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Assessing Water Footprint and Associated Water Scarcity Indicators in New Zealand

A Case Study of Concrete Manufacture in New Zealand

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BRANZ
Allied Concrete

"The water footprint is a measure of humanity's appropriation of fresh water in volumes of water consumed and/or polluted."

What is a Water Footprint?

- A water footprint, as defined by ISO 14046, is a set of metric(s) that quantify(ies) potential environmental impacts related to water use.

- Water footprint assessments are a compilation and evaluation of the inputs, outputs and potential environmental impacts related to water used or affected by a product, process or organisation.

- Some examples include:

Chocolate

17,196 L / Kg

Beef

15,415 L / Kg

Milk Powder

4,715 L / Kg

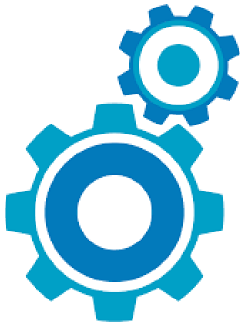
Why Calculate a Water Footprint?

- Everything we use, wear, buy, sell and eat takes water to make

- The water footprint measures the amount of water used to produce each of the goods and services we use.

- It can be used to measure the water use of:

A process,



a product,

or an entire nation

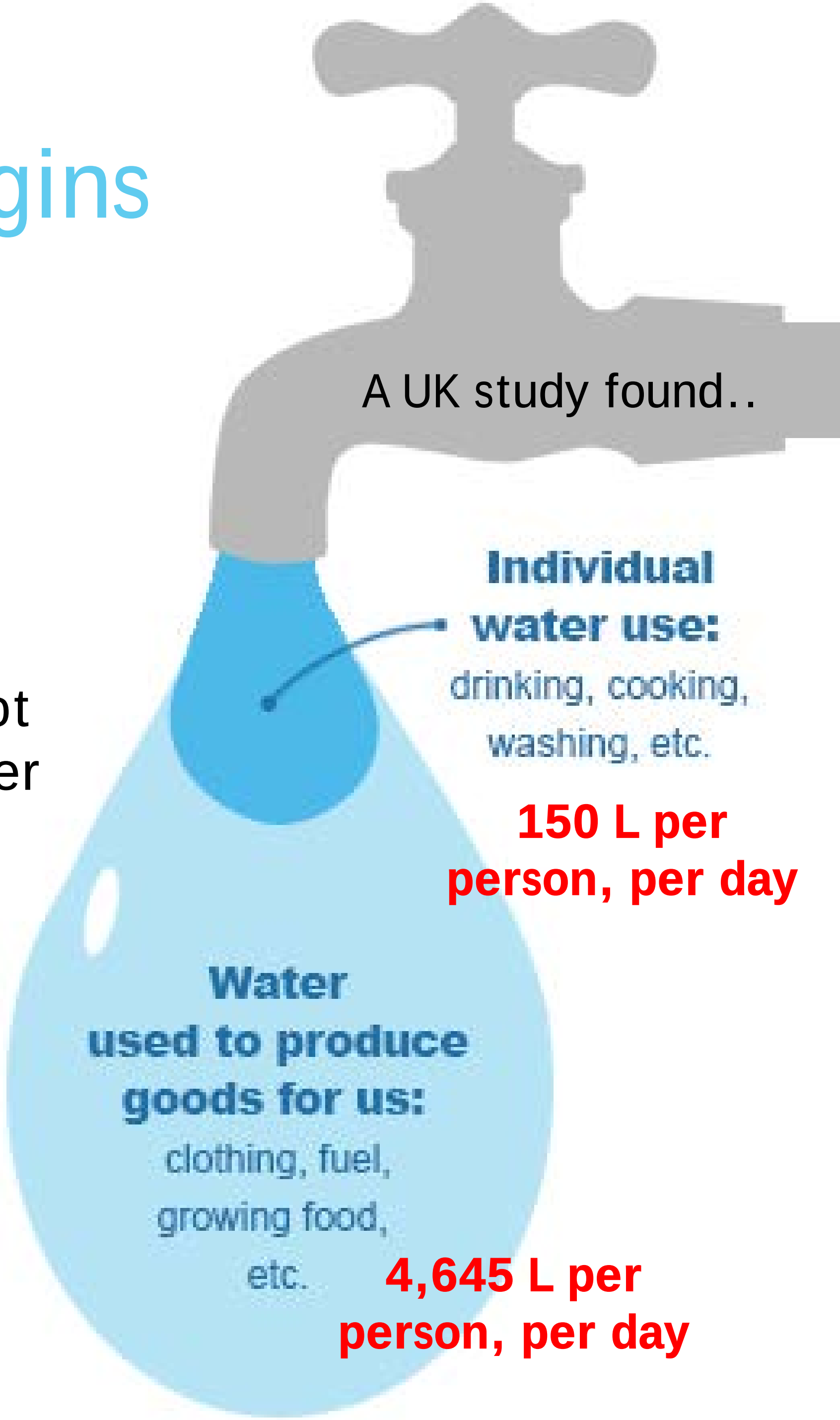
The water footprint concept: Origins

The term **Virtual Water** was coined in the 1990’s.

It refers to the volume of water required to produce a product.

For example, a single cup of tea contains **28L of water.** This is not only the volume of water in your cup, but also the volume of water required to grow, harvest, package and transport your tea bag.

A UK study found..

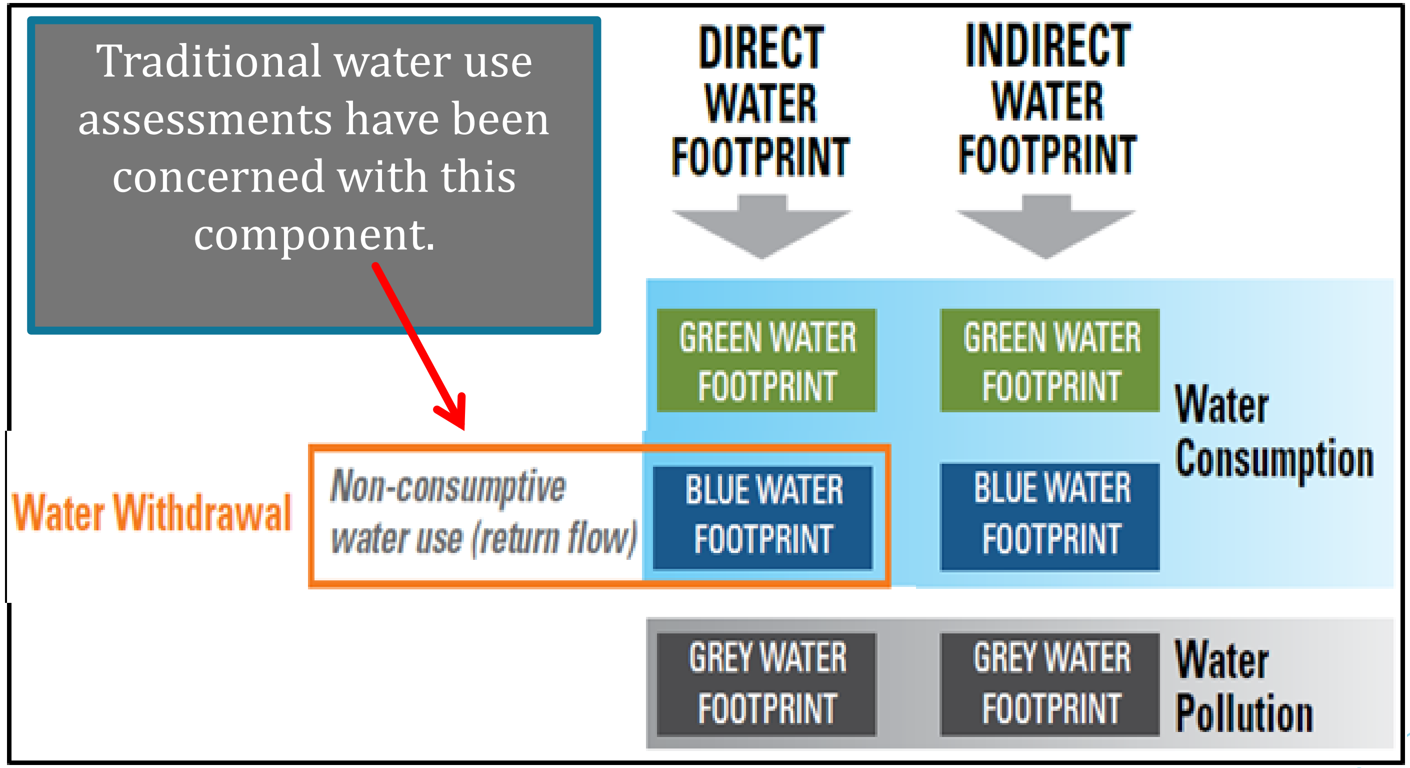


150 L per person, per day

4,645 L per person, per day

The water footprint concept: Contemporary definition

Traditional water use assessments have been concerned with this component.



The water footprint concept is concerned with the rest of the picture.

Differentiating between water 'colours'

Water Footprinting methodologies differentiate between three different 'colours' of water

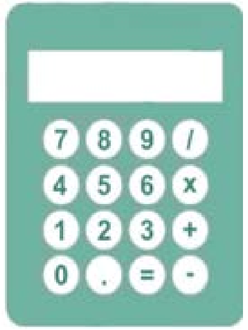
Blue + **Green** + **Grey**

Freshwater

Rainwater

Polluted Water

The Four Stages of a Water Footprint Assessment

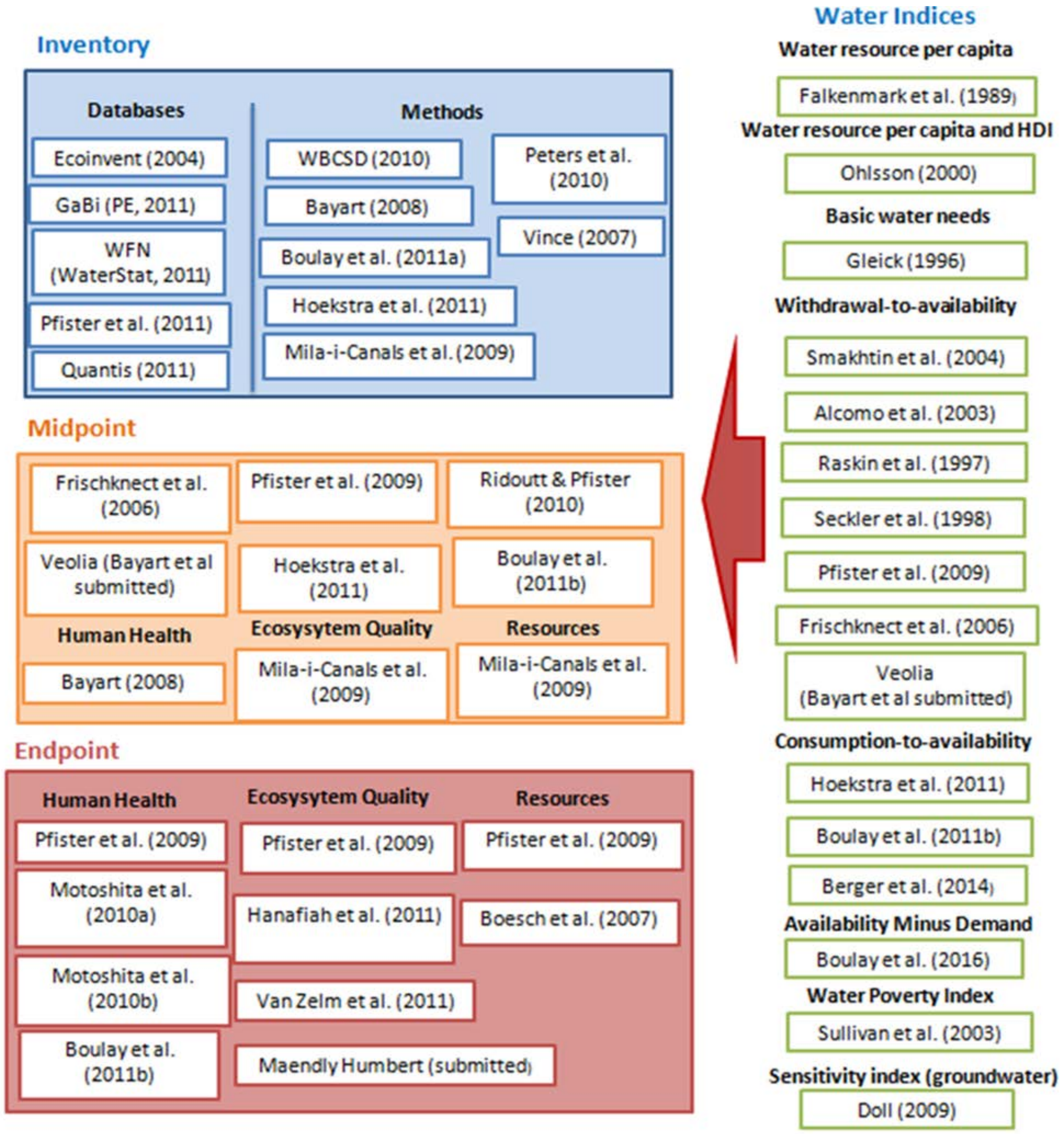


Setting goals and scope

Accounting

Sustainability assessment

Response formulation

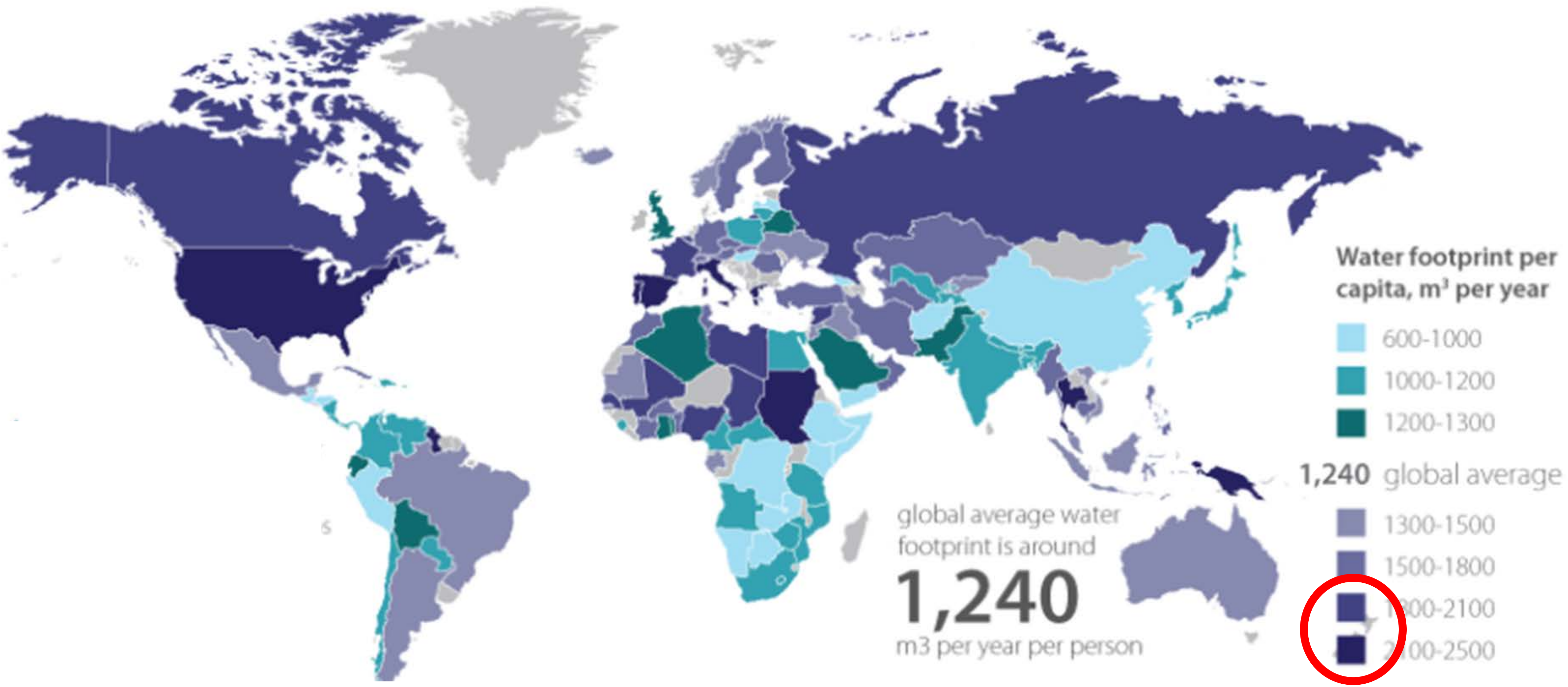


The Problem?
Too many methods

- Up until recently there has been no standardized approach

- Existing methods use varying assumptions and data sources

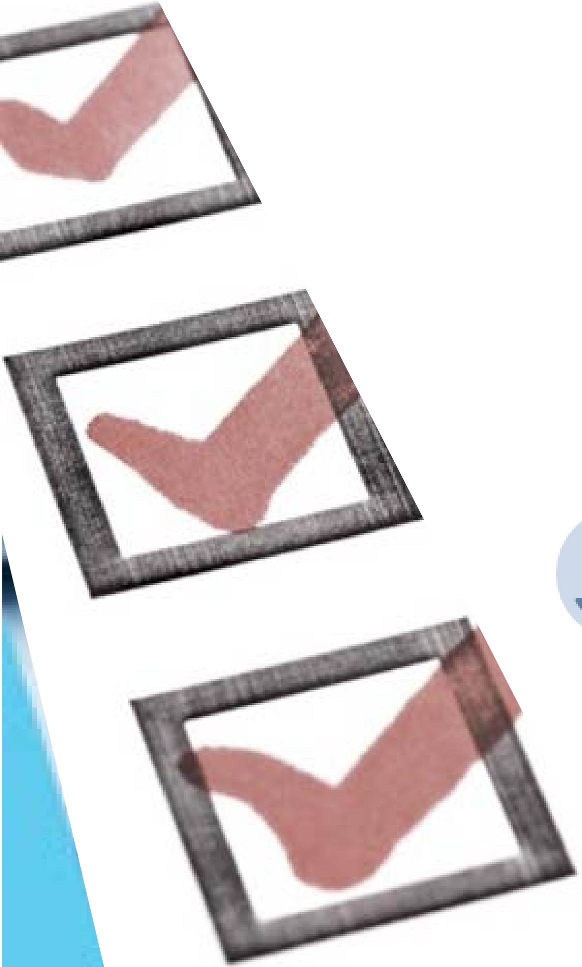
The Problem?
The Scale of Assessments



New Zealand
Water Footprint Examples

The focus of water footprint studies to date in New Zealand have focused on the agricultural sector. Globally, the agricultural sector is responsible for ~70% of global freshwater consumption.

However, the water used by the industrial sector, has in recent times been receiving more attention.



Concrete Case Study:

Setting Goals and Scope

A Case Study: Concrete Manufacture in New Zealand

<u>Research Aim</u>

- To investigate the feasibility of adapting different water footprint methods, and water scarcity indicators, for the assessment of water use in the building and construction sector of New Zealand.

Step 1: Method Selection

1 Availability Minus Demand (AMD)
Boulay et al. 2016

2 Water Footprint Impact Index (WFII)
The Water Footprint Network (2011)

3 ~~Water Stress Index (WSI)~~
Pfister et al. 2009

Only considers withdrawals and not specific consumptive water use – thus over estimating
Has no consideration for EFR

4 ~~Water Depletion Index (WDI)~~
Berger et al. 2014

Requires data unavailable in NZ.
Has no consideration for EFR.

Step 2: Establishing a Functional Unit

A functional unit is an quantified parameter of standardisation used to describe the final results.

There was found to be no water use difference between compressive strengths of concrete manufactured at the studied plants. Thus data pertaining to compressive strengths was averaged for the purposes of the study.

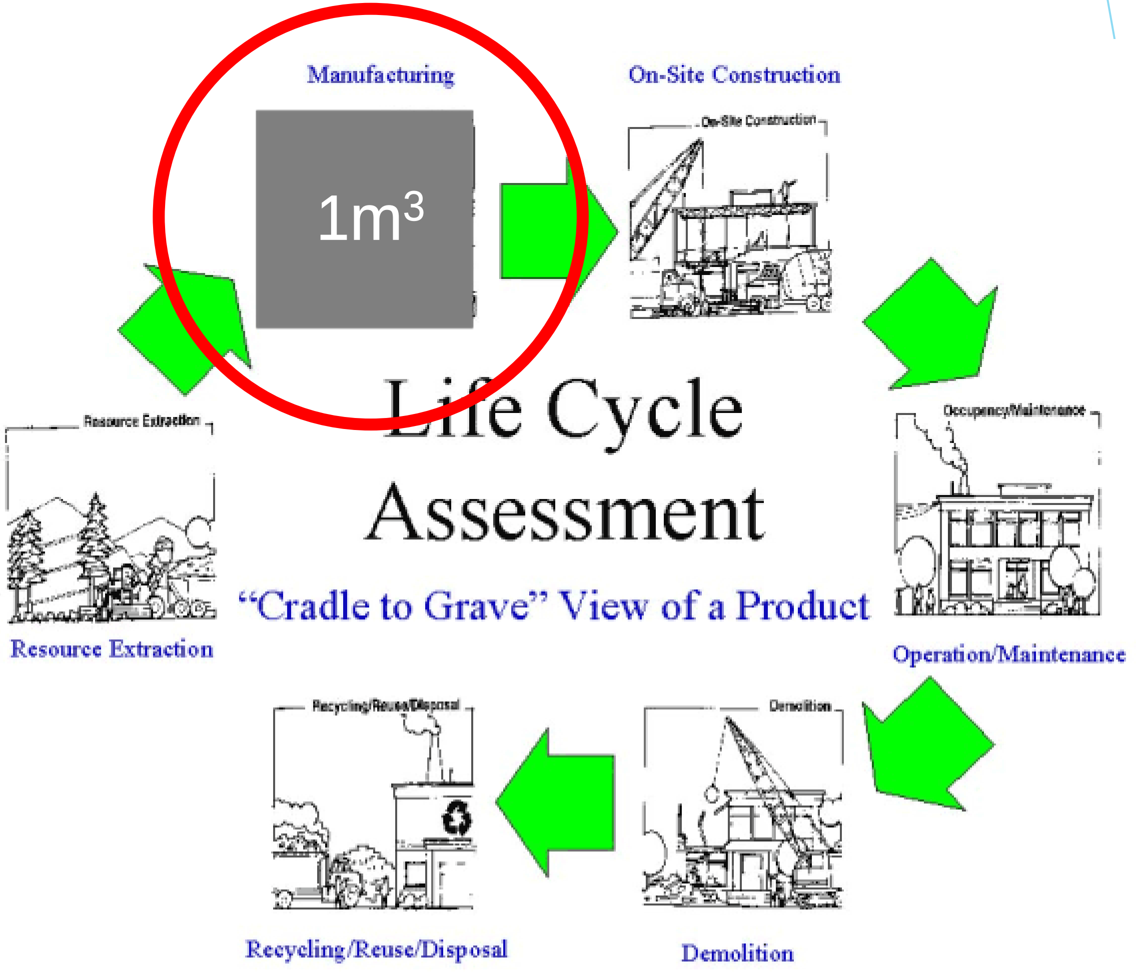
In this instance, the functional unit is $1m^3$ of concrete produced.

$1m^3$

Step 3: Determining the System Boundary

The system boundary determines which unit processes are to be included in the study.

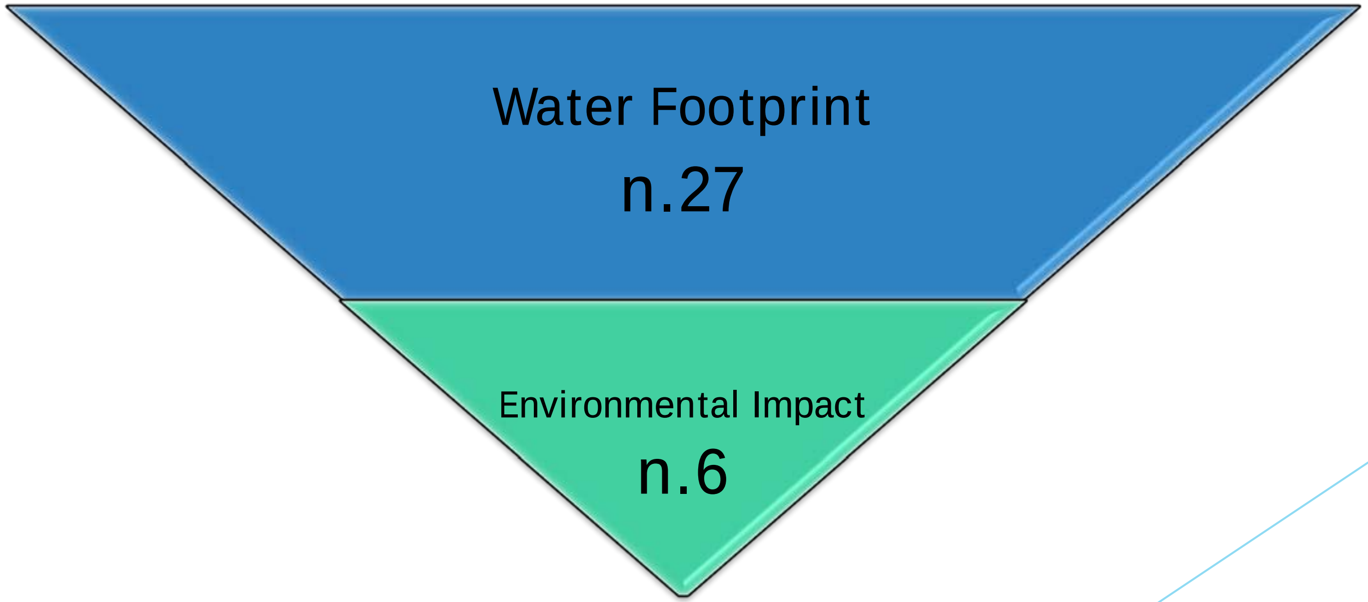
In this case, the system boundary focuses solely on the manufacture stage and can be described as a 'gate to gate' approach in LCA



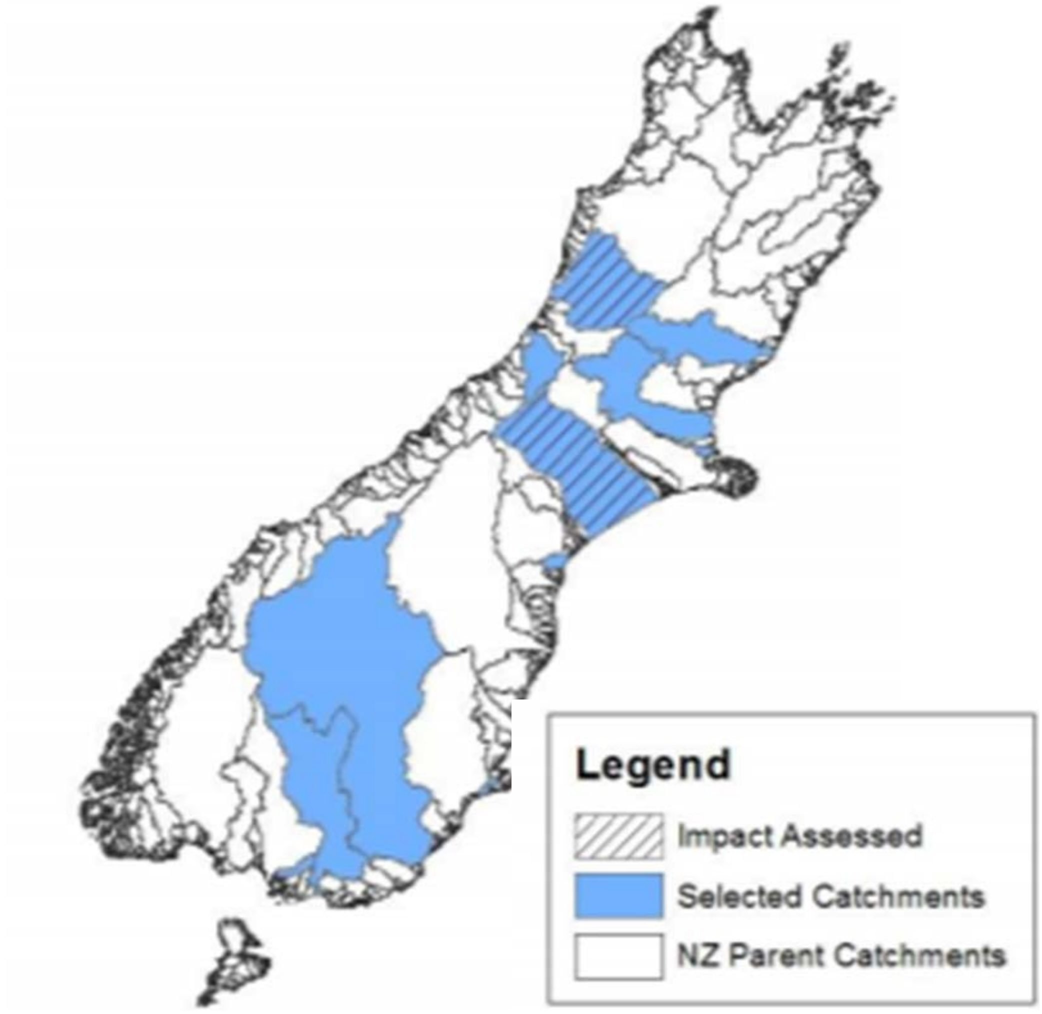
Step 4: Identifying Concrete Batching Plants

Using data collected to support Allied Concrete's Environmental Product Declaration (EPD), the water footprint of 27 concrete batching plants of varying sizes throughout New Zealand were studied.

In terms of the environmental impact of concrete manufacture, the impact of 6 of these plants was assessed.

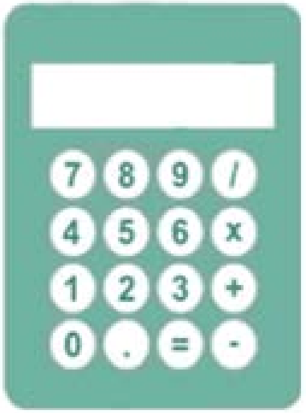


Step 5: Determining the Spatial Resolution: The Catchment Scale



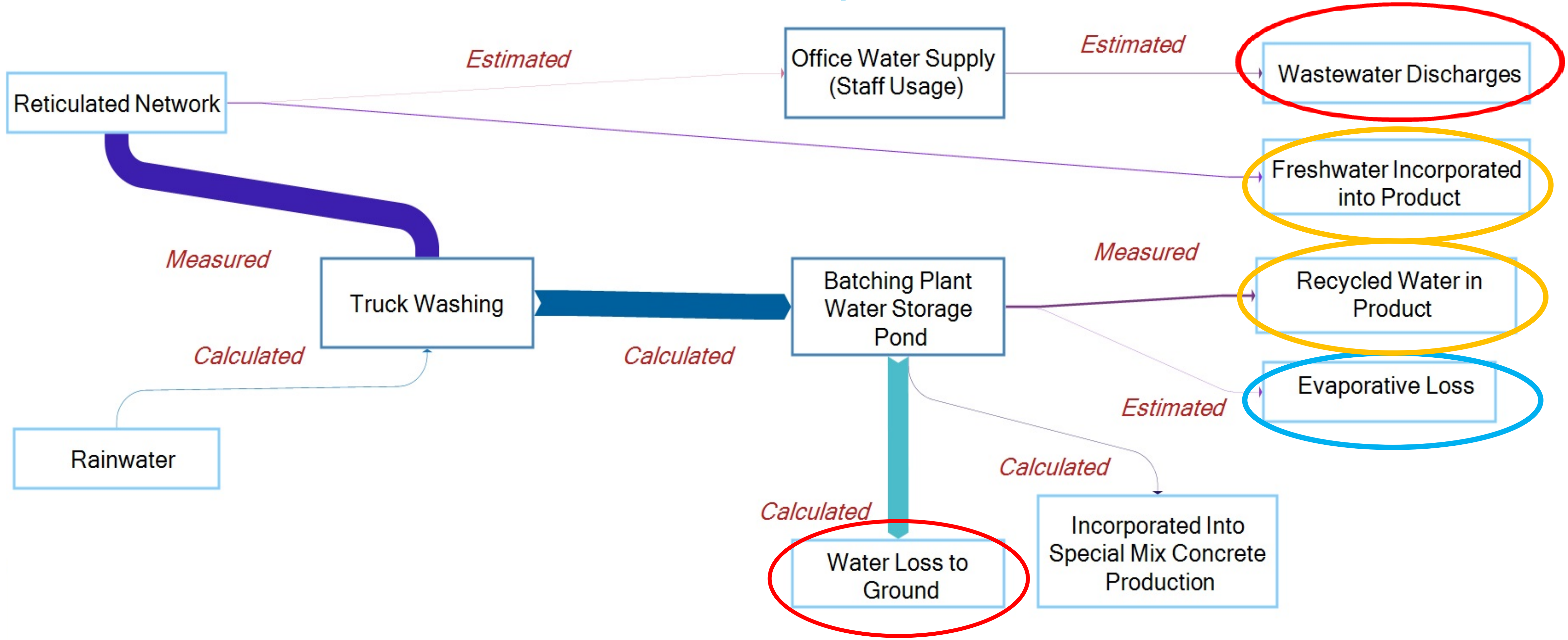
Concrete Case Study:

Accounting



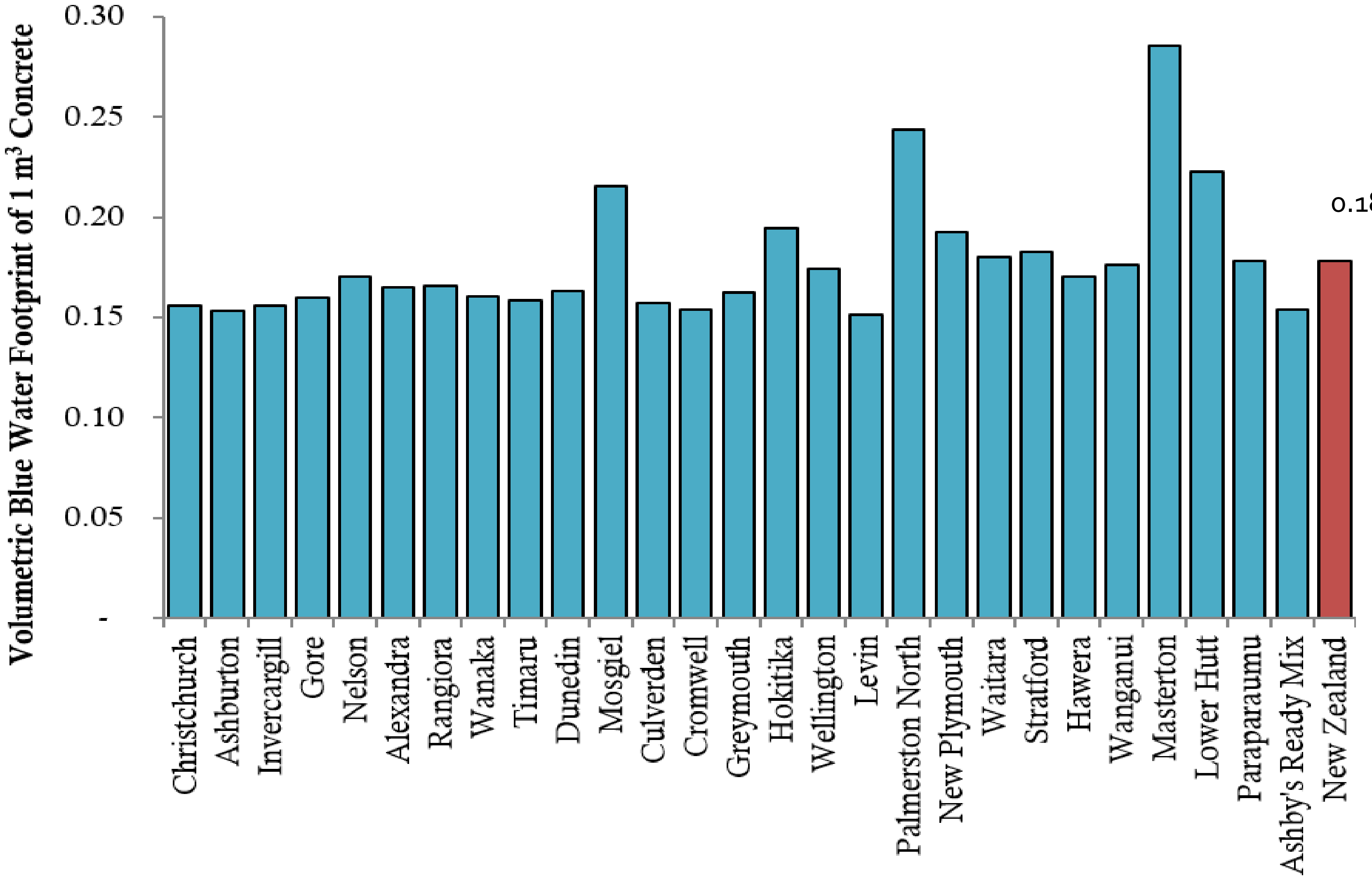
Data requirements:

Water Footprint

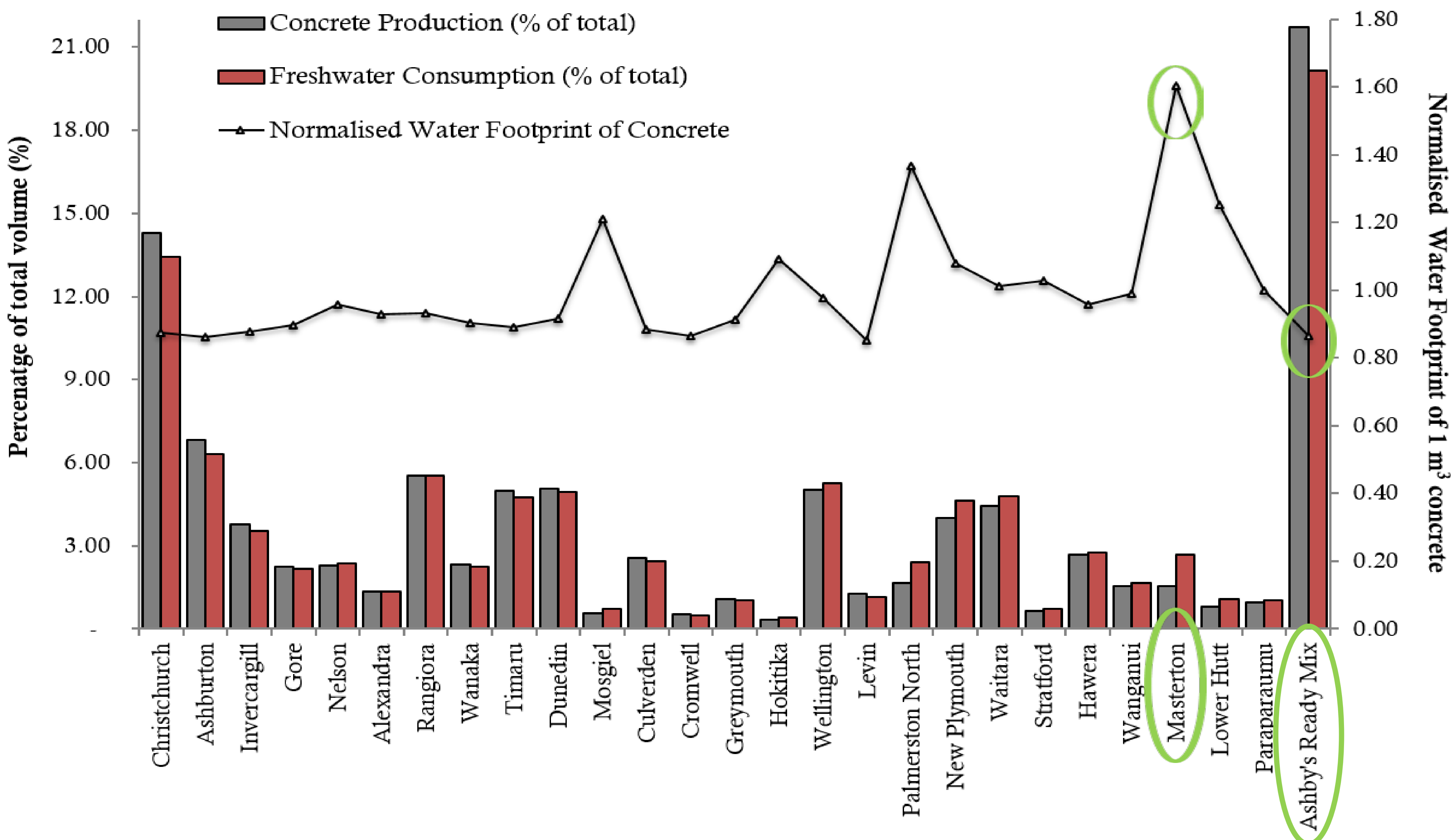


$$WF_{proc} = Water\ Evaporated + Water\ Incorporated + Lost\ Return\ Flow \quad [\text{volume/time}]$$

$$WF_{blue,concrete} = \frac{WF_{blue}}{Concrete\ Production\ Volume} \quad \left[m^3 water/m^3 product\right]$$



0.18 m^3 water/ m^3 concrete

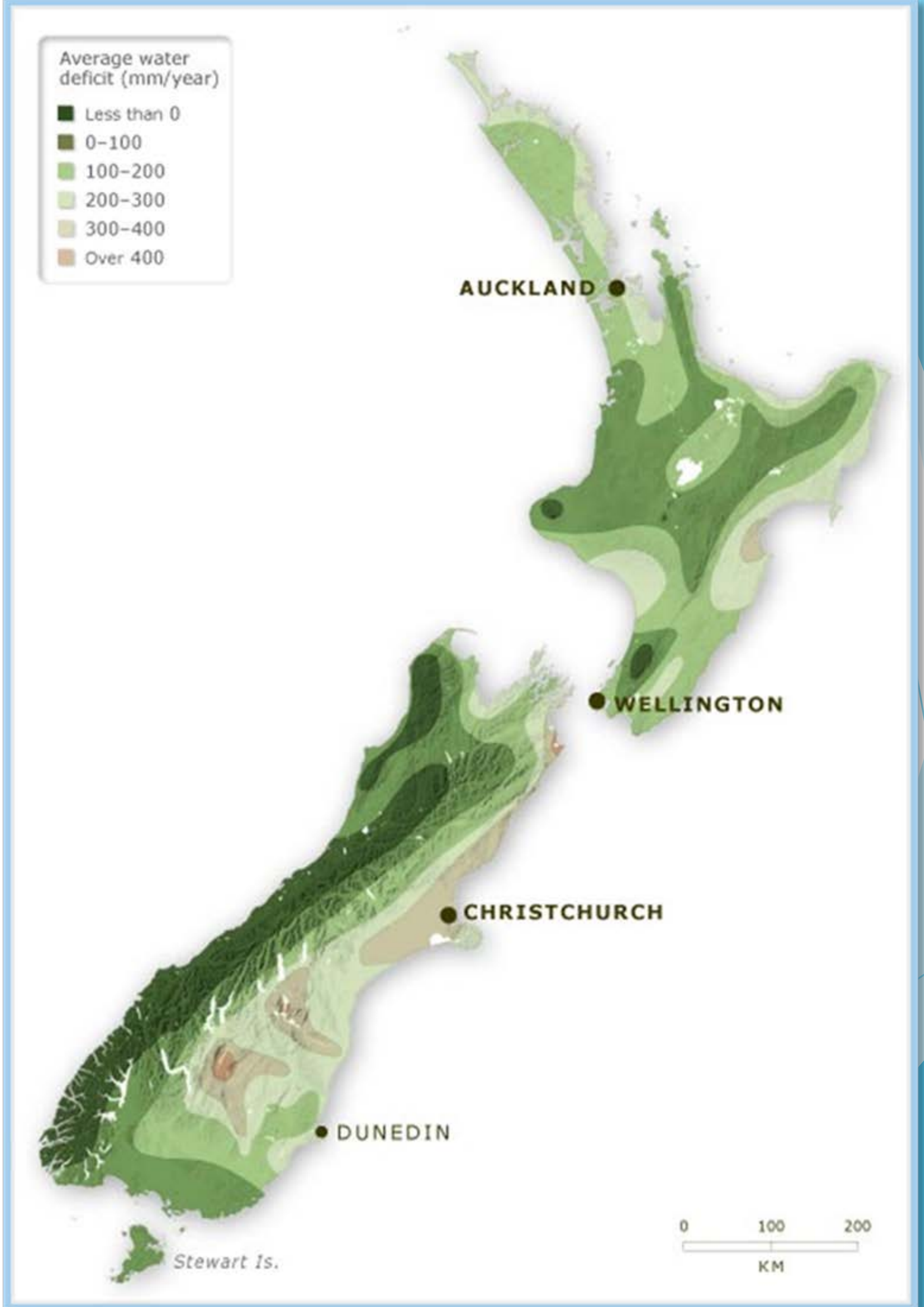

Concrete Production (% of total)
Freshwater Consumption (% of total)
Normalised Water Footprint of Concrete
Percenatge of total volume (%)
Normalised Water Footprint of 1 m^3 concrete
21.00
18.00
15.00
12.00
9.00
6.00
3.00
-
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Christchurch
Ashburton
Invercargill
Gore
Nelson
Alexandra
Rangiora
Wanaka
Timaru
Dunedin
Mosgiel
Culverden
Cromwell
Greymouth
Hokitika
Wellington
Levin
Palmerston North
New Plymouth
Waitara
Stratford
Hawera
Wanganui
Masterton
Lower Hutt
Paraparaumu
Ashby's Ready Mix

Concrete Case Study:

Sustainability (Impact) Assessment

Why?

- 1 litre of water use in Australia, for example, does not have the same impact as a litre of water used in New Zealand
- Similarly, a litre of water used in one catchment may have a very different impact in a different catchment

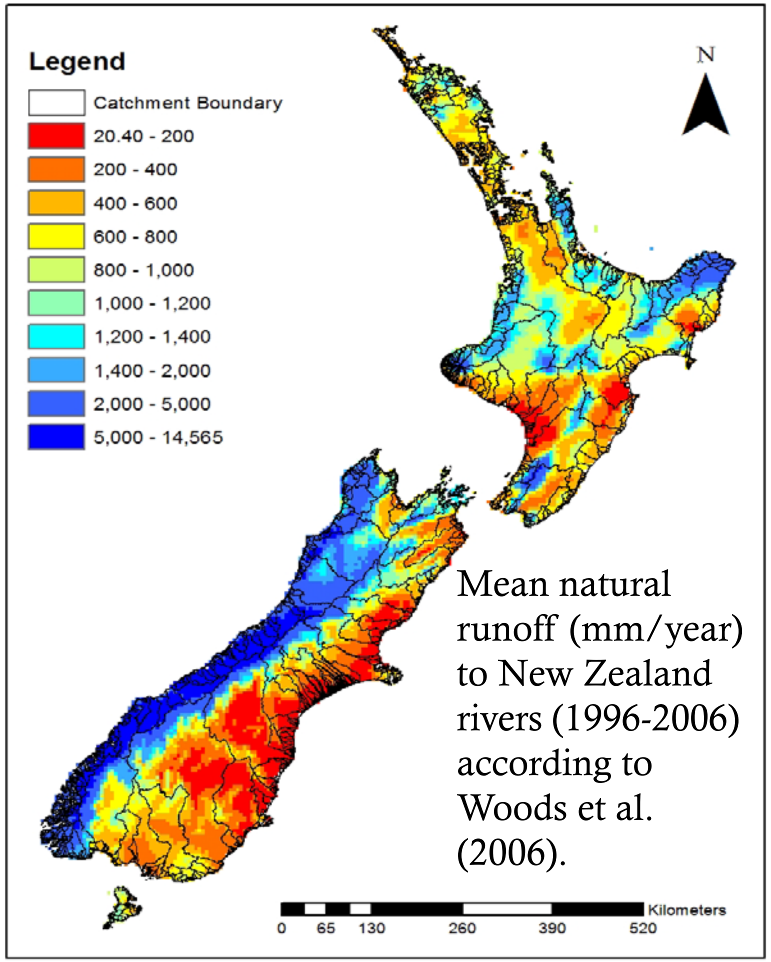


WFN Method

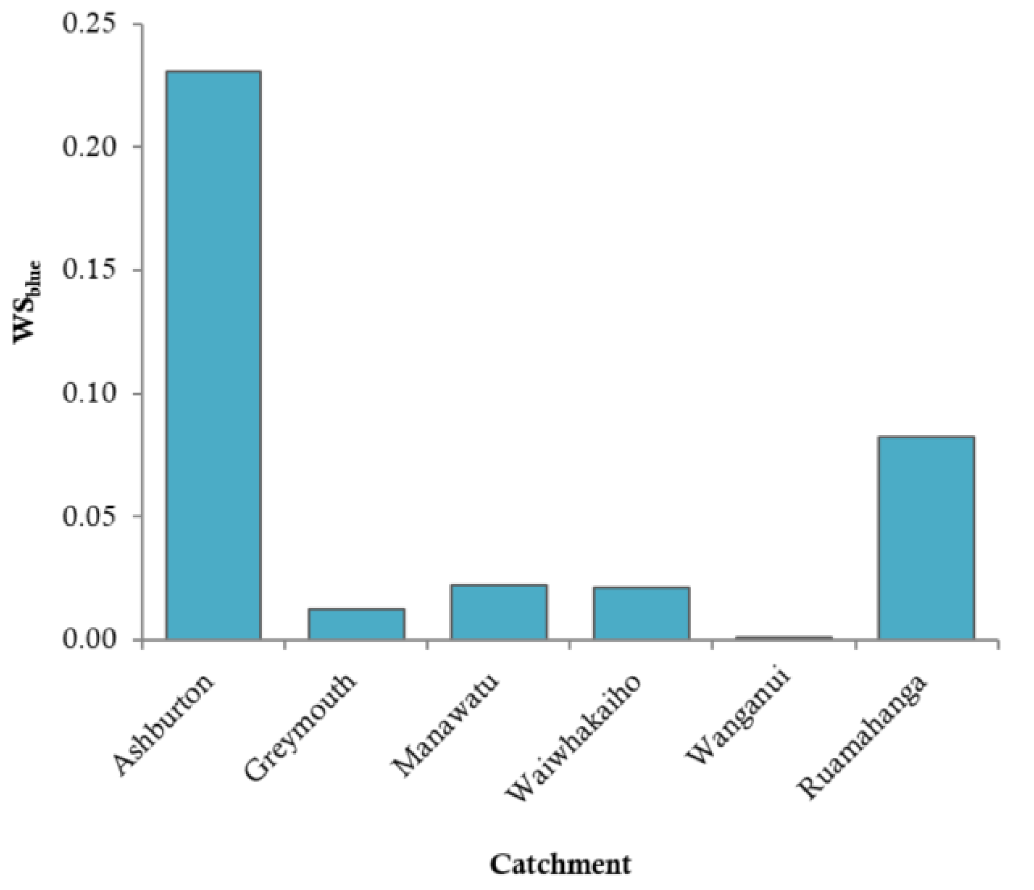
Data requirements:
Impact Assessment

$$WA_{blue\,[x,t]} = R_{nat}\,[x,t] - EFR[x,t] \quad [\text{volume/time}]$$

$$WS_{blue}[x,t] = \frac{\sum WF_{blue}[x,t]}{WA_{blue}[x,t]} \quad [-]$$



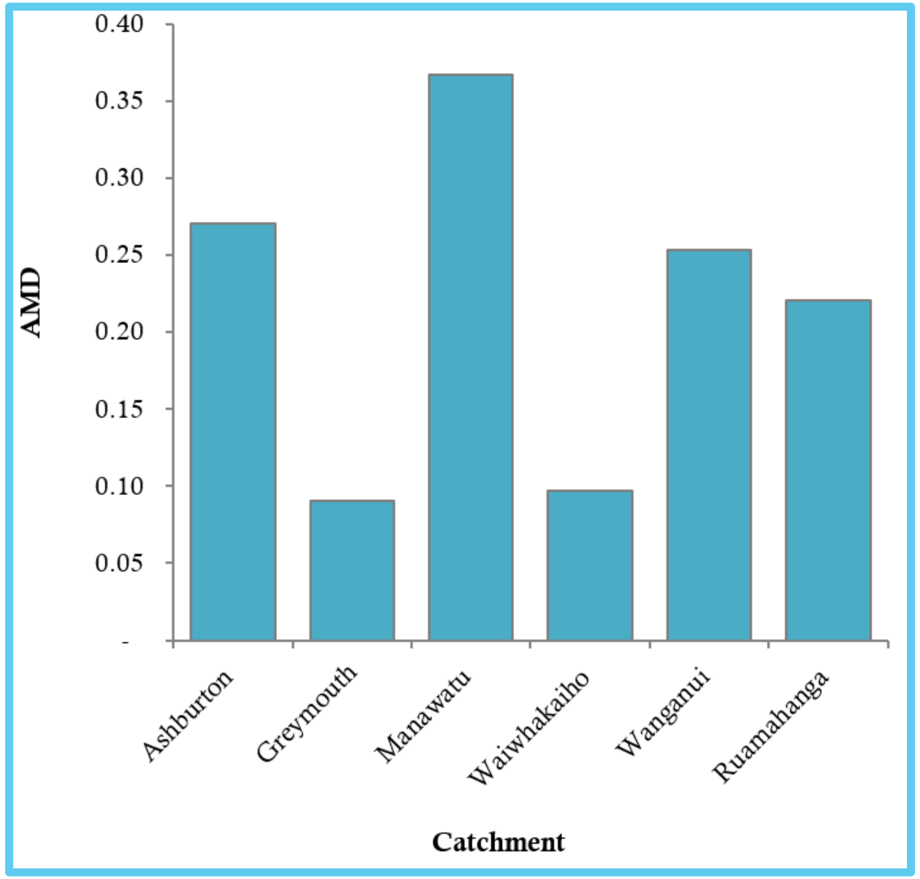
Mean natural runoff (mm/year) to New Zealand rivers (1996-2006) according to Woods et al. (2006).



Boulay et al. Method

Data requirements: *Impact Assessment*

$$AMD_i = \frac{Availability - HWC - EFR}{Area} \quad [\mathrm{m^3/m^2\ month^{-1}}]$$



Where;

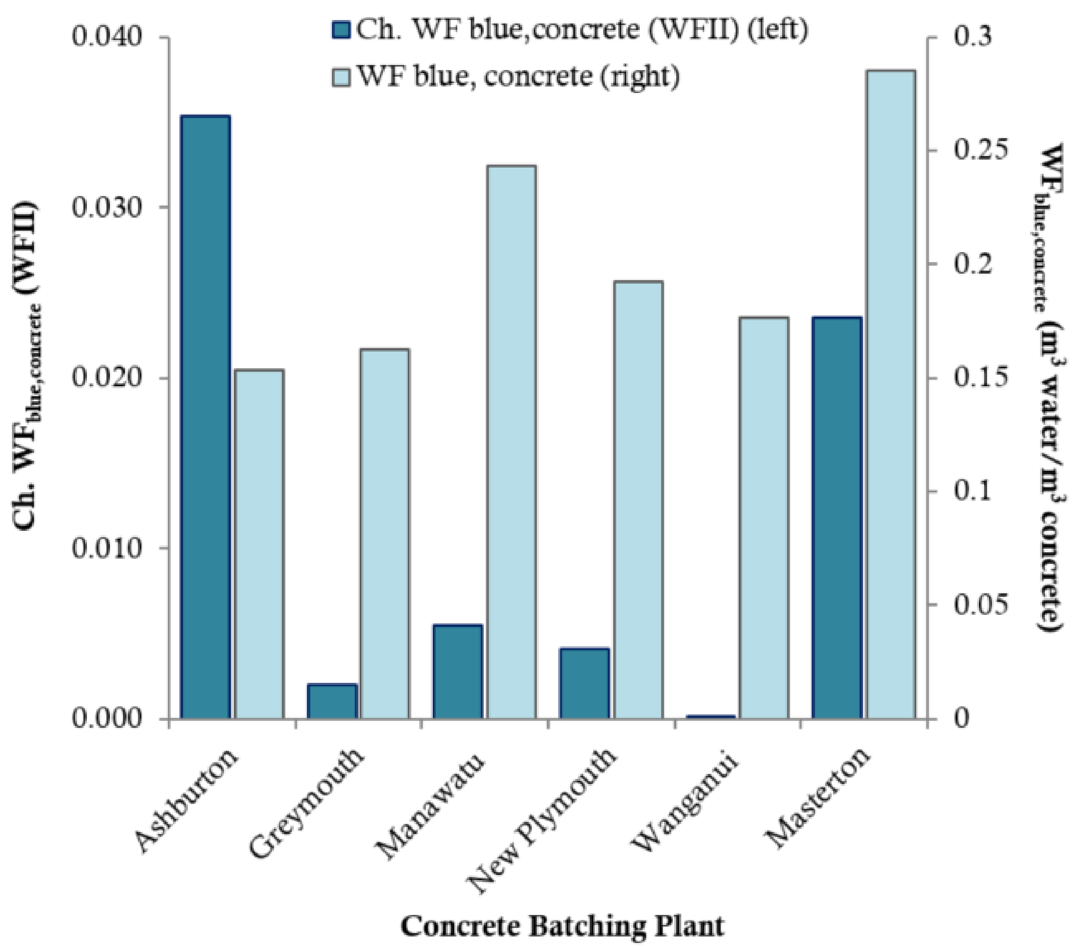
Availability = Natural Runoff

HWC = estimates of consented water takes that are actually abstracted (MfE, 2010)

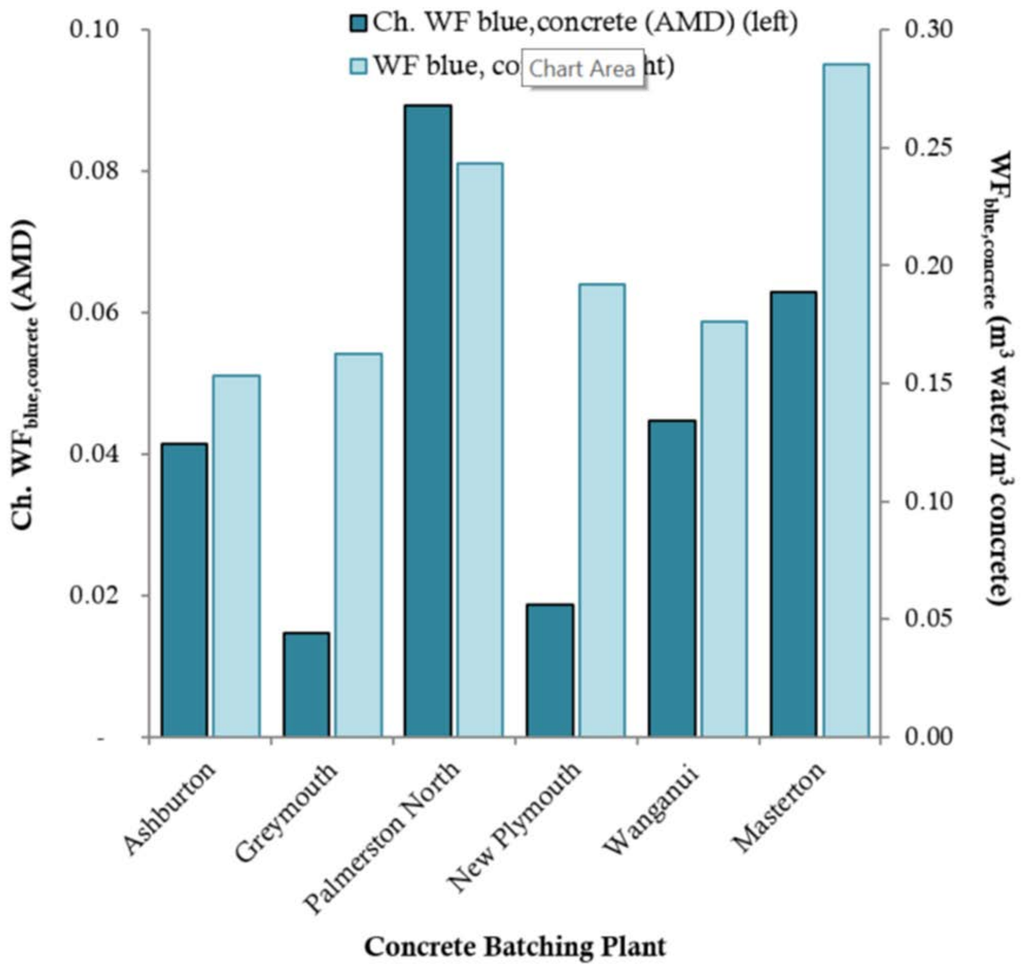
EFR = provided by the method, calculated at the basin level and calculated monthly scale.

$$CF = \frac{0.0136}{AMD_i} \quad [-]$$

WFN Method

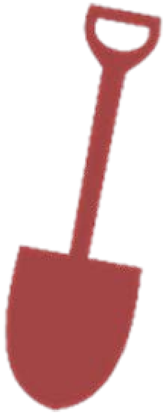


Boulay et al. (2016) Method



Concrete Case Study:

Response Formulation



Research Aim

- To investigate the feasibility of adapting different water footprint methods, and water scarcity indicators, for the assessment of water use in the building and construction sector of New Zealand.

	ISO 14046 Compliant	Comprehensive (ISO 14046)	Adaptable for NZ?	EFR Considered?
Hoekstra et al. (2011)	✓*	✓**	✓***	✓****
Pfister et al. (2009)	✓	✓	✓	X
Berger et al. (2014)	✓	✓	X	X
Boulay et al. (2016)	✓	✓	✓*****	✓

* Compliant as long as an impact assessment using the *WFII* is calculated
**Comprehensive as long as it includes a grey water impact assessment (otherwise there is no other metric for water quality impacts to human health, as with LCA methods).
*** Calculations for the water footprint of a specified boundary had to be adapted due to data unavailability
**** Using a blanket value of 80% of natural flow (but could be adapted to use more site specific *EFR*)
***** Difficulty in adaptation may arise from the normalisation with a global average *AMD*

Limitations & Recommendations

Limitations

Water Footprint

- Obtaining standardised primary data
- No differentiation between the type of water used (Network vs. Recycled)

Impact Assessment

- Data Availability and Quality
- Temporal Resolution
- No NZ specific EFR values used

Recommendations

- More work to standardise data: Creation of a NZ specific database
- If recycled water is used, need to consider this in response formulation, as the methods won't consider that for you.
- Ideally assessments should be at the monthly or finer resolution

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Thank You!

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