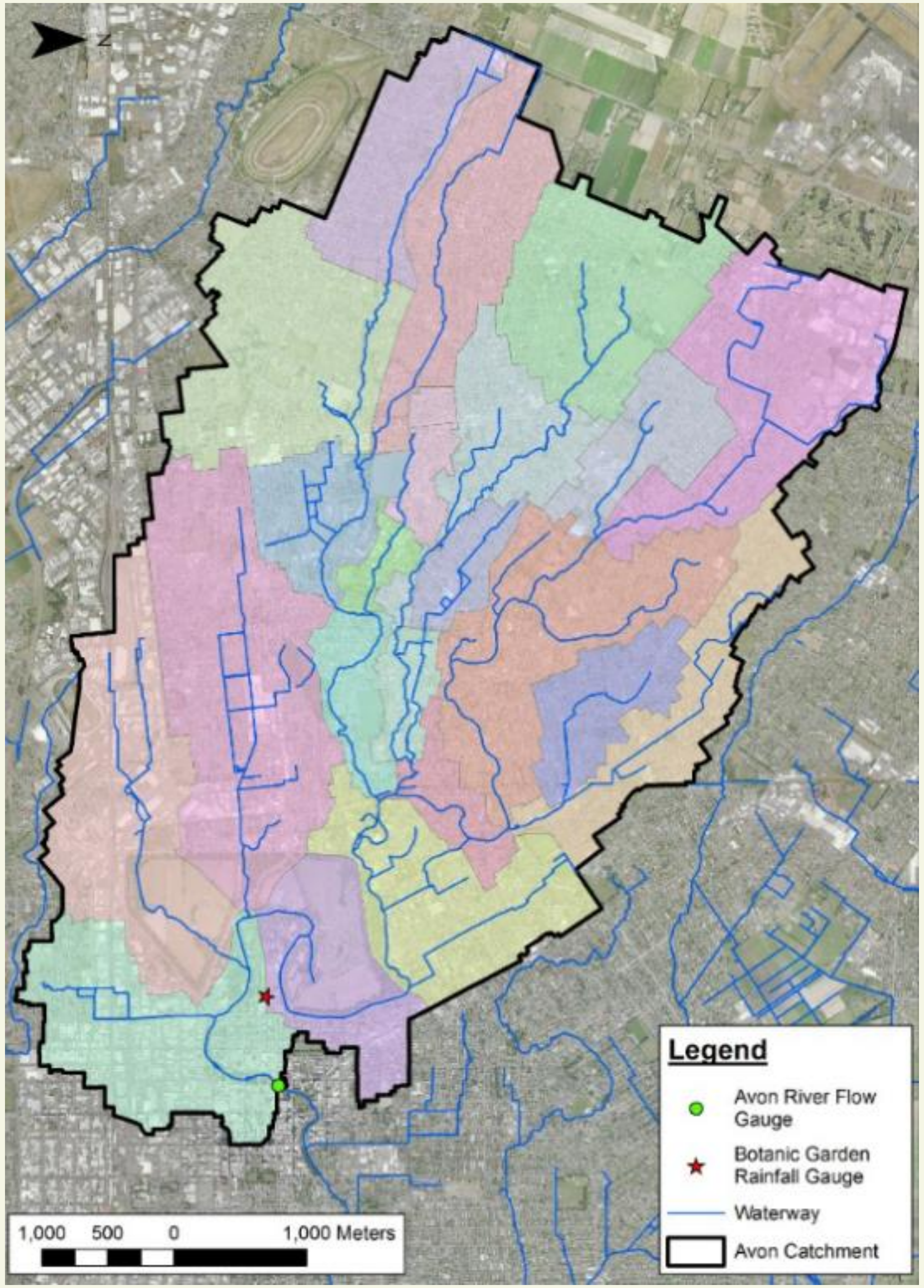
- Quantify the removal efficiency of multiple stormwater devices in a treatment train configuration
- Identification of problematic areas which require further treatment
- Enables rapid cost benefit analysis for a number of configurations
- Quantify loads entering receiving waterways (before and after treatment)

Disadvantages

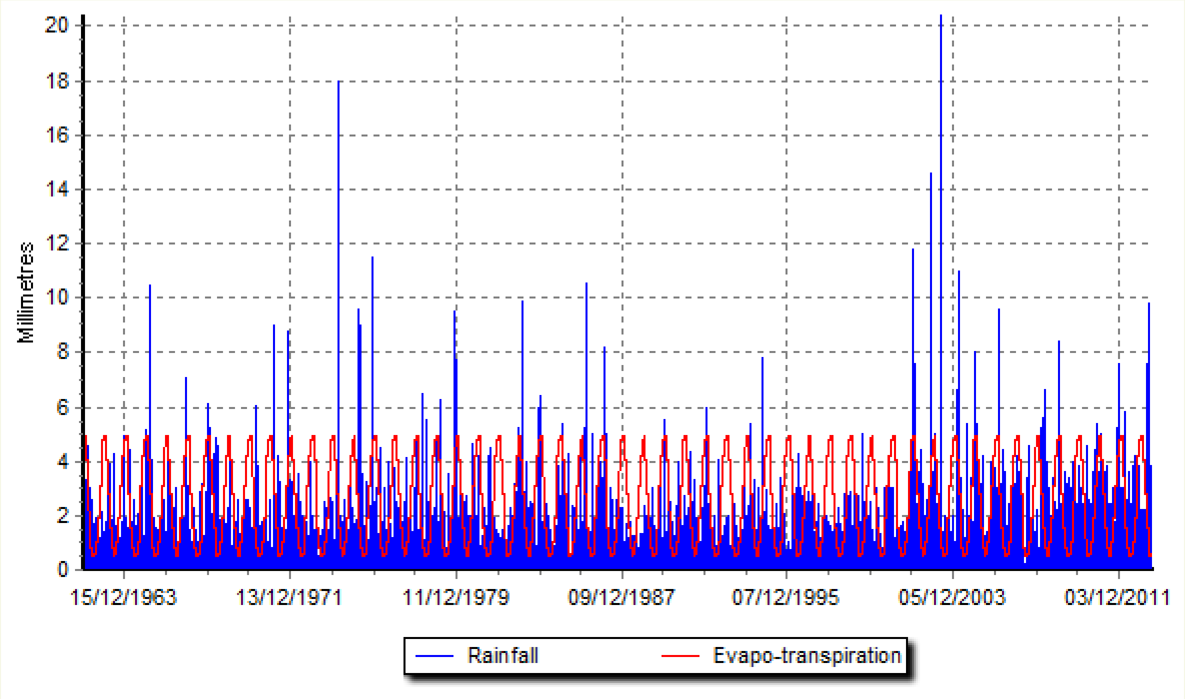
- Potentially additional investment to develop model
- Requires continual updating

Avon River MUSIC model

- MUSIC model developed for Avon River to calibrate rainfall-runoff parameters to local conditions
- The model was calibrated against historic data from the Avon River stream gauge at the Gloucester Street bridge
- Two different approaches for impervious area, Total Impervious Area (TIA) and , Directly Connected Impervious Area (DCIA)
- Land use quantified using CCC zoning plan
- TIA parameters from CCC land use zoning
- DCIA parameters from GIS layers and aerial imagery



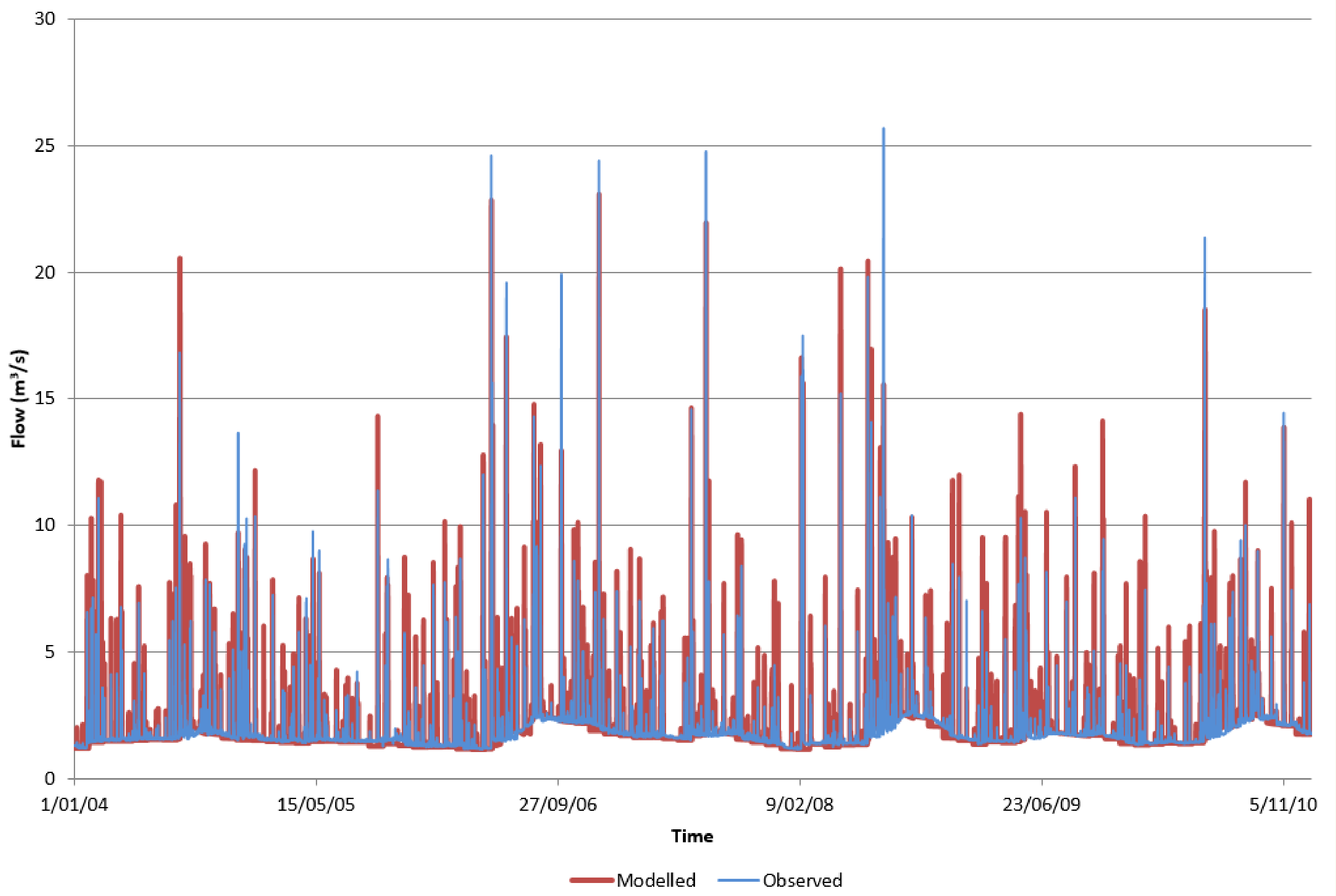
Model Inputs for hydrological calibration



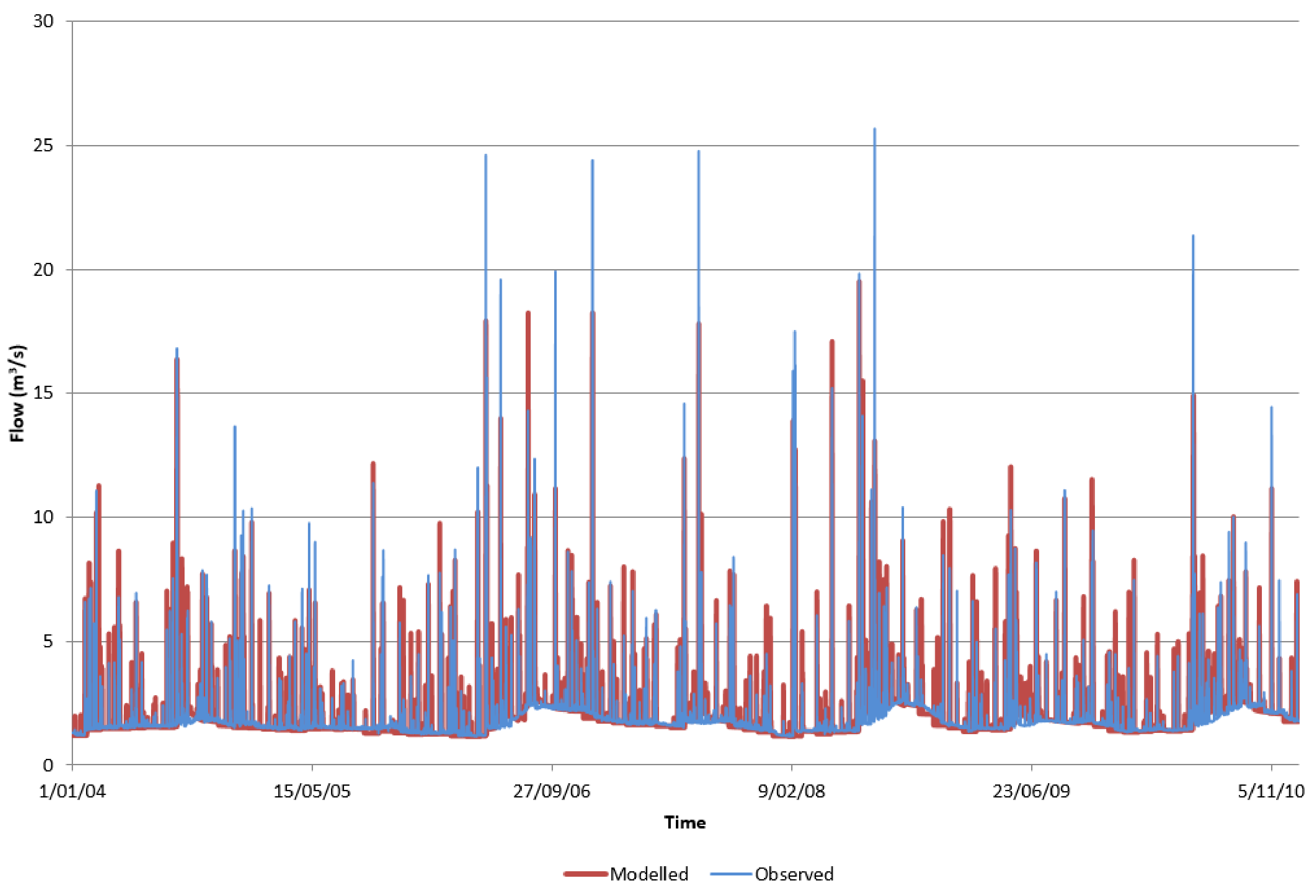
Christchurch continuous rainfall and evapotranspiration record

1. Continuous rainfall data from the Christchurch Botanic Garden site
2. Average monthly evapotranspiration data from NIWA for Christchurch
3. Subcatchment source nodes; roads, open areas, business and residential areas
4. Soil classification
5. Avon River baseflow
6. Lag time between subcatchments

Total Impervious Area results



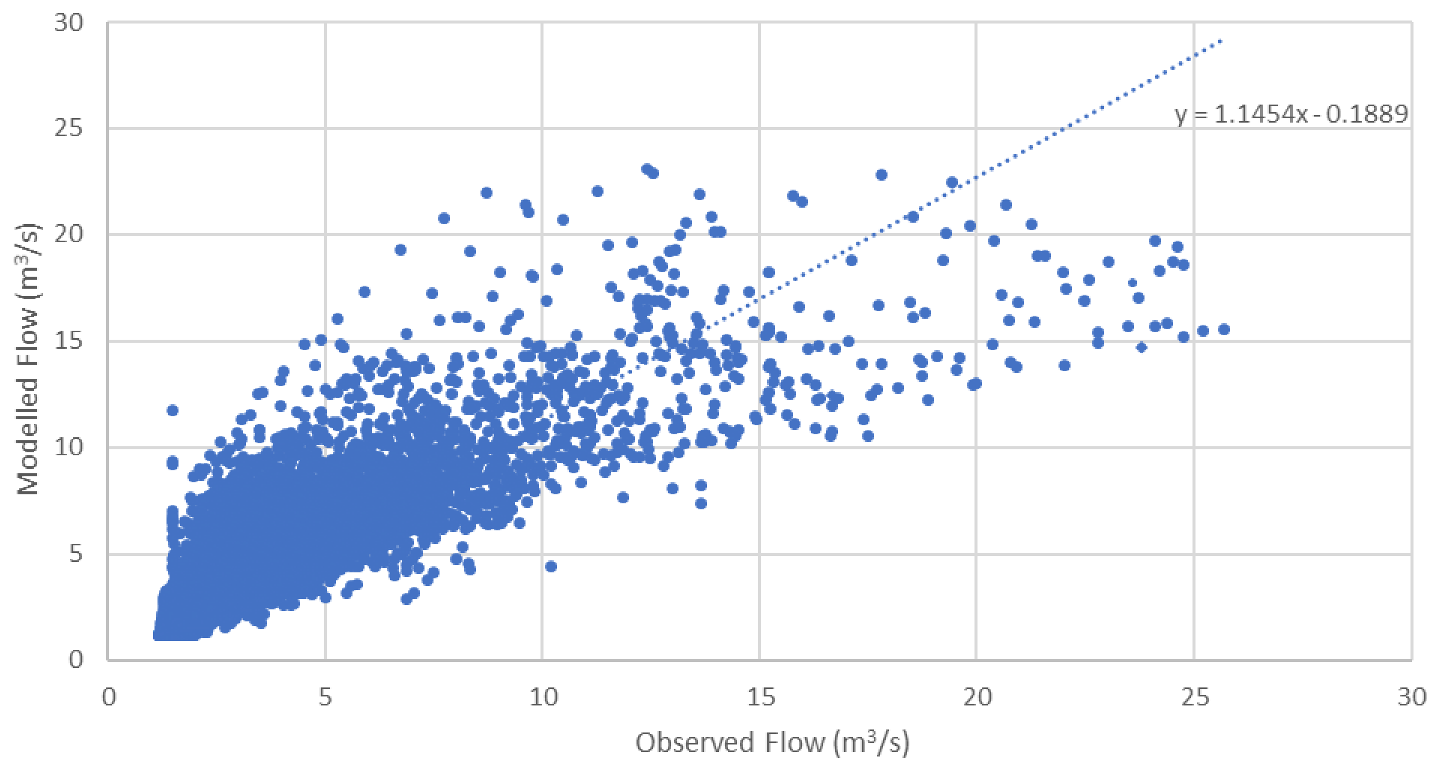
Directly Connected Impervious Area results



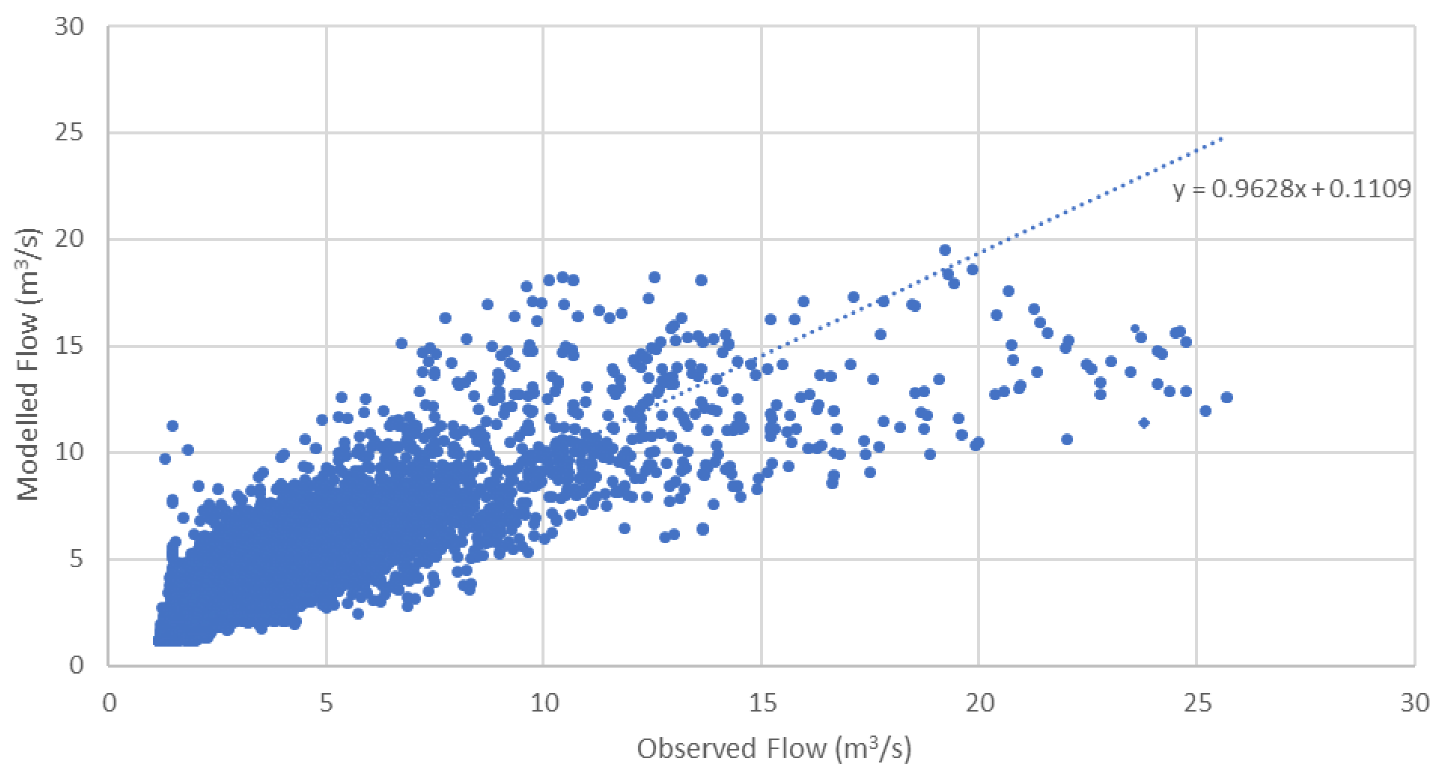
GRAPHICAL AND STATISTICAL ANALYSIS OF RESULTS

1. Linear graphical plot
2. Nach-Sutcliffe Efficiency (NSE)
3. Percent bias (PBIAS)
4. Root mean square error - observations standard deviation ratio (RSR)

Total Impervious Area results



Directly Connected Impervious Area results



Summary of MUSIC model calibration

DCIA

- Hydrological calibration deemed "Very Good"
- Modelled results have a good fit with historic flow data for flows under 15 m^3/s

TIA

- Hydrological calibration deemed "Satisfactory"
- Model overpredicts minor and moderate flow events but better represents large flows

Model Parameters	NSE	PBIAS	RSR	Overall Classification
DCIA	0.76	-2.25	0.49	Very Good
TIA	0.63	-4.39	0.62	Satisfactory

Project Example – Curlett’s Stream

The Problem

Proposed stormwater treatment facility for large developed industrial catchment with high zinc runoff concentrations. Insufficient area for a facility sized to the CCC’s WWDG.

How MUSIC was used

MUSIC allowed for the water quality removal efficiencies to be compared for a number of proposed undersized stormwater facility configurations. Additionally, the benefits of proprietary stormwater treatment devices in treatment train could be quantified

Image from Christchurch City Council

Project Example – Curlett's Stream MUSIC Results

Option	First Flush Volume (m³)	First Flush Depth (mm)	Wetland Area (m²)	Flow Rate through wetland (m³/day)	Wetland Residence Time (hours)
1	50,800	25.8	26,500	12,700	9.4
2 / 2b	16,800	8.5	45,000	4,200	48.2
3 / 3b	27,000	13.7	37,400	6,750	24.9

Parameter	Curletts Stream Stormwater Facility Scenario		
	Option 1	Option 2	Option 3
	Large FFB with 25mm WQD, small wetland	Small FFB with 8.5mm WQD, large wetland	Medium FFB with 13.7mm WQD, medium wetland
TSS mean annual load from Curletts Stream catchment (kg/year)	217,000	217,000	217,000
Mean annual flow from Curletts Stream catchment (ML/year)	1,220	1,220	1,220
TSS removal efficiency by FFB	68.0%	49.1%	57.9%
TSS removal efficiency by wetland	78.9%	88.1%	86.0%
Mean annual flow bypassing proposed Stormwater Facility (ML/year)	160	550	378
TSS mean annual residual load entering Heathcote River (kg/year)	31,400	82,100	55,400
TSS removal efficiency (by Stormwater Facility)	85.5%	62.2%	74.1%

Project Example – Knights Drain

The Problem

CCC required assistance with quantifying the water quality benefits of a number of proposed stormwater facility configurations

How MUSIC was used

MUSIC allowed for a number of different types of stormwater facilities and configurations to be modelled in a short period of time. Once a final option was selected it was used to quantify the removal efficiencies of the proposed facility and residual pollutant load entering the Avon River

Project Example – Knights Drain MUSIC Results

Wet Pond and Conventional Wetland Stormwater Facility

Parameter	TSS Mean Annual Load (kg/year)	TSS Mean Annual Load (m^3/year) (2.)	Mean Annual Flow (ML/year)
Catchment Source Load	10,300	3.9	84.7
Catchment Residual Load (1.)	1,590	0.6	64.2
% Reduction	84.6%	84.6%	24.2%

Wet Pond only Stormwater Facility

Parameter	TSS Mean Annual Load (kg/year)	TSS Mean Annual Load (m^3/year) (2.)	Mean Annual Flow (ML/year)
Catchment Source Load	10,300	3.9	84.7
Catchment Residual Load (1.)	4,410	1.7	81.5
% Reduction	57.3%	57.3%	3.8%

Project Example – An Accessible City / He Taone Wātea

The Problem

Quantifying the removal efficiencies of integrated street-scale stormwater devices which are size constrained due to existing services

How MUSIC was used

MUSIC was used to size these stormwater treatment devices for a minimum 75% TSS removal efficiency whilst allowing for the devices to be integrated into the road corridor

Project Example – King Edwards Barracks

The Problem

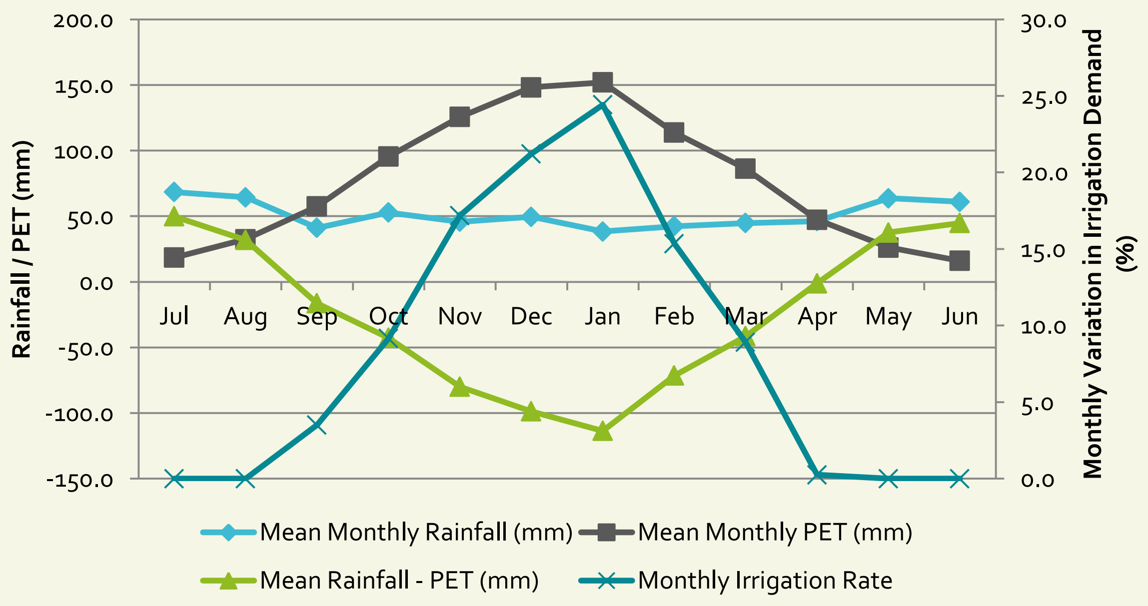
Ngāi Tahu's wished to assess the viability of implementing rainwater harvesting tanks into the King Edward Barracks development

How MUSIC was used

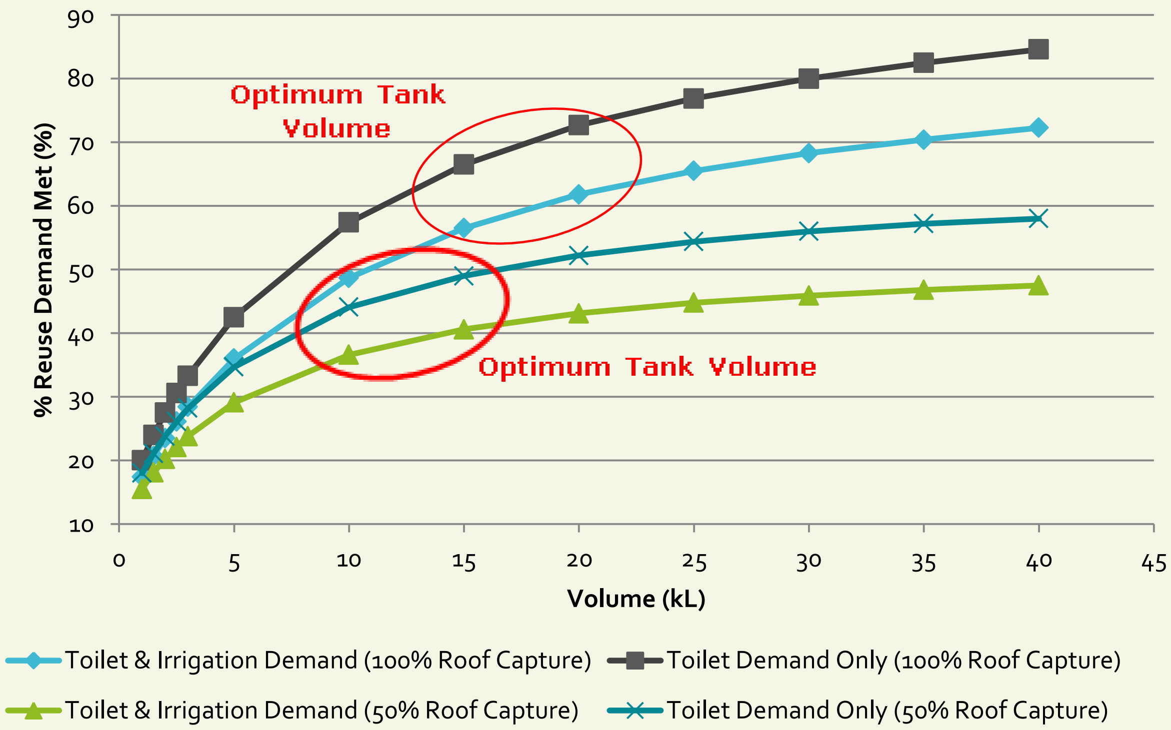
MUSIC was used to optimally size rainwater harvesting tanks by incorporating historic rainfall data and monthly reuse demands into a model of the development

Project Example – King Edwards Barracks

Christchurch Monthly Climate Data



King Edward Barrack's Tank Curve



CONCLUSION

In summary

- MUSIC model developed for Avon River catchment and was calibrated to local conditions
- The model demonstrated a good hydrological calibration
- Successfully implemented on a number of small scale projects
- Able to quantify removal efficiencies for undersized facilities and quantify contaminant loads entering receiving waterways

Where to next?

- Further calibration for pollutant generation parameters based on local measurements for TSS and other heavy metals
- Implementation of MUSIC in future projects
- Catchment wide contaminant load modelling

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THANKS FOR YOUR TIME, QUESTIONS?