Spatial Analysis and Planning System to Determine the Impact of Urbanisation on Freshwater Quality

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Acknowledgments

- **Tom Cochrane** and **Frances Charters** (UC)
- **Hema Kumar** and **Suzana Shipton** (DHI)
- Clients

Property Prices

Aggregate waterfront property values could increase by roughly **$400–$700M** in response to water clarity improvements.

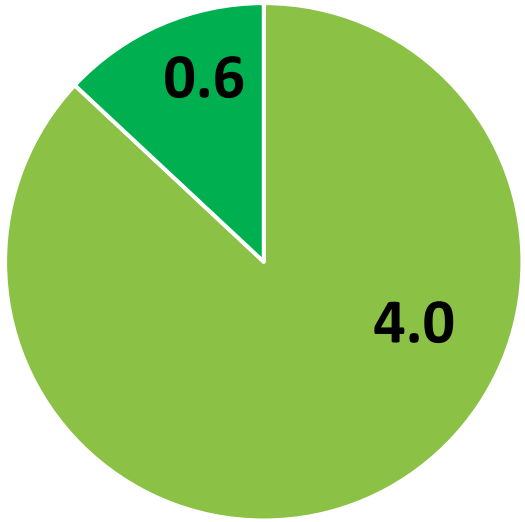
Total aggregated present value of benefits (discounted to the year of 2017) with a 25% decrease in Chlorophyll concentration was **$45.52M**.

Ref: Klemick, H., Griffiths, C., Guignet, D. and Walsh, P., 2018. Improving water quality in an iconic estuary: an internal meta-analysis of property value impacts around the Chesapeake Bay. Environmental and Resource Economics, 69(2), pp.265-292.
Ref: Nicholls, S. and Crompton, J., 2018. A Comprehensive Review of the Evidence of the Impact of Surface Water Quality on Property Values. Sustainability, 10(2), p.500.
Ref: https://ourhamilton.co.nz/growing-hamilton/big-jump-in-hamilton-property-values/

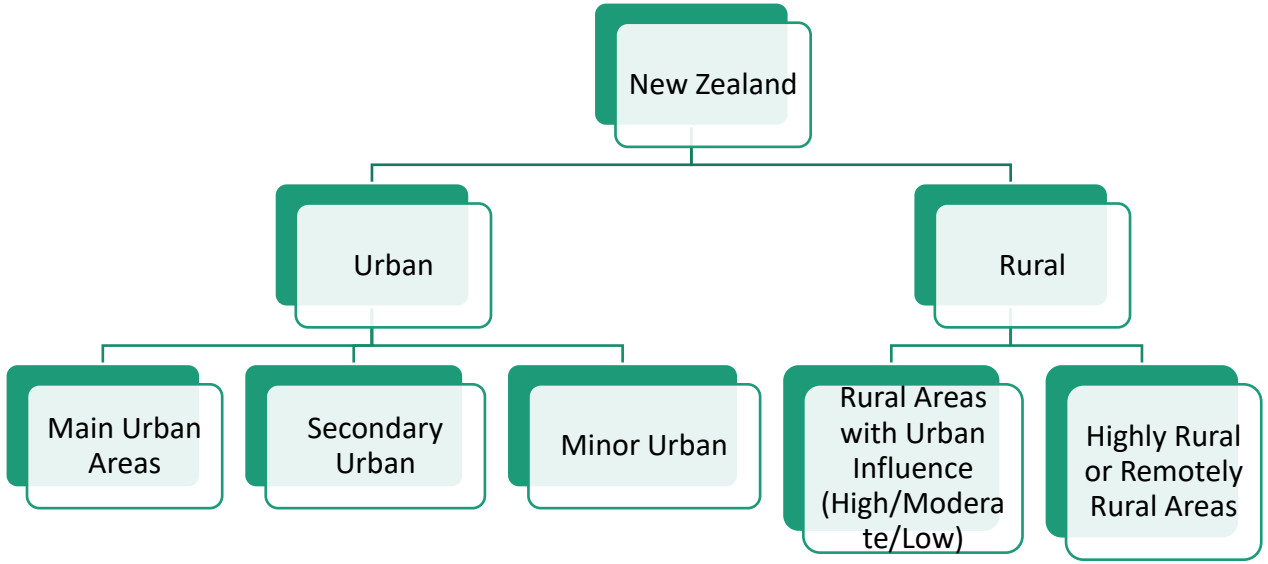
Population Distribution of New Zealand

1915: 1 million

2015: 4.6 million



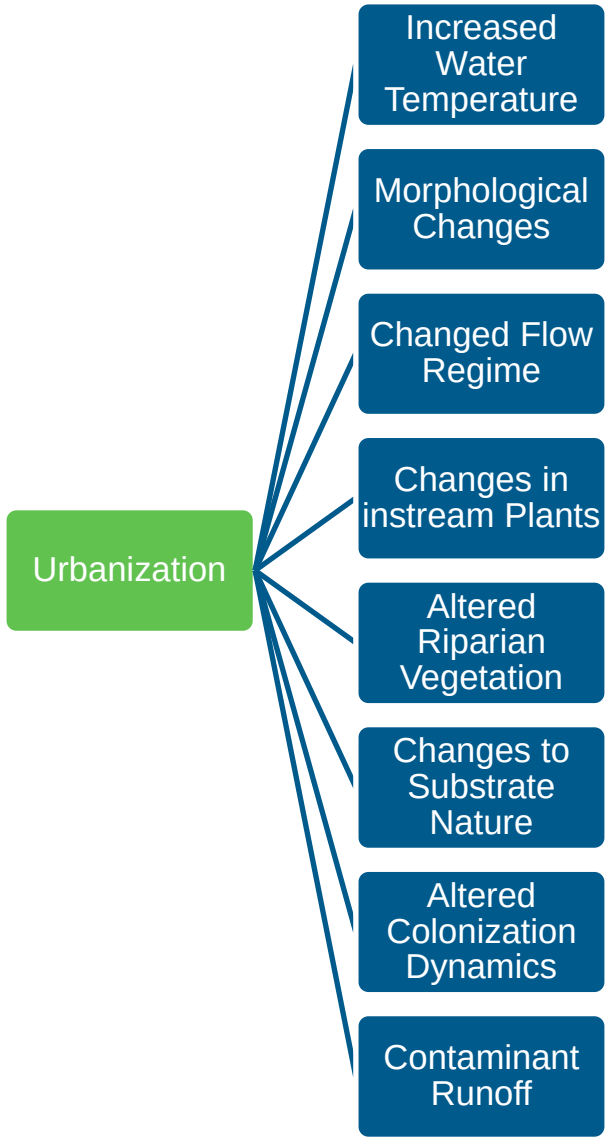
Almost all population growth during last century has been in towns and cities

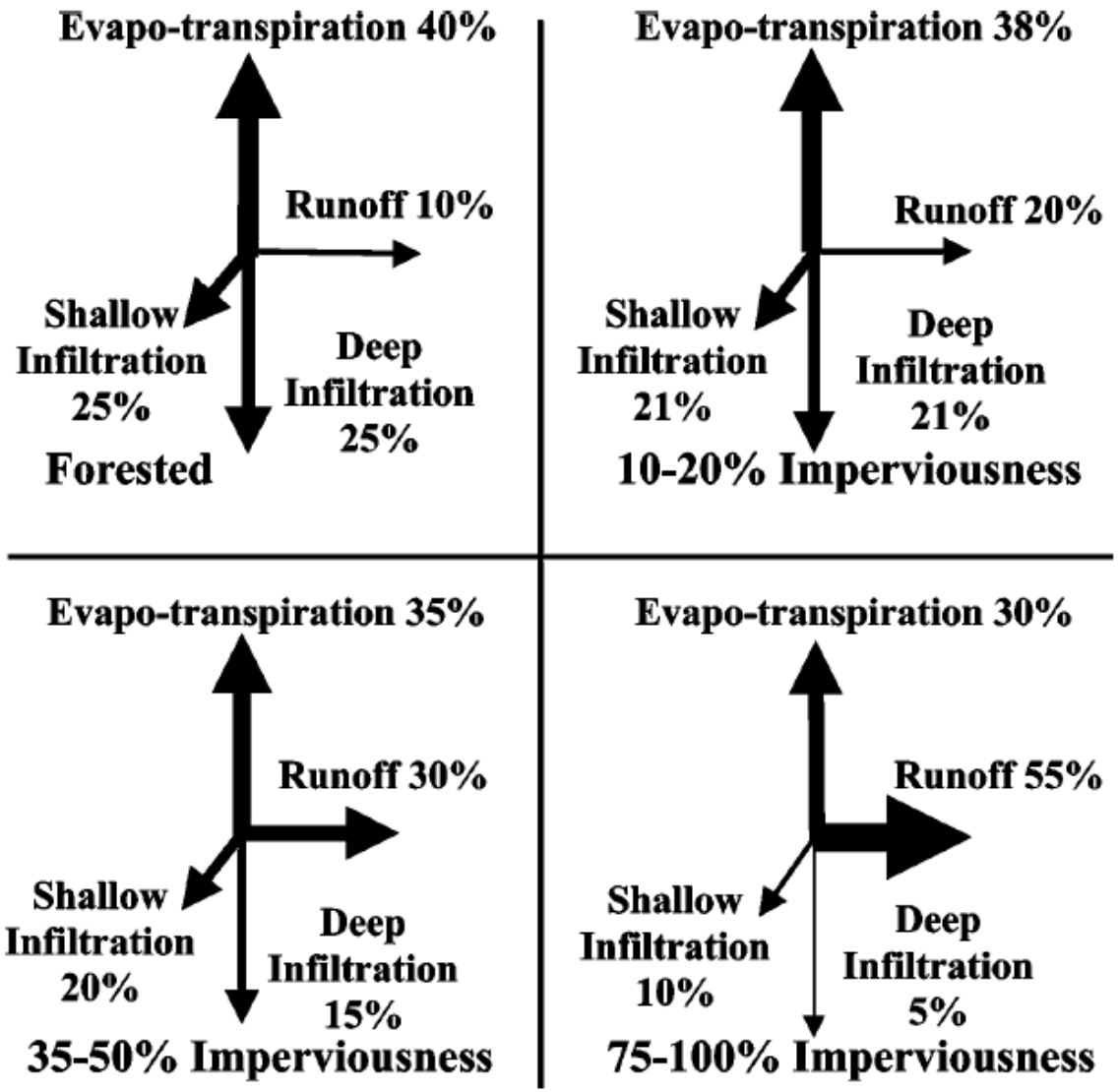


Areas	1991 (%)	1996 (%)	2001 (%)	2006 (%)
Main Urban (>30,000)	69.6	70.2	71	71.8
Secondary Urban (>10,000)	6.9	6.5	6.3	6.0
Minor Urban (>1,000)	9.0	8.7	8.4	8.1
Rural (>300)	2.3	2.3	2.1	2.0
Highly Rural	12.2	12.3	12.1	12.0

Ref: http://archive.stats.govt.nz/browse_for_stats/Maps_and_geography/Geographic-areas/urban-rural-profile/defining-urban-rural-nz.aspx

Impact of Urbanisation on Freshwater





Ref: SUREN, A.M. AND ELLIOT, A., 2004. Impacts of urbanisation on streams. In: Freshwaters of New Zealand. Eds. J. Harding, P. Mosley, C. Pearson, & B. Sorrell. Chapter 35. NZ Hydrological Society & NZ Limnological Society.
Ref: Paul, M.J. and Meyer, J.L., 2001. Streams in the urban landscape. Annual review of Ecology and Systematics, 32(1), pp.333-365.

Current state of Urban waterways




Stormwater discharges into receiving environment

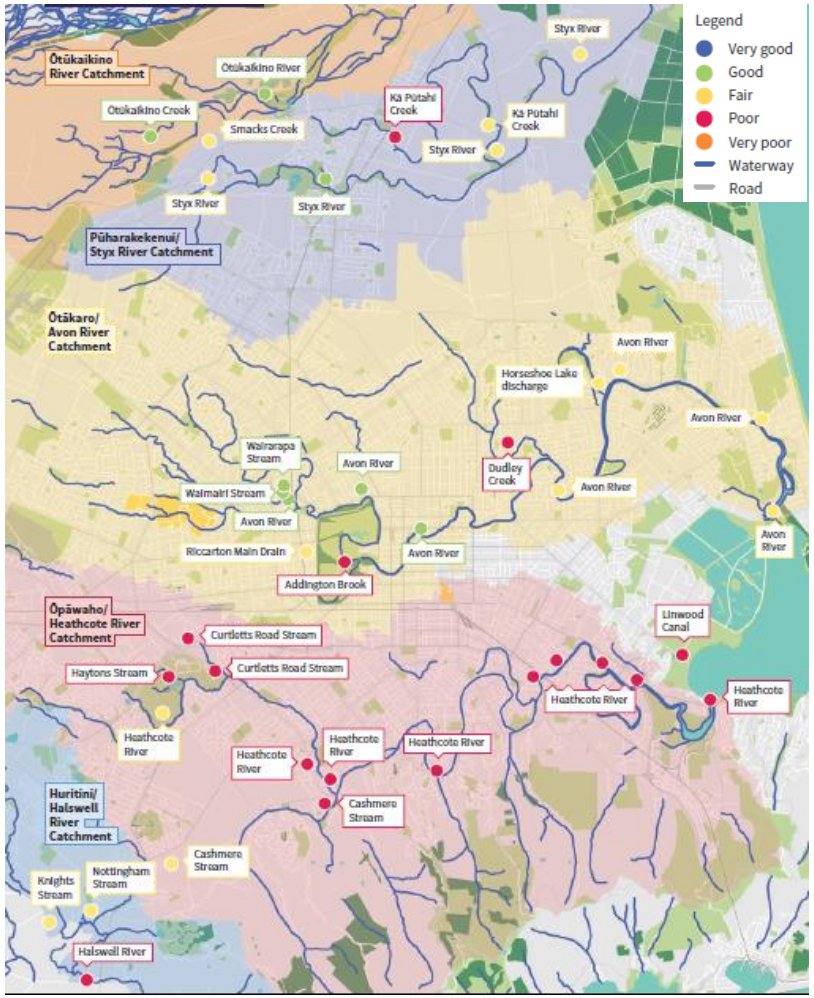
City	No. of Discharge Outlets
Auckland	19,919
Christchurch	5206
Tauranga	2590
Wellington	2200
Dunedin	734
Palmerston North	274
Timaru	177
Invercargill	147
Whakatane	43
Napier	14

Example from NZ

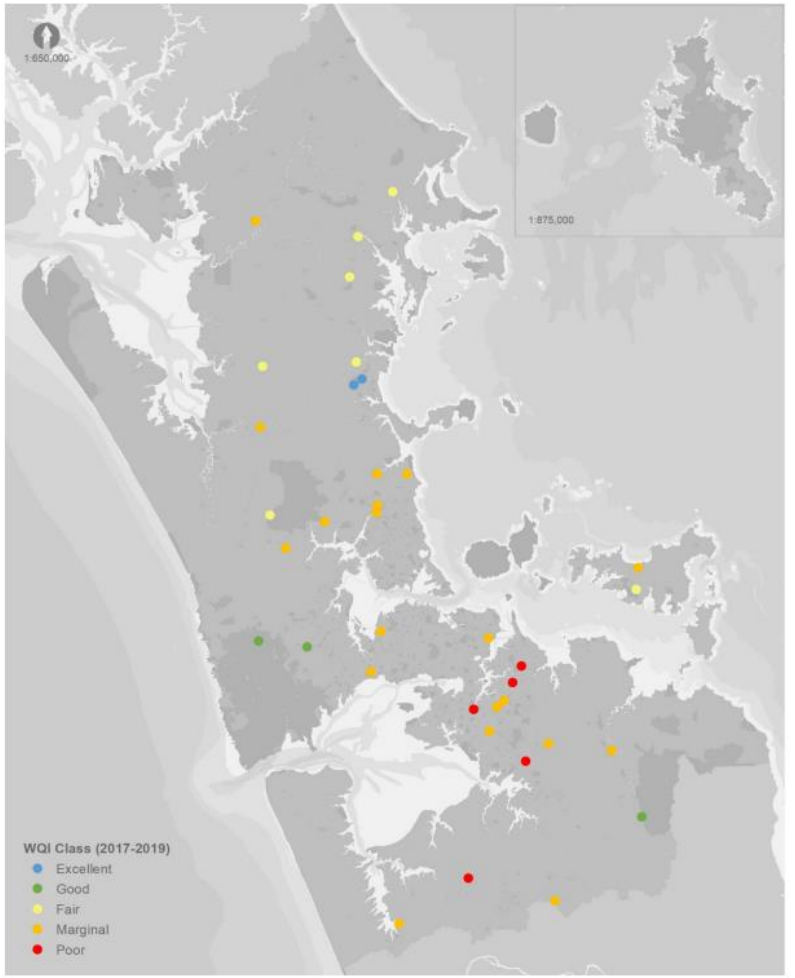
Ref: NPR 2016-17: http://www.waternz.org.nz/NationalPerformanceReview
Ref: https://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=12193311

New Zealand Cities

Christchurch



Auckland



Ref: Christchurch City Council , Surface Water Quality Monitoring Report.
Ref: River water quality in Tāmaki Makaurau / Auckland 2019 annual reporting

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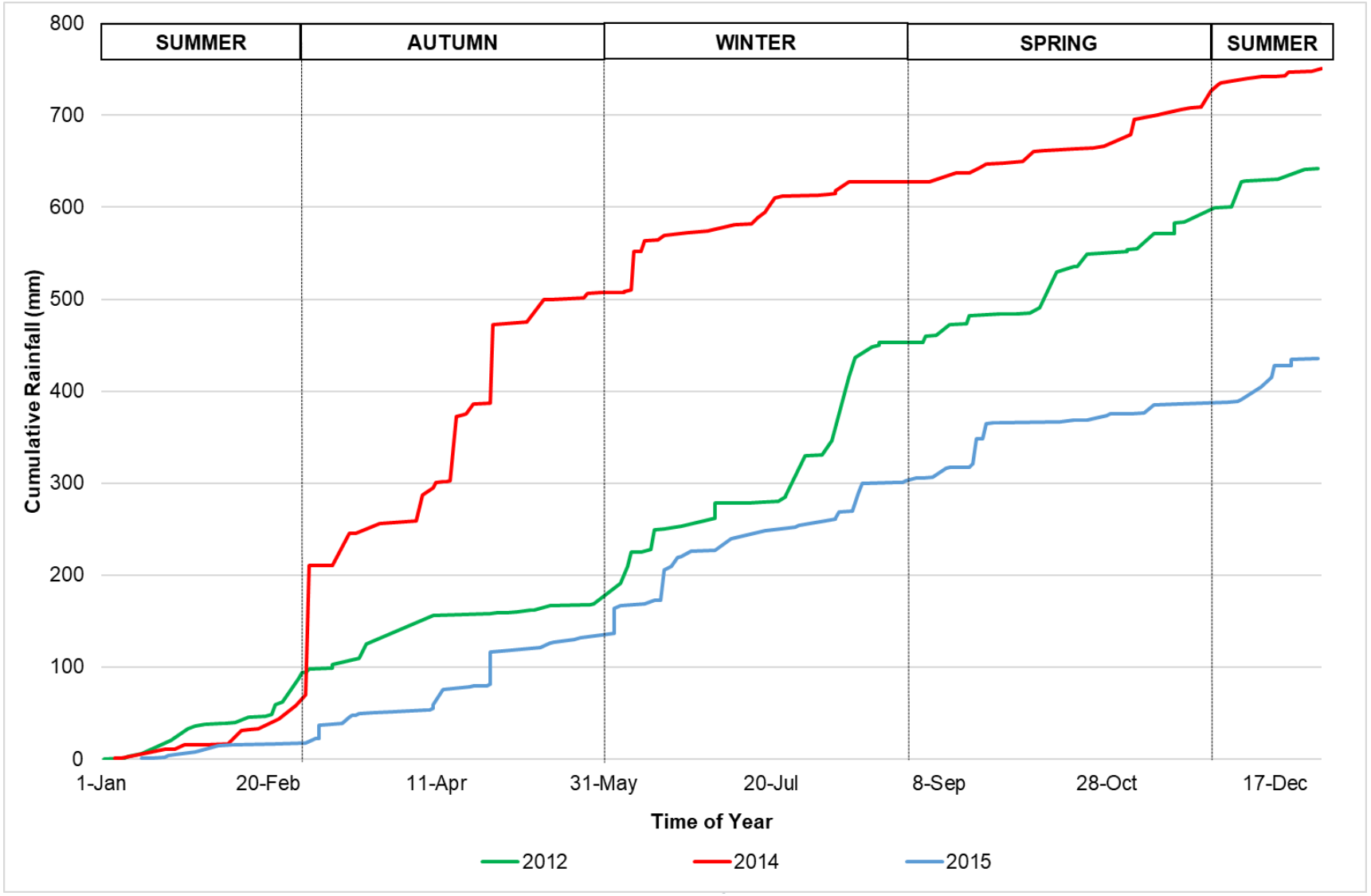
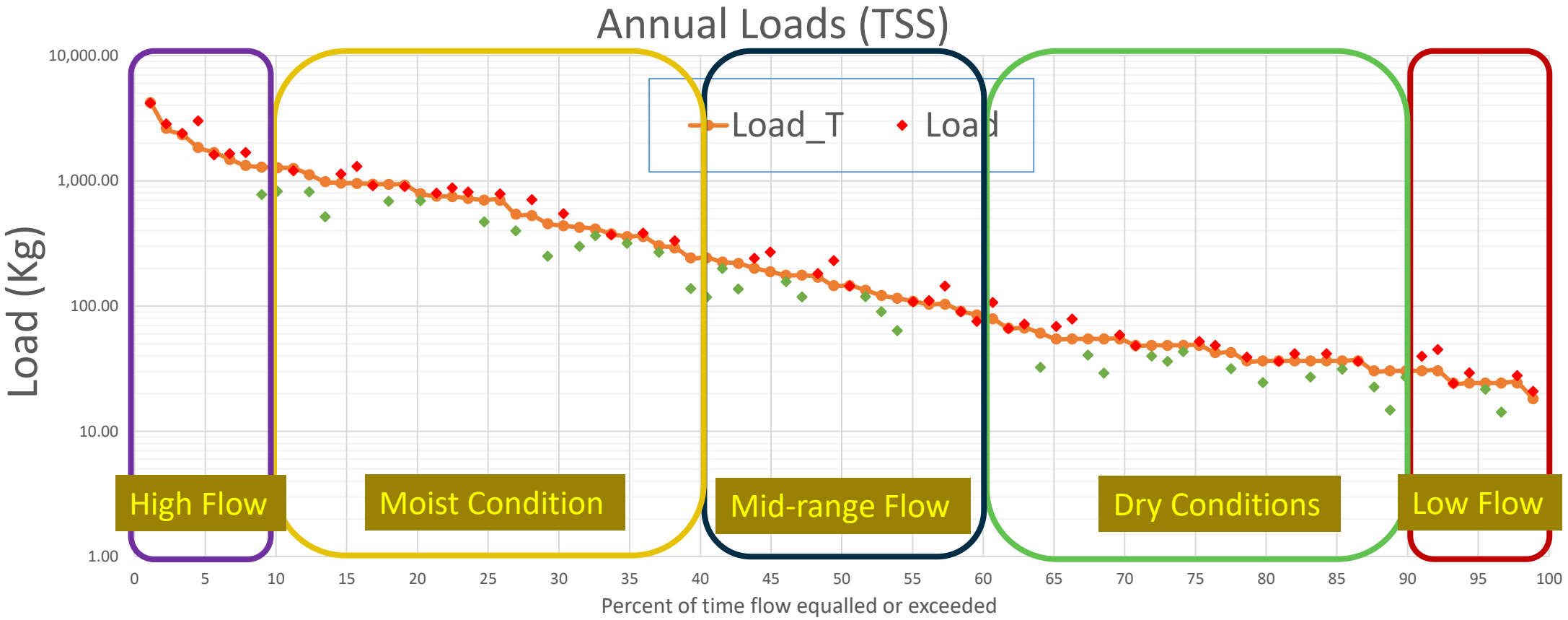
Urban Contaminant Yields for Annual Load Models

Land use	Specific elements	Contaminant yield (kg/ha/year)			
		Total suspended solids (TSS)	Total zinc	Total copper	TPH
		These values need to account for rainfall variation			
Roofs	Galvanised steel	50	22.4	0.003	0
	Zinc/aluminium	50	2.0	0.009	0
	Zinc/aluminium coated	50	0.2	0.016	0
	Concrete	160	0.2	0.033	0
Roads	< 1k vpd	210	0.044	0.015	0.335
	1k-5k vpd	280	0.26	0.089	2.013
	5k-20k vpd	530	1.1	0.37	8.387
	20k-50k vpd	960	2.57	0.86	19.474
	50k-100k vpd	1580	4.7	1.57	35.645
Paved	Residential	320	1.95	0.36	0
	Industrial	220	5.9	1.07	0
	commercial	320	-	0.03	0

Annual Rainfall Variations



Example of Load Duration Curve



Stormwater Management – Green Infrastructure

Benefits - source reduction and on-site treatment
Limitations - Difficult to retrofit established areas

Ref: http://blog.waal.co.nz/wp-content/gallery/wsud

What about “RE”?

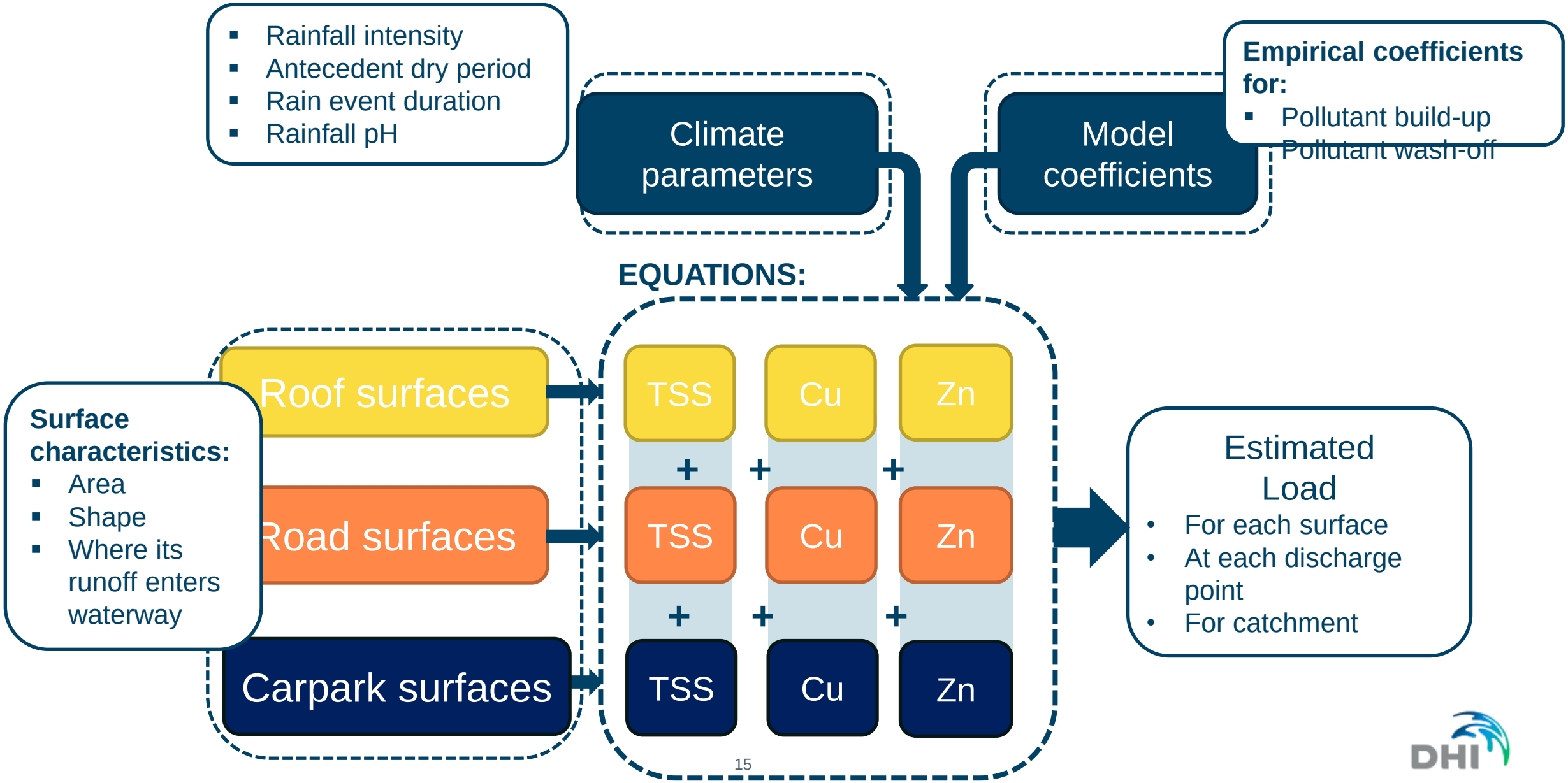
- What is the impact on **Receiving Environment?**
- Where should **Green Infrastructure** be sited to get the **maximum benefit?**
- Is mitigating **Chronic Risk** useful**?**
- Are **surface-aggregated annual loads** sufficient**?**

MEDUSA Online: Contaminant Loading On Demand

Spatial Analysis and Planning System -

1. Partnership with University of Canterbury **(MEDUSA –** Load Generation**)**
2. MIKE Hydrology and Hydraulic Stormwater Model
3. Loads and Flow -> **Concentration**
4. **Scenario Comparison on Demand**

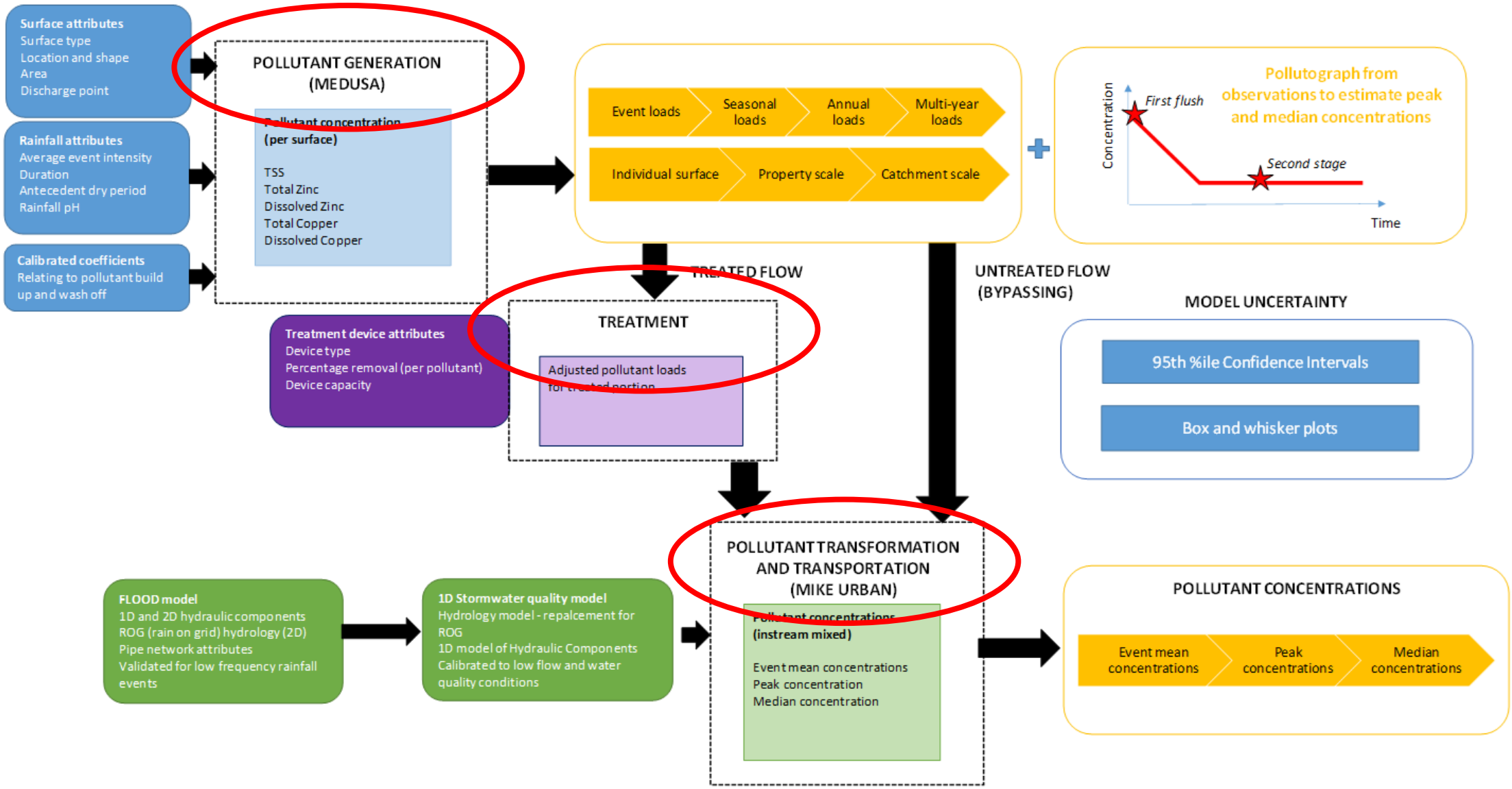
Pollutant Generation



Sampled data from urban surface types

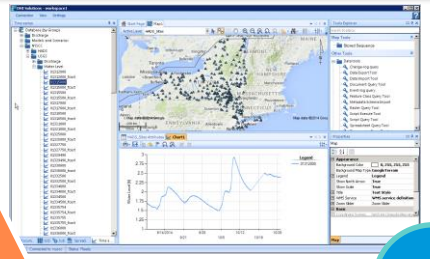
Sampled Site Description	
Carparks	**Roofs**
Commercial carpark (retail zone)	Concrete roof with polyvinyl chloride guttering, approx. 60 years old
Commercial carpark (light industrial zone)	Concrete roof with galvanized guttering, installation date unknown
Industrial carpark with heavy vehicle manoeuvring	Copper roof, approx. 40 years old
Industrial carpark with heavy vehicle through access	Colorsteel® roof, <1 year old
Roads	Colorsteel® roof, 22 years old
Local road	Painted galvanized roof, repainted in 2013
Collector road	Painted galvanized roof, approx. 15 years old
Minor arterial road	Uncoated GalvSteel® roof, <1 year old
Major arterial road	Uncoated, poor condition galvanized roof, >40 years old

MEDUSA Online Framework

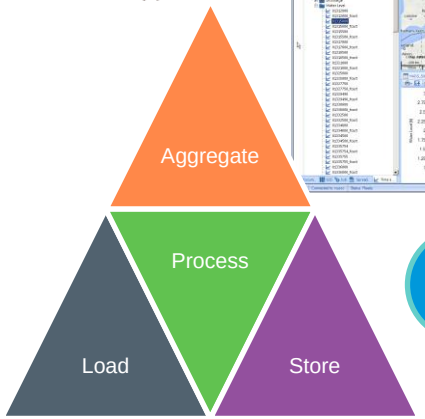


MEDUSA Online Platform

Platform Backend



Configurator UI



MIKE API

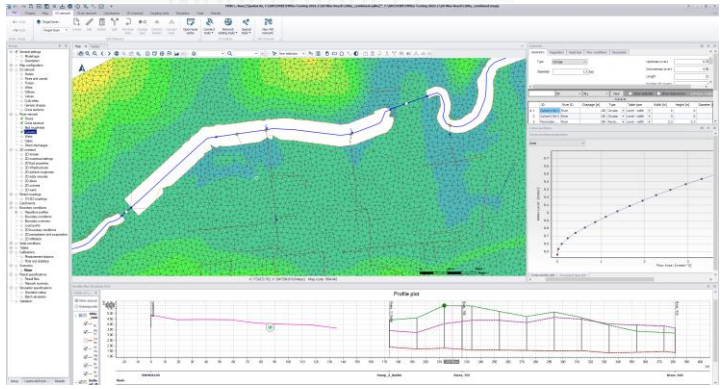
Platform Core DB — Platform Core containing Model

Reports — Internal, Power BI

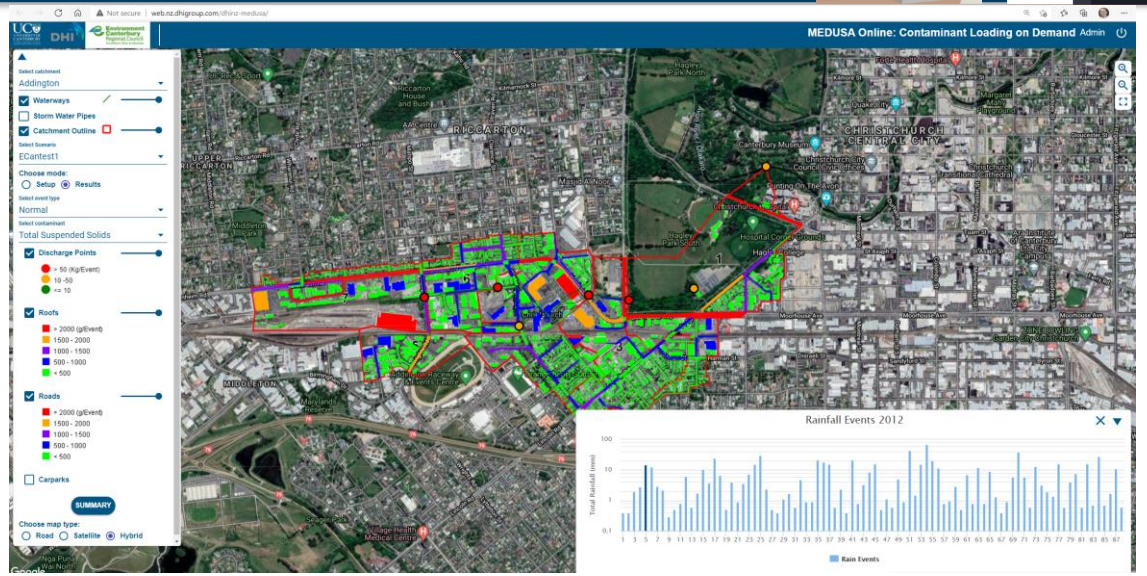
Generic functional building blocks

time series, scripts, spreadsheets, GIS, job configurators, scenario managers

Model runners



Platform Frontend



Whole city coverage with workflows for:

- Baseline simulations analysis and interrogation, spatial and temporal
- What-if scenarios including impact from:
  - Pollution at-source treatment options (across the catchment or localised)
  - Placement of active capture/treatment devices within the catchments and "end of pipe"
  - Surface types and land use changes

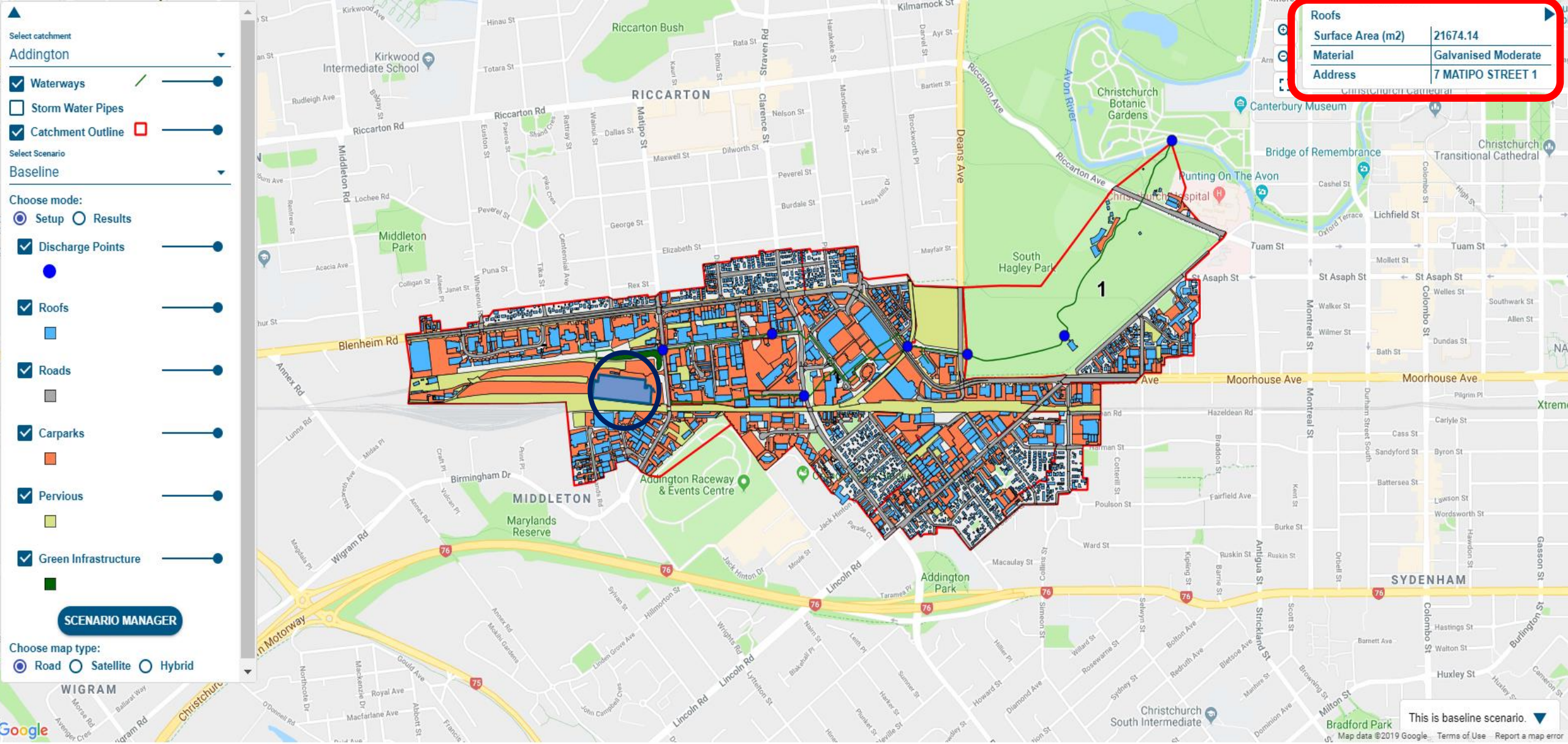
Fully automated, running scripts and/or executing the full WQ model – as appropriate.

3-Step Process for Water Quality Management

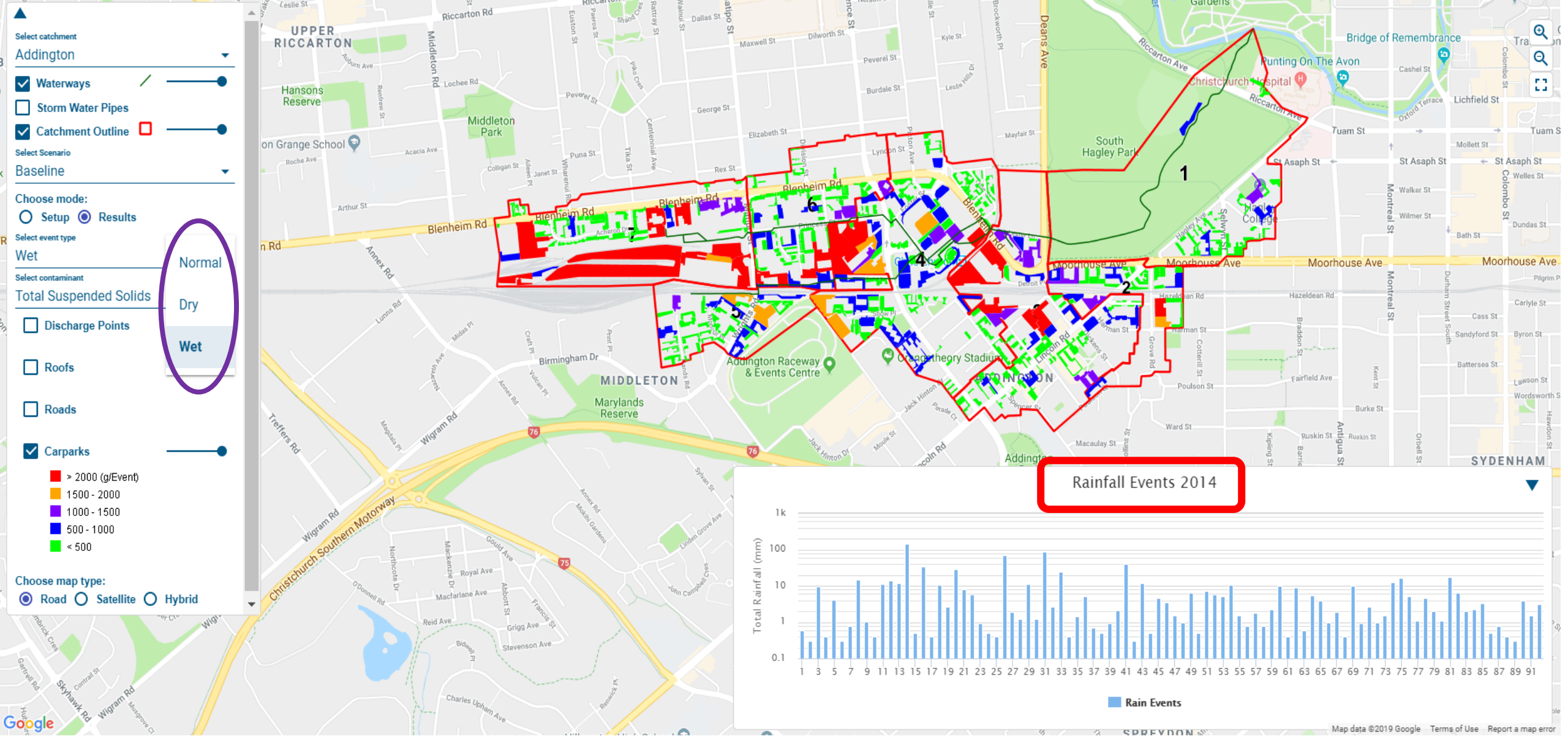
1. "**Identification**" of critical source areas for pollutant load reduction;
   - Identify **pollutant 'hotspots'** in the urban catchment
   - Generates **surface-specific** and **event-based** loads
   - Computes **in-stream concentrations**

2. "**Prioritization**" based on contaminant influence on in-stream water quality and ecological health;
   - **Comparison** of **Loads** and **Concentrations**
   - **Catchment** and **Sub-catchment** level

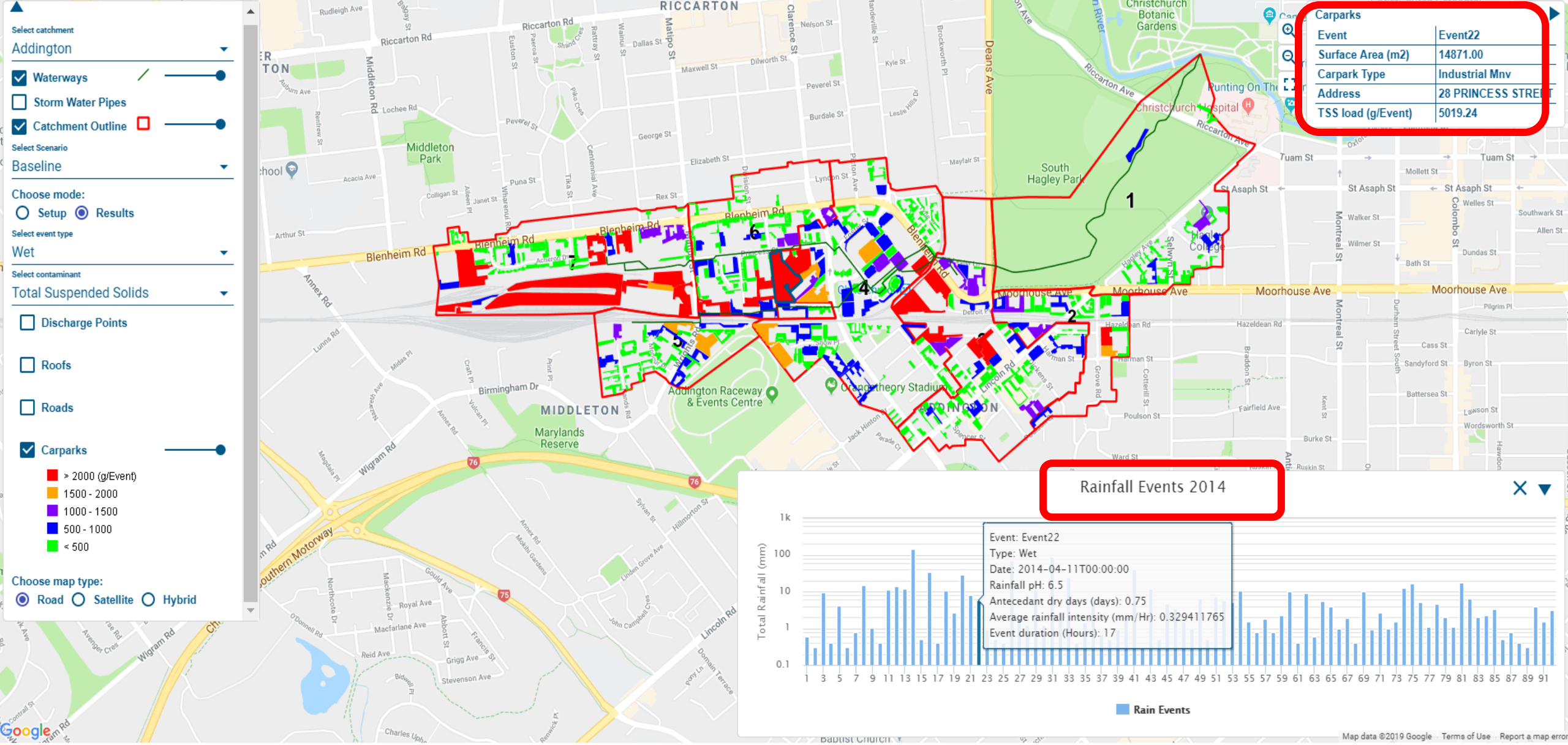
3. "**Mitigation**" through best management practice systems.
   - Develop **targeted treatment options** to **mitigate impacts**
   - Characterise the **processes** in the **receiving environment**



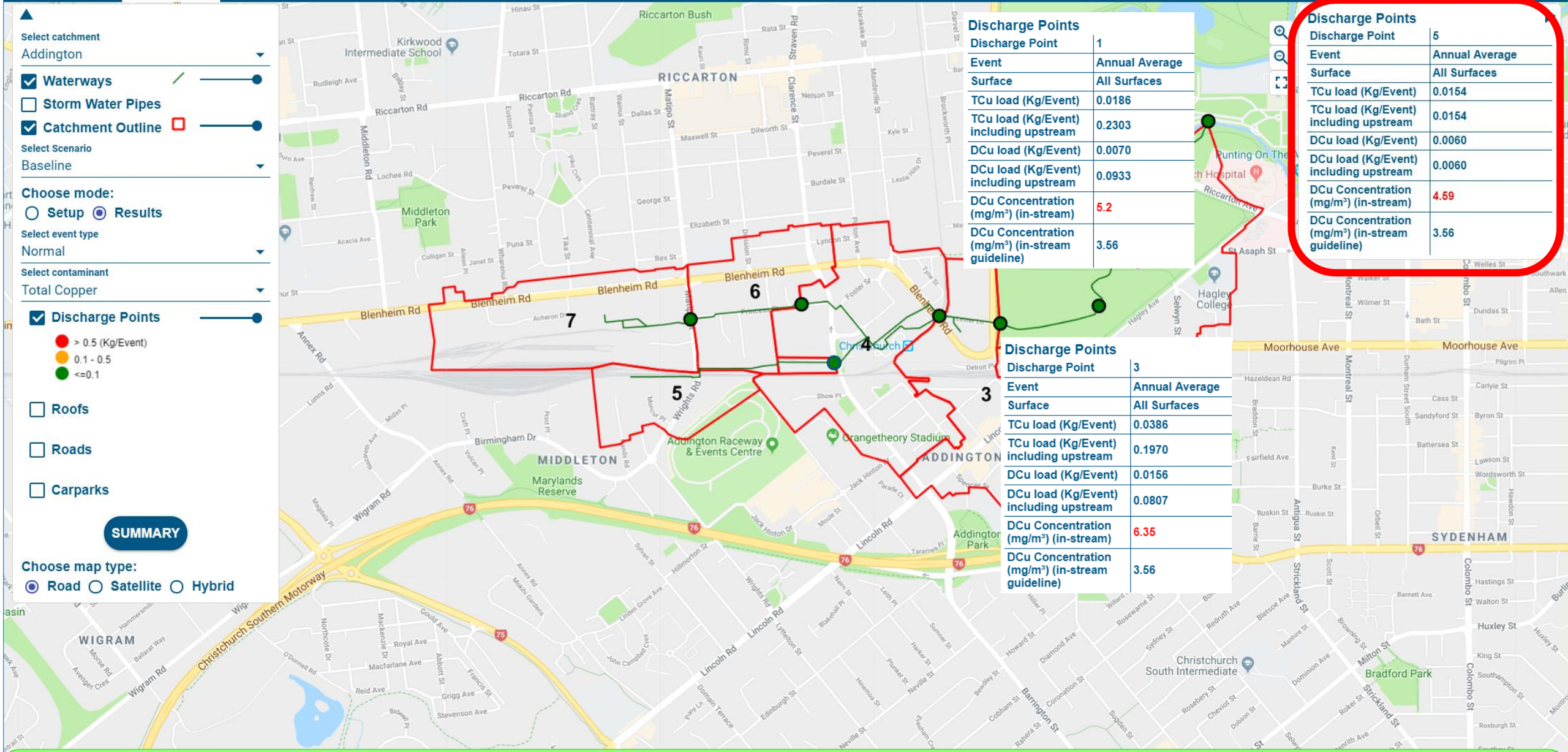
Query Catchment Characteristics



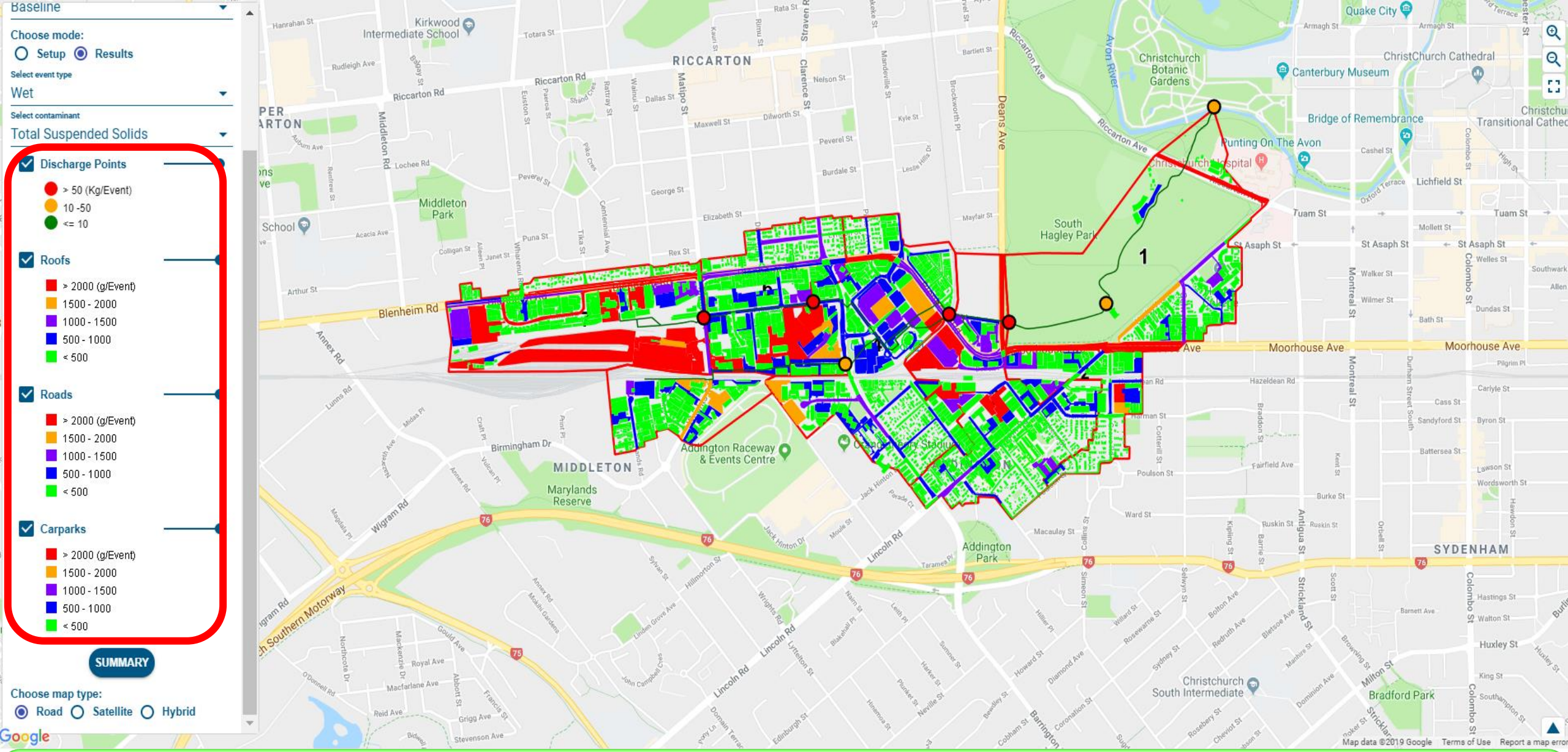
Load Results for different rainfall patterns



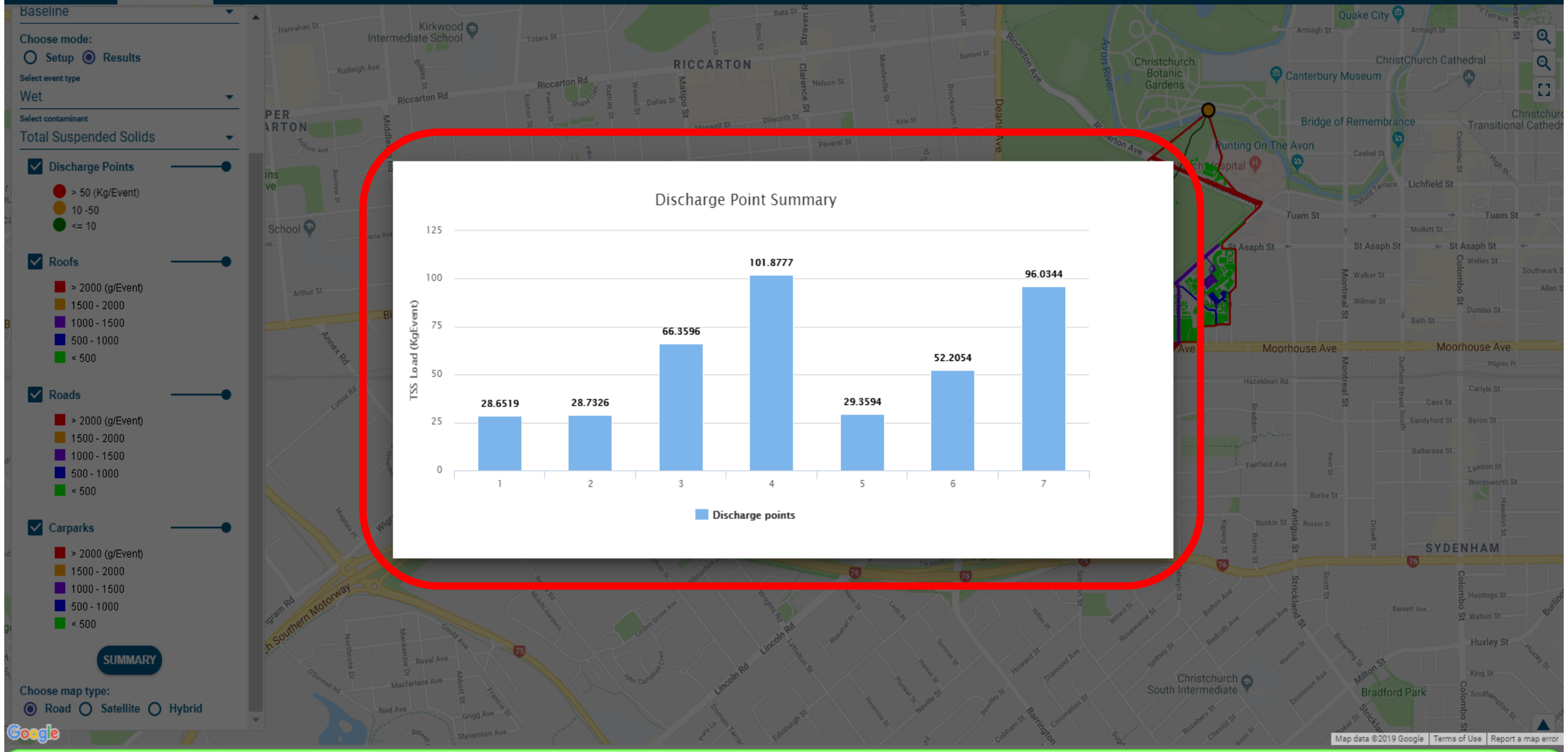
Surface Load Results – TSS (Event Specific)



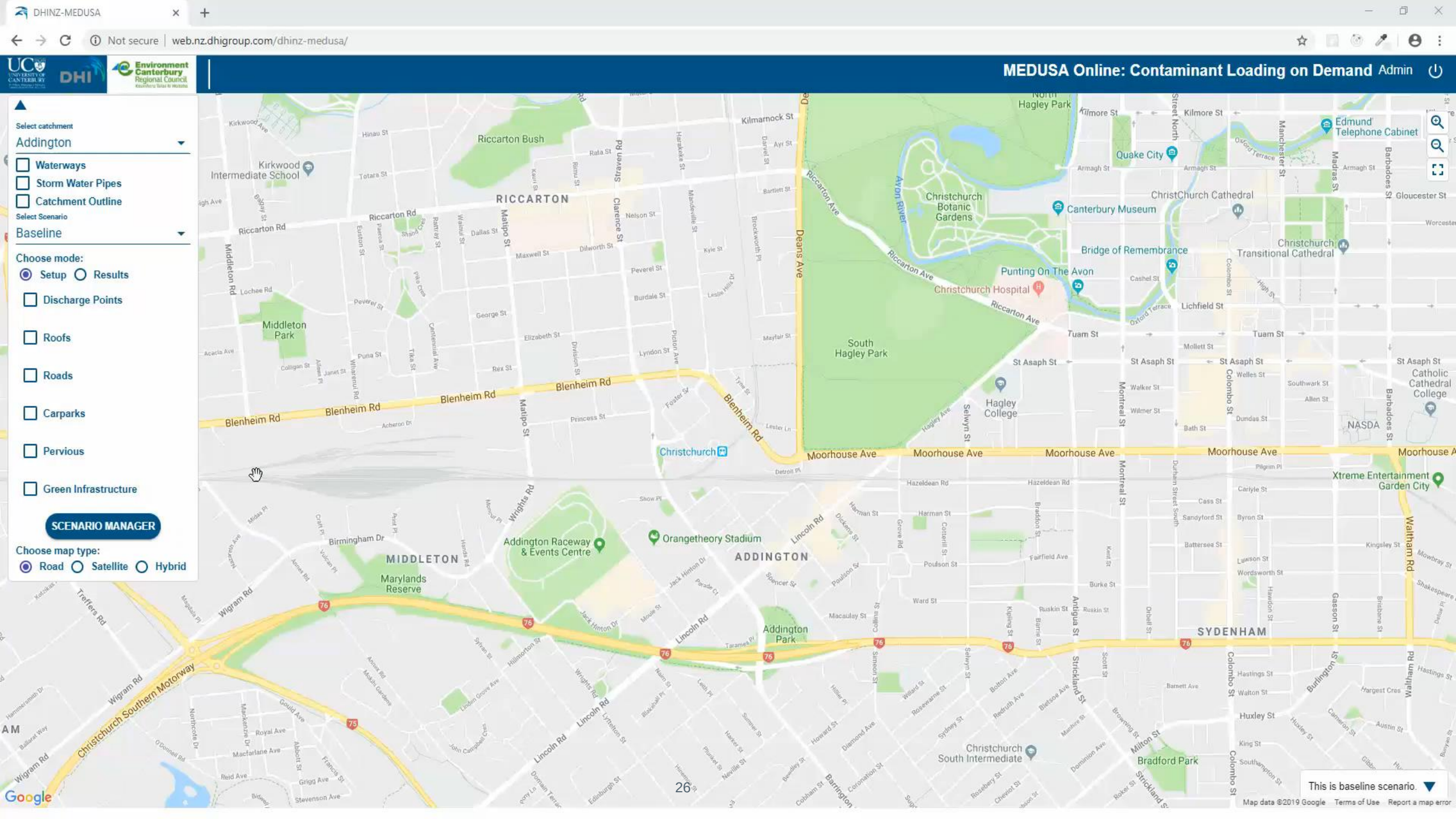
Loads and Concentration



Catchment-level Load Distribution Pattern



Sub-catchment level Load Distribution


DHINZ-MEDUSA
Not secure | web.nz.dhigroup.com/dhinz-medusa/
MEDUSA Online: Contaminant Loading on Demand
Admin
Select catchment
Addington
Waterways
Storm Water Pipes
Catchment Outline
Select Scenario
Baseline
Choose mode:
Setup
Results
Discharge Points
Roofs
Roads
Carparks
Pervious
Green Infrastructure
SCENARIO MANAGER
Choose map type:
Road
Satellite
Hybrid
RICCARTON
MIDDLETON
ADDINGTON
SYDENHAM
South Hagley Park
Addington Park
Marylands Reserve
Middleton Park
Riccarton Bush
Addington Raceway & Events Centre
Orangetheory Stadium
Christchurch Botanic Gardens
Canterbury Museum
ChristChurch Cathedral
Christchurch Transitional Cathedral
Bridge of Remembrance
Punting On The Avon
Christchurch Hospital
Hagley College
Quake City
Edmund Telephone Cabinet
Kirkwood Intermediate School
Christchurch South Intermediate
Bradford Park
Catholic Cathedral College
NASDA
Xtreme Entertainment Garden City
Blenheim Rd
Moorhouse Ave
Riccarton Ave
Deans Ave
Avon River
Wigram Rd
Lincoln Rd
Christchurch Southern Motorway
Waltham Rd
This is baseline scenario.
Map data ©2019 Google
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Report a map error
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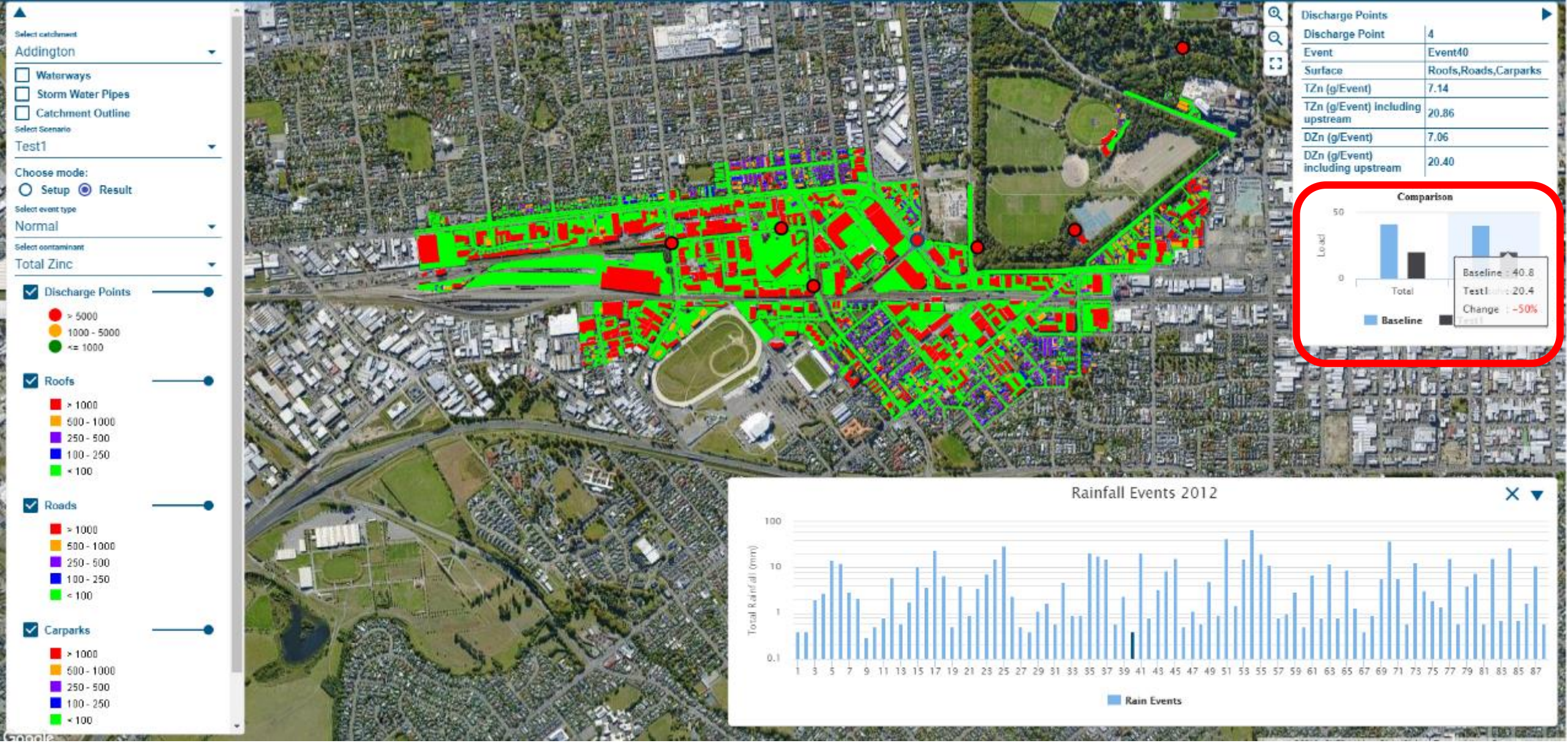
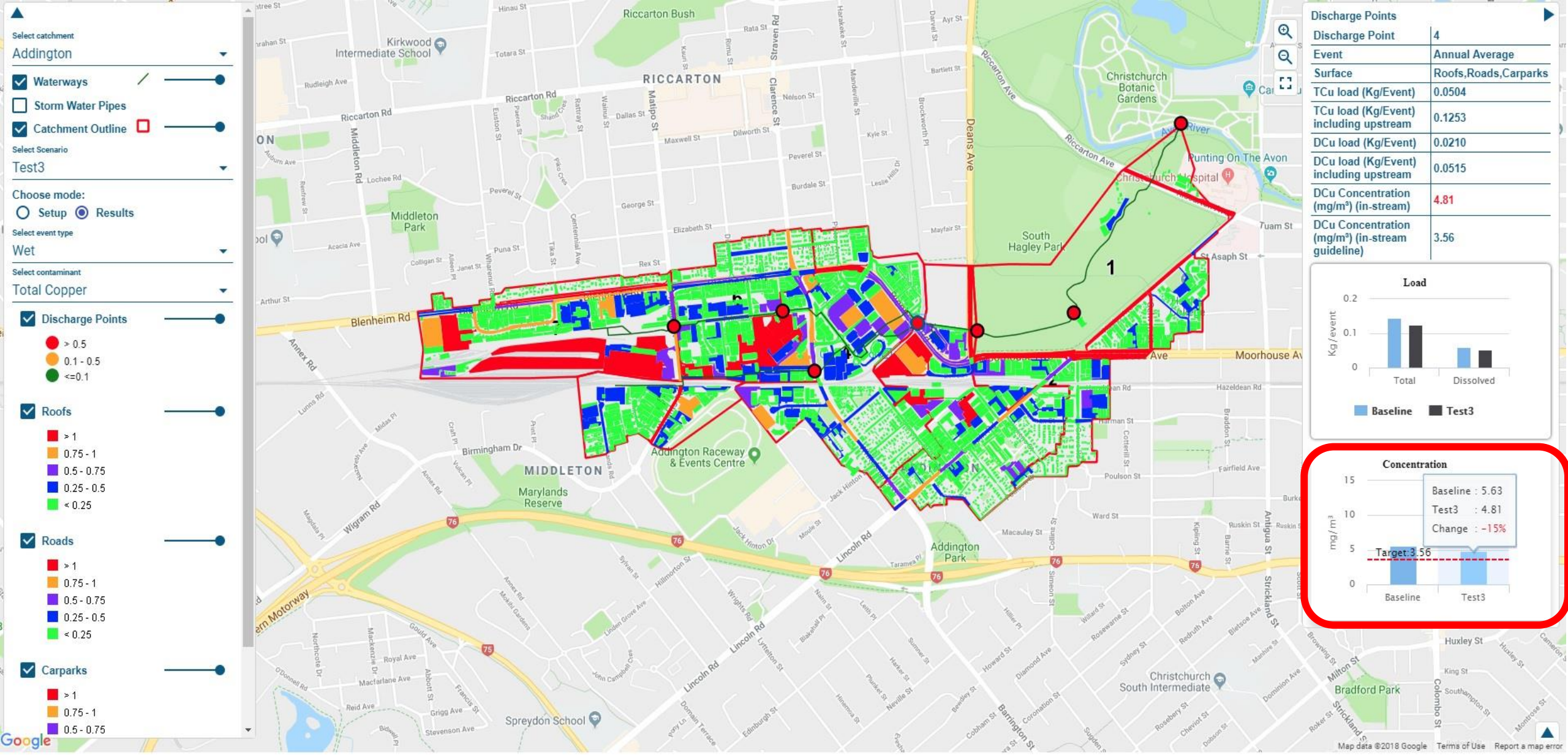


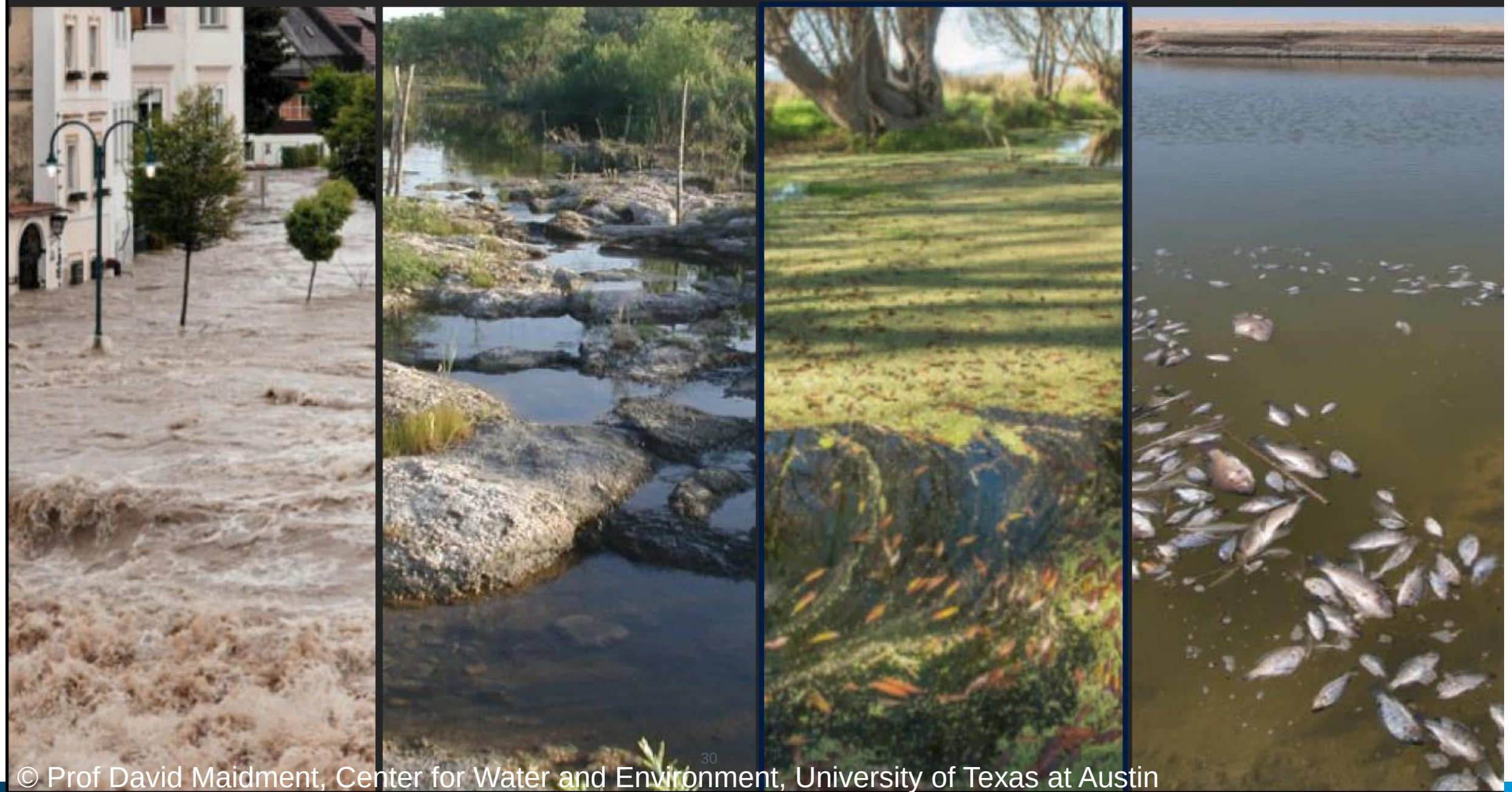
Comparing Loads (Scenario vs. Baseline)



Comparing in-stream Concentration

How can the system assist you?

- Applicable to any urban catchment with information on **surface types** and **rainfall characteristics**
- Determines **event-based** pollutant **loads**
- **Peak loadings** quantified for every surface, event, and discharge point
- **Integrates local climatic conditions** into the contaminant load calculations.
- Combines **pollutant at-source model** with **flow routing models (MIKE+)**.
- Informs the **loading criteria** to be used in the design of stormwater management infrastructure for sustainable receiving waters.



Thank you

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Ref: Auckland Design Manual (http://www.aucklanddesignmanual.co.nz/)