LDCP Framework for Setting Load Limits in Urban catchments

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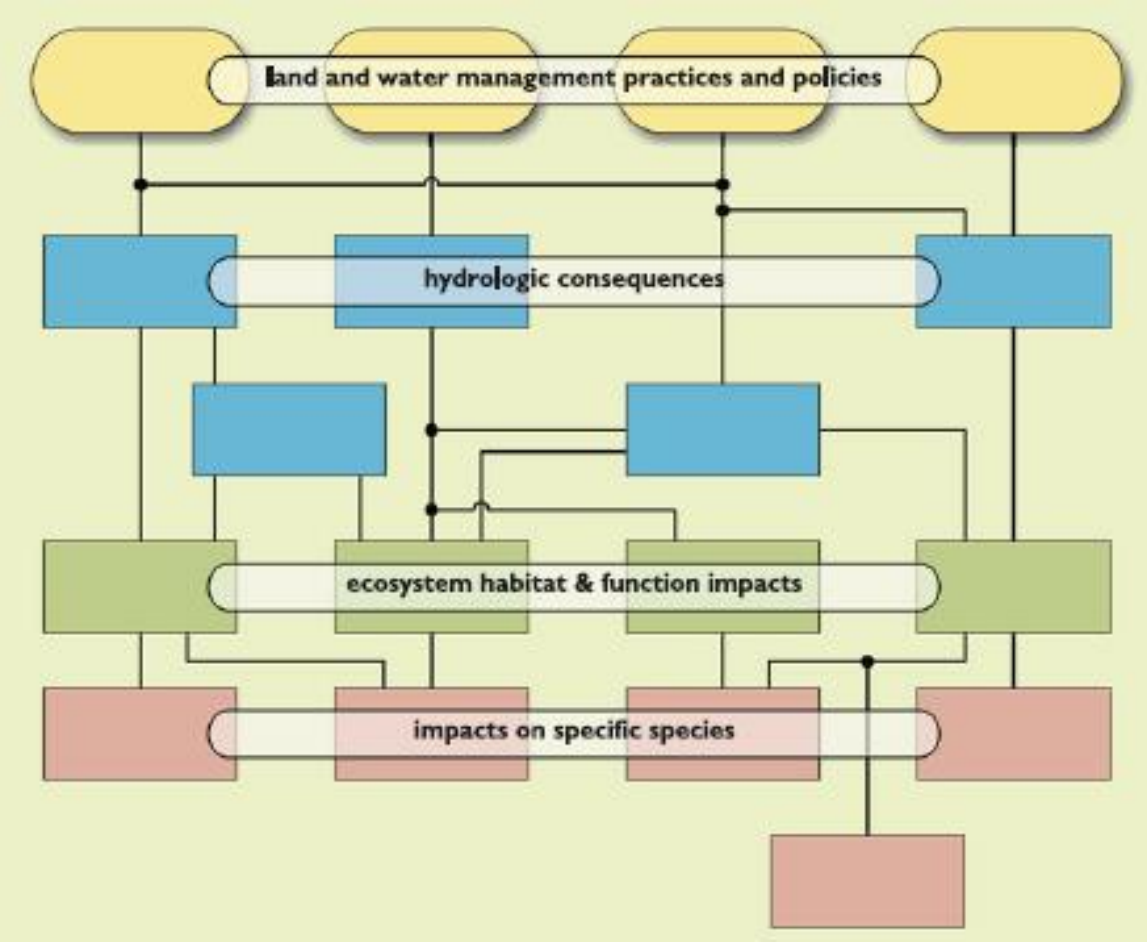
Synopsis

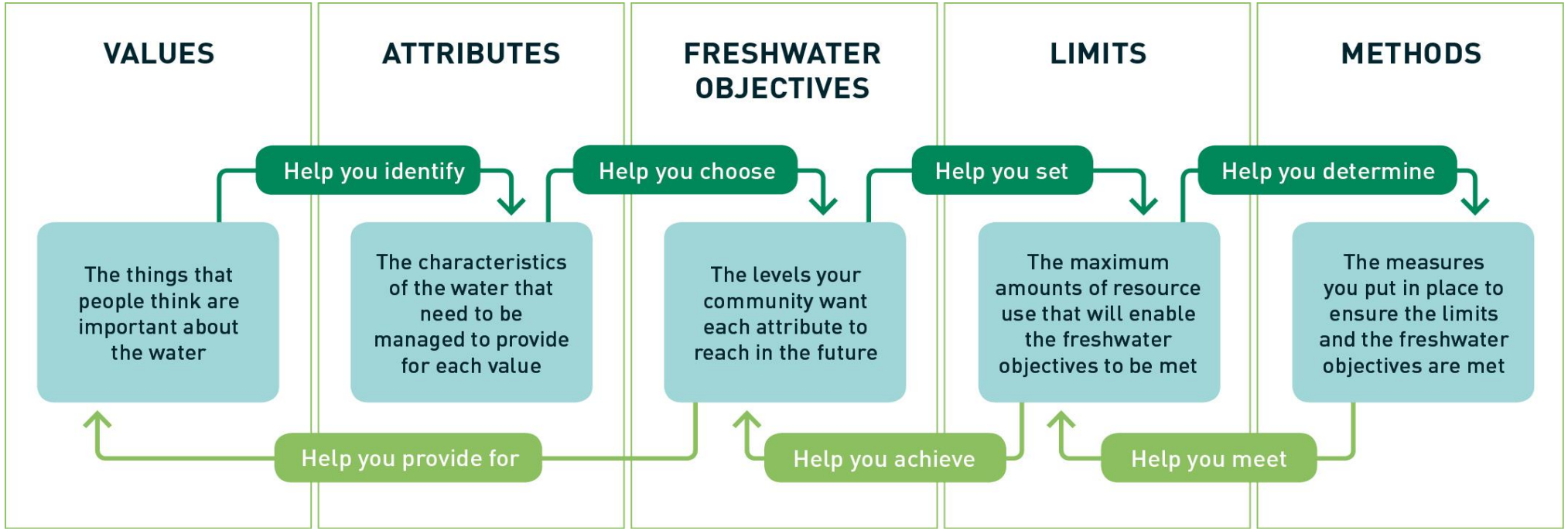
- NPS FM and limits
- Limits and Flows
- Limitations of conventional processes
- Proposed framework
- Application for a catchment
- Summary

How do we set load limits?



Ref: Loucks, D.P. and Van Beek, E., 2017. *Water resource systems planning and management: An introduction to methods, models, and applications*. Springer.

NPS FM and setting limits



Waterways are suitable for primary contact (Eg.: swimming)	**Bacterial levels (E.coli)**	**E.coli concentration and % exceedance**	**???**	• **STOP direct discharges** • **Fencing** • **Riparian Planting**

Ref: - Ministry for the Environment. 2017. *A Guide to the National Policy Statement for Freshwater Management 2014 (as amended 2017)*
- *Bay of Plenty Regional Council*

NPS FM and Limits

Freshwater Objective – Desired state of water

Limits – Maximum use of the assimilative capacity of the resource to achieve the **desired state of water**

Limits and Flows

Limits and Flows

Limits and Flows

MfE's recommendations to set limits

- **Current state** of water quality
- **Quantity** of water available and how it fluctuates seasonally and over time
- **Attribute(s)** and **Objective(s)** that limit is intended to manage
- Identify the **Sources** of relevant contaminants
- Consider **interactions** between contaminants and possible lag effects
- **Timeframes** over which the limit can be achieved
- **Targets** required to reach the limit
- **Scale** at which the limit is to be applied

MfE - Important considerations

- Changes in **frequency** and **severity** of droughts and floods
- Changes in **temperatures** which may influence water quality
- Increase in anthropogenic effects (land-use impacts or nutrient runoff)
- Presence or absence of **natural features** to mitigate the effects of climate change, including:
  - Shading (and cooling) effects provided by riparian vegetation
  - Wetlands providing a water source for irrigation
- Deterioration of water quality in some areas due to lower flows

What is happening now?

- **Annual** contaminant loads from large heterogeneous urban areas.
- Estimates based on **average pollutant loads**.
- Impacts reflect the **average conditions** under the assumption that most pollutant loads are transported by frequent low intensity events.

Proposed Framework – Load Duration and Catchment Prioritization (LDCP)

- **Premise** - Correlation of water quality impairments to flow conditions.
- Characterizes water quality concentrations at **different flow** regimes across the catchment.
- **Frequency** and **magnitude** of water quality standard exceedances
- Size of **load reductions**
- Accounts for how stream flow patterns affect changes in water quality **over time**.

Proposed Framework – Load Duration

- Particularly applicable in catchments where stream flow determines loading capacities – **Urban Catchments**
- Result - **Maximum daily load** for any given interval based on the stream flow.

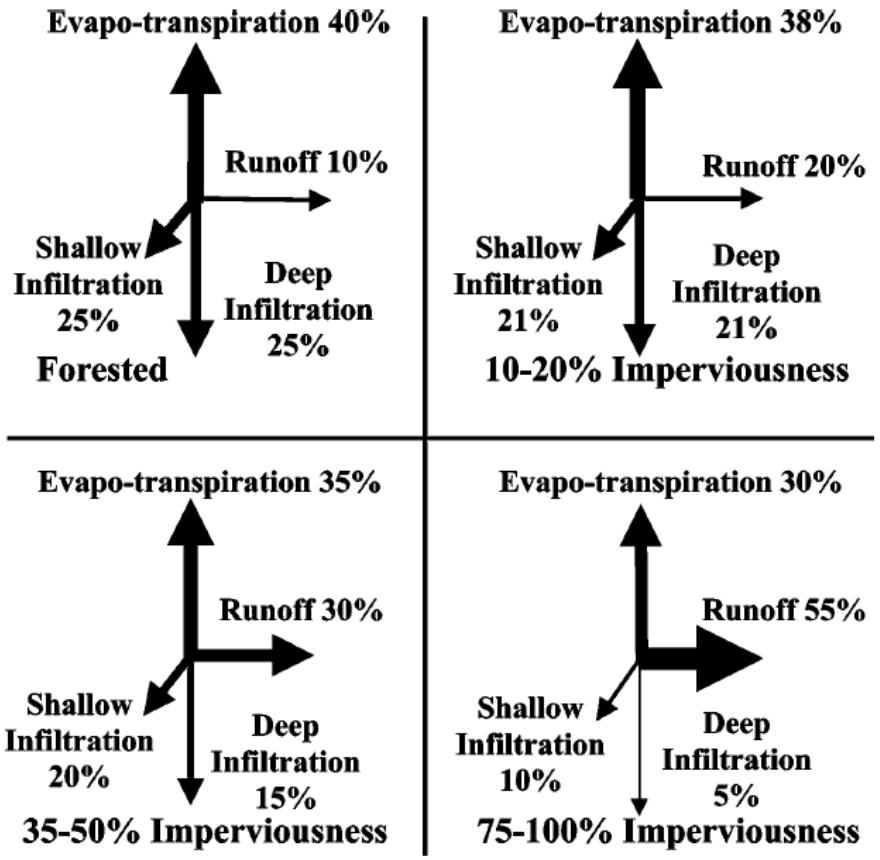


Figure 1 Changes in hydrologic flows with increasing impervious surface cover in urbanizing catchments (after Arnold & Gibbons 1996).

Proposed Framework – Catchment Prioritization

- To identify the order of relative need for water quality improvement
  - **Catchment Prioritization Index (CPI)**
- CPI indicates the **degree of water quality impairment** in the sub-catchment
- CPI provides a means to facilitate the targeting of **mitigation measures**
- **Higher CPI value** indicates that proportionately more mitigation measures are required to improve water quality as compared to lower CPI values.
- CPI includes **weight** according to its **location across the zones of flow patterns**

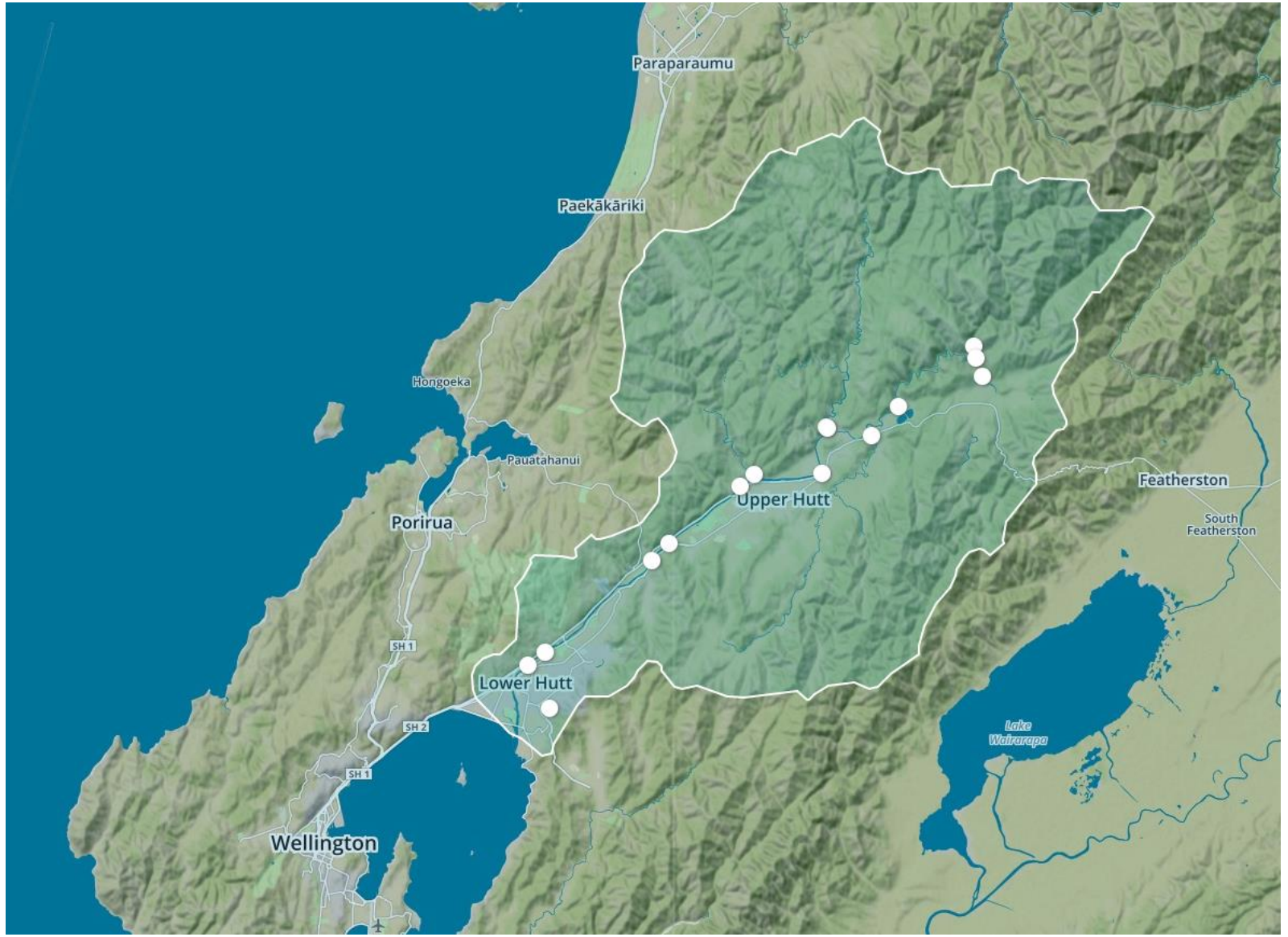
Benefits of LDCP Framework

- **Defines allocations** - Reflects differences in the types of sources that may be dominant under various flow conditions.
- Understand the effect of **temporal scale on load variability** and water quality violations.
- Catchment water quality characterizations are based on **all the flow conditions** rather than on a single flow event.
- Determine appropriate **loading reduction targets**.
- Characterize **wet-weather concerns** - Stream discharge measurements on contiguous days before/after ambient water quality collection determine run-off events.

Benefits of LDCP Framework

- **Connect allocations** and **implementation** efforts - Allocations and reduction targets can be linked to source areas, delivery mechanisms, and the appropriate set of management practices.
- Use of **flow zones** allows to define allocations to summarize potential implementation actions to effectively address water quality concerns.
- CPI works as a **risk assessment index** to locate critical source areas of contaminants within catchment.
- CPI directs **catchment managers** to the possible problem areas of contamination in the catchment.
- **Minimal data requirements, simplicity, and as an illustrative model**.

Application (Demonstrative Purpose Only)



Ref: - https://www.lawa.org.nz/explore-data/wellington-region/river-quality/hutt/

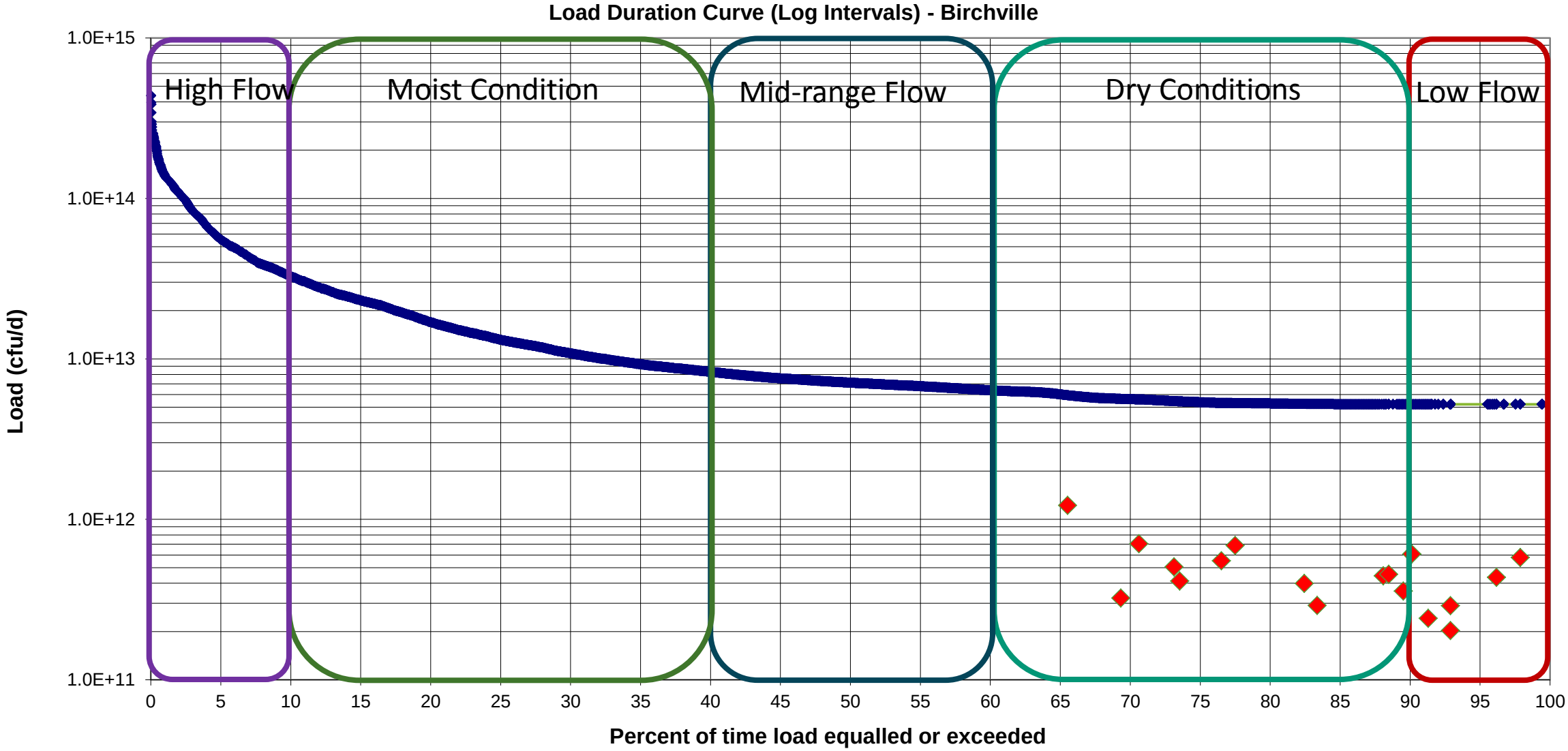
Hutt River Catchment – Monitoring Data

- Flow and water quality data - GWRC portal
- Data - 1st December 2015 to 30th November 2016
- The flow data was obtained from locations – Hutt River at Taita Gorge, Hutt River at Birchville, and Mangaroa River at Te Marua.
- Water quality data (E.coli in cfu/100ml) was collected from locations – Hutt River at Birchville, Mangaroa River at Te Marua, Waiwhetu Stream at Whites Line East, and Akatarawa River at Hutt Confluence.

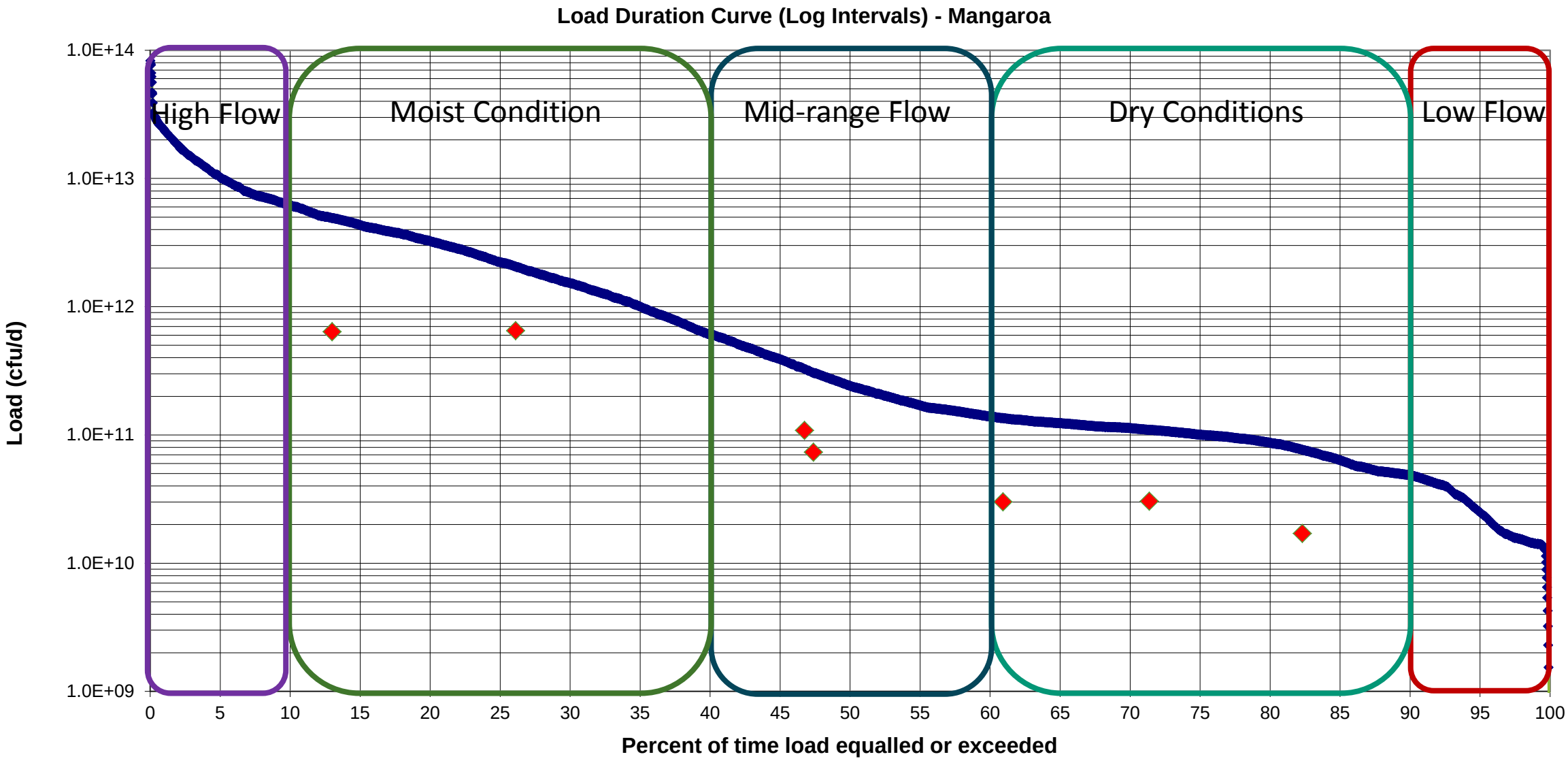
Hutt River Catchment- Modelling

- MIKE 11 used to simulate the flow of the Hutt River along with the discharges of its tributaries (such as Akatarawa River and Mangaroa River).
- A rainfall-runoff (RR) model and hydrodynamic (HD) model for the Hutt River were developed in MIKE 11.
- RR model calibrated and verified based on measured data including rainfall, evaporation, water level and discharge.
- The model calibration was carried out against the flow data recorded at different locations along the Hutt River over the period 1st December 2015 to 30th November 2016, with rainfall records as the input, to generate sub-catchment and river flows for the period.

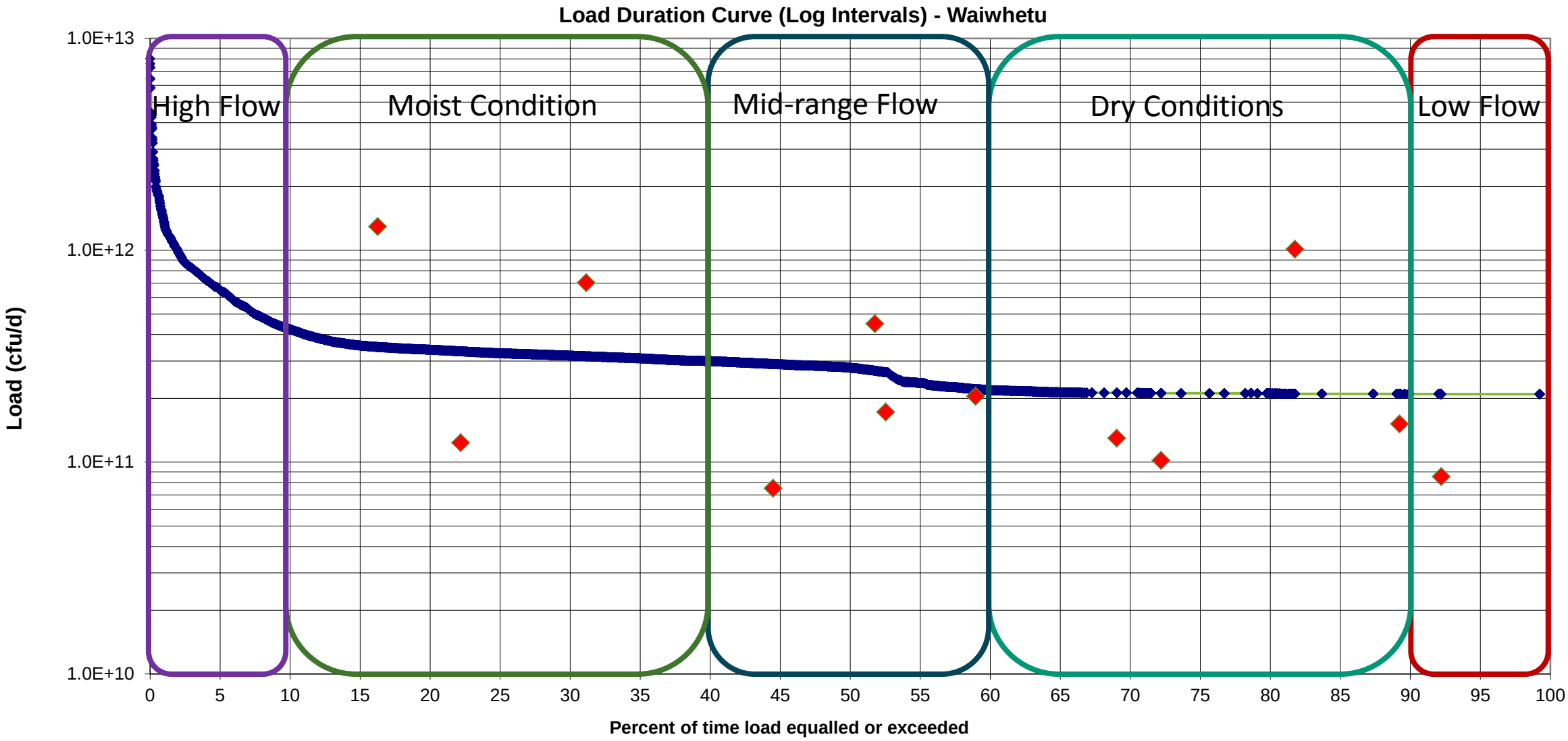
Birchville sub-catchment



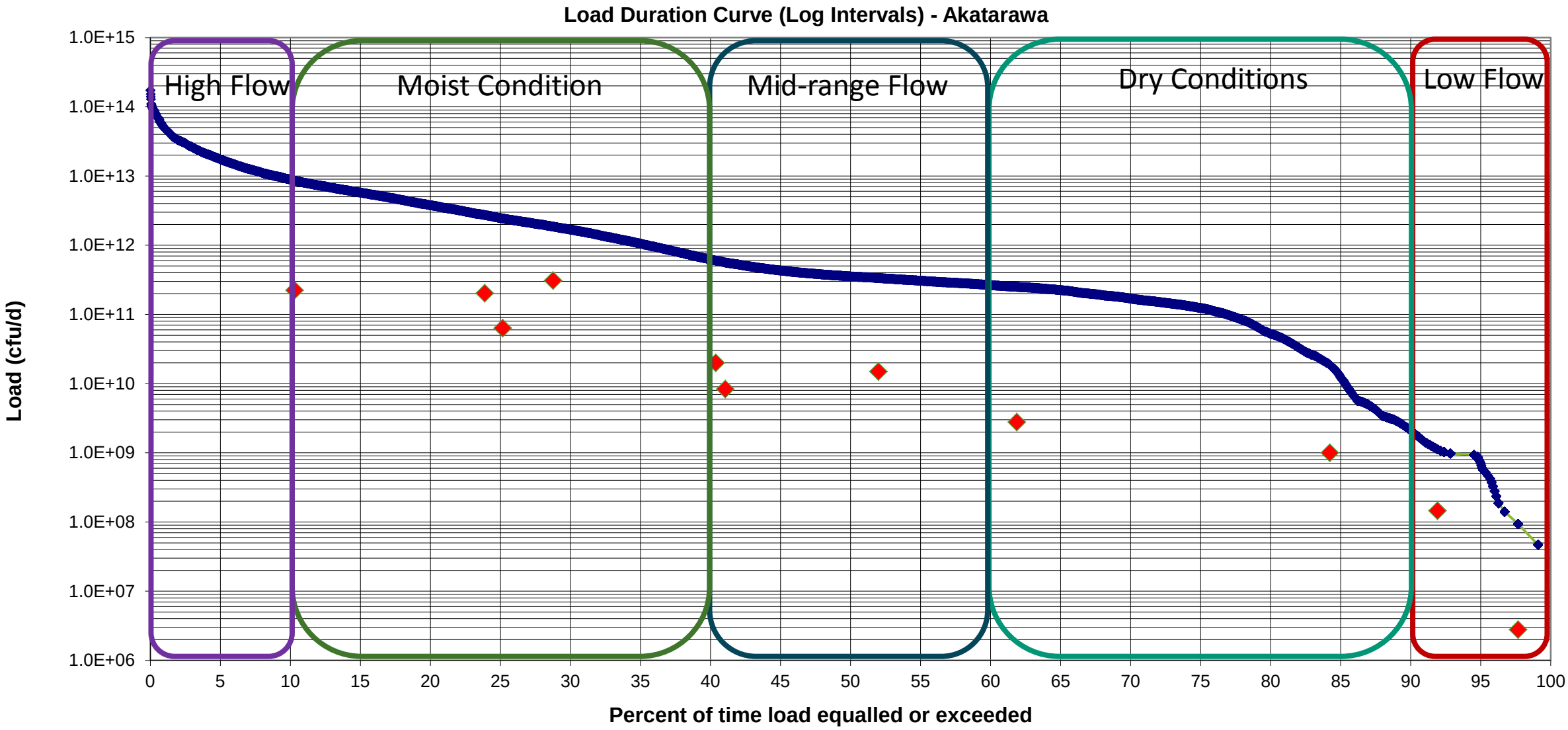
Mangaroa sub-catchment



Waiwhetu sub-catchment



Akatarawa sub-catchment



CPI for Hutt River Sub-catchments

Sub-catchment	CPI Value
Birchville	1.73
Mangaroa	3.78
Waiwhetu	3.12
Akatarawa	3.93

CPI for Hutt River Sub-catchments

- Loads in **Akatarawa** were observed in four of five zones similar to **Waiwhetu**
- In **Akatarawa**, the loads proportionately increased from “Low Flow” zone to “Moist Condition” zone.
- In **Waiwhetu**, loads were evenly spread across the four zones.
- Stream flow has a higher influence on water quality changes in **Akatarawa**.
- Higher levels of loads are discharged from possible **point sources**.
- **Akatarawa** should receive more **mitigation measures** as compared to **Birchville**.

Summary

- “Load Duration and Catchment Prioritization” (LDCP) framework approach to **characterize water quality** in the catchment.
- The framework was applied on Hutt River catchment to showcase its potential.
- This framework accounted for **influence of stream flow patterns** on water quality.
- Catchment Prioritization Index (CPI) **ranks sub-catchments** according to the relative water quality improvement needed.
- LDCP helps catchment managers to **prioritize** for **load reduction.**
- LDCP helps set catchment specific enforceable **water quality limits** to meet the requirements of NPS FM.

Acknowledgments

- Mark Hooker from GWRC for his support in allowing us to use the Hutt River model
- Mike Harkness from GWRC for provision of rainfall and flow data for the Hutt River.

Thank You

LDCP FRAMEWORK FOR SETTING LOAD LIMITS IN URBAN CATCHMENTS

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