Water Footprinting In New Zealand: Case Study of Concrete

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A systems approach

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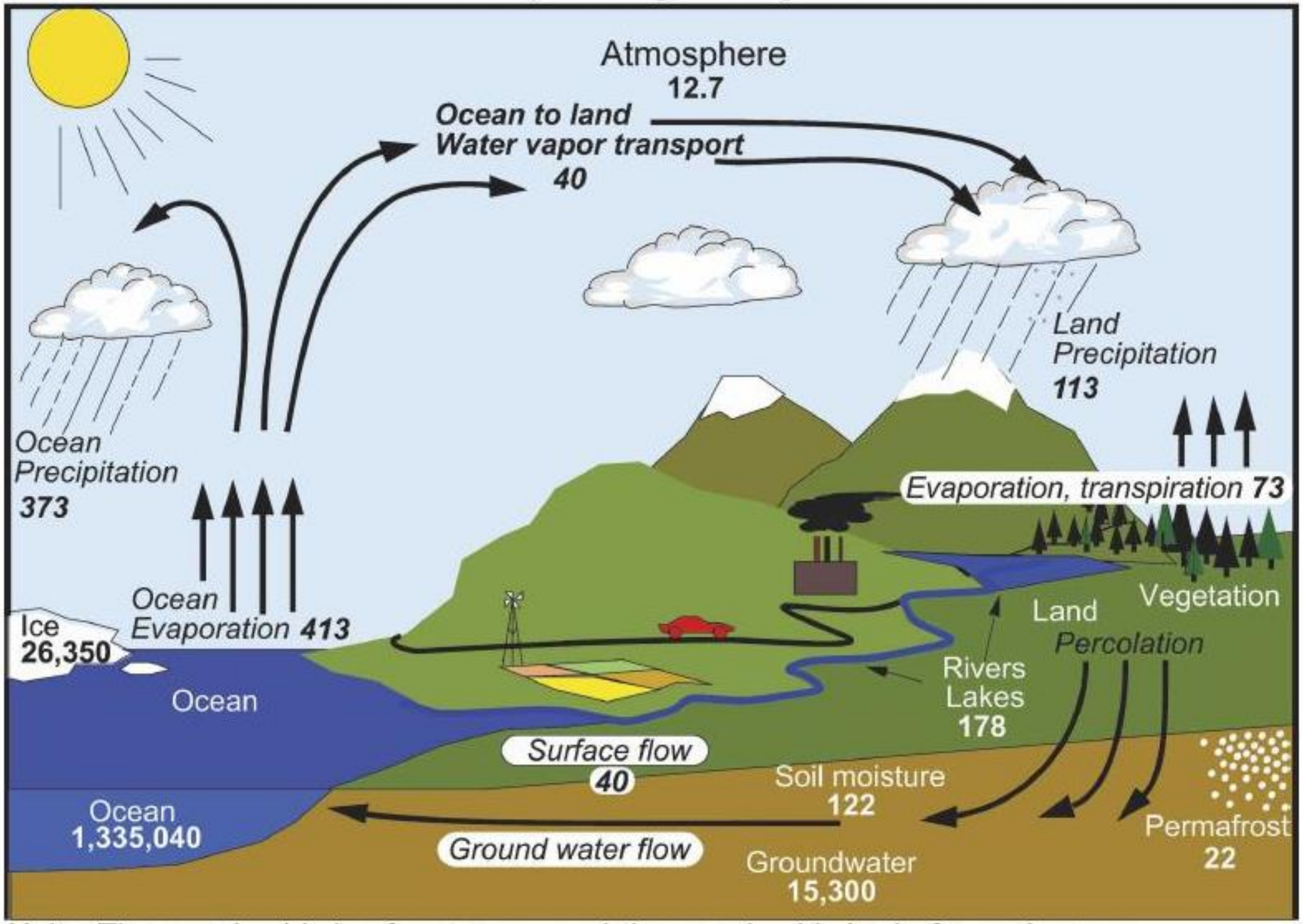
Hydrological Cycle



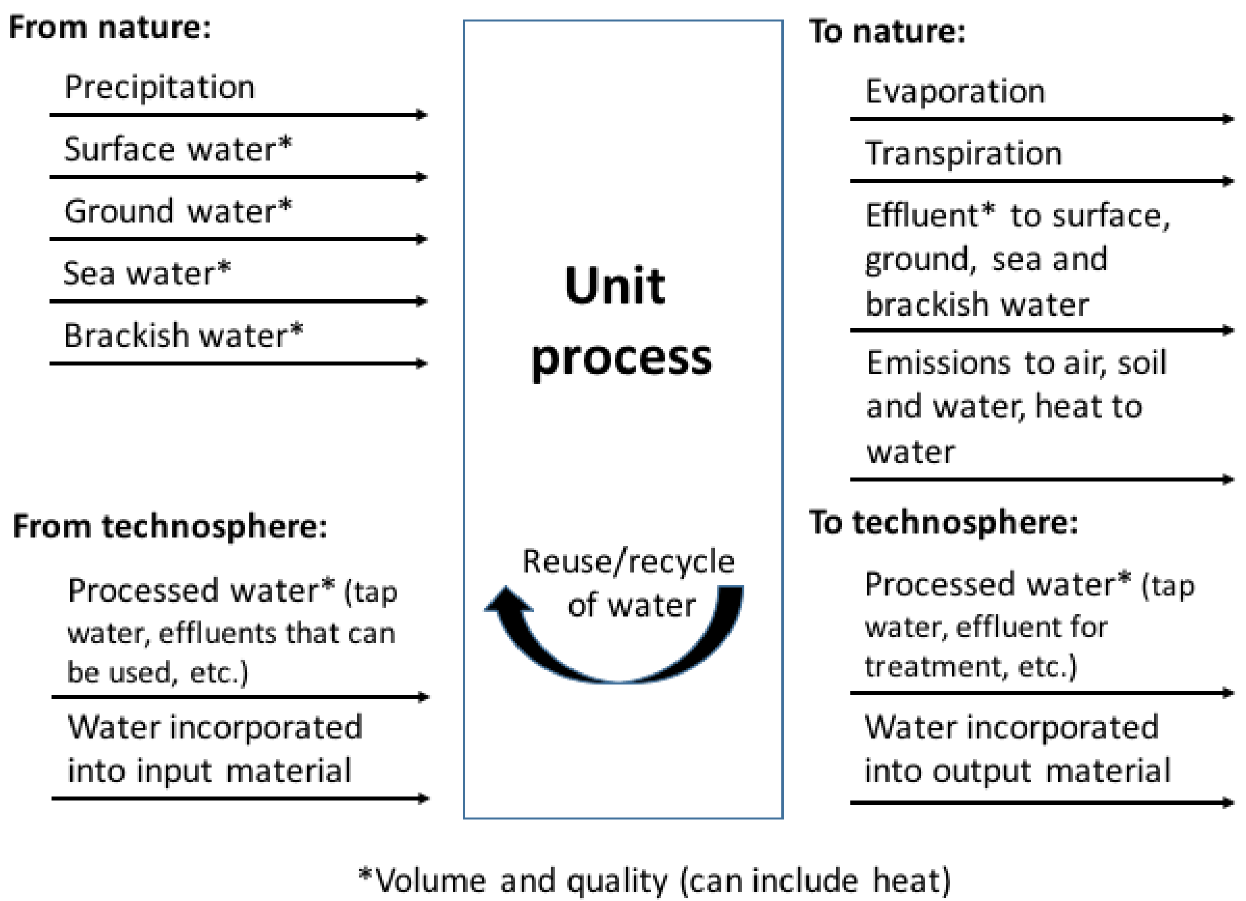
Units: Thousand cubic km for storage, and *thousand cubic km/yr* for exchanges

FIG. 1. The hydrological cycle. Estimates of the main water reservoirs, given in plain font in 10^3 km^3, and the flow of moisture through the system, given in slant font (10^3 km^3 yr^{-1}), equivalent to Eg (10^{18} g) yr^{-1}.

Source: Trenberth et al., 2007

At Inventory Analysis …

Water consumed: no longer available in the same watershed, because it has been evaporated, integrated into a product or released into a different watershed or the sea.



Source: ISO TR 14073, Figure 2

Environ-mental Impacts

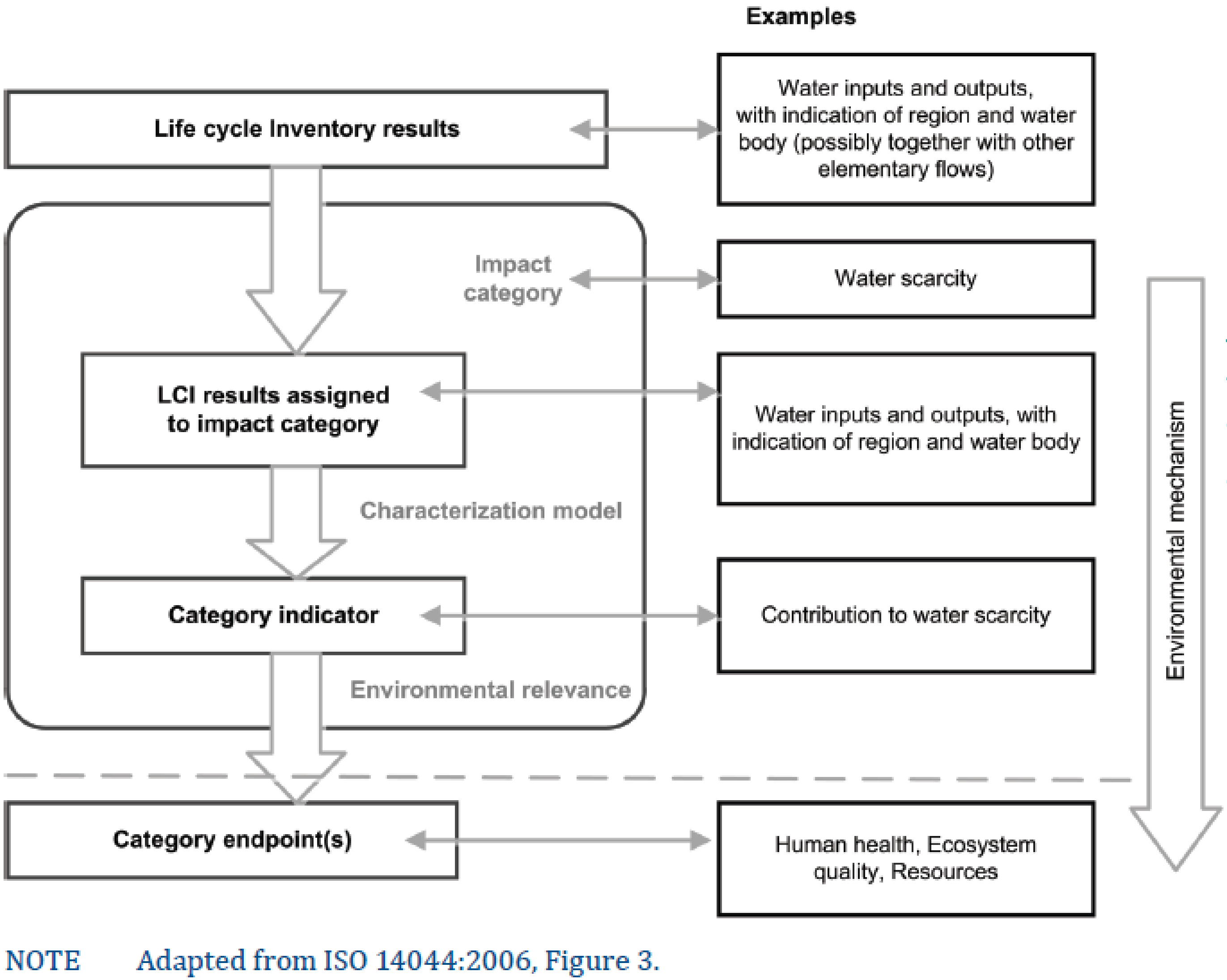


Figure 4 — Concept of category indicators illustrated for an impact category addressing water scarcity

Source: ISO 14046, Figure 4

Method of Pfister et al. (2009)

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$$\mathrm{WTA}_i = \frac{\sum_j \mathrm{WU}_{ij}}{\mathrm{WA}_i}$$

Water use by industry, agriculture, households

Freshwater available (10,000 watersheds)

Ratio of total annual freshwater withdrawals to hydrological availability

Pfister et al. (2009)

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$$\mathrm{WTA}_i = \frac{\sum_j \mathrm{WU}_{ij}}{\mathrm{WA}_i}$$

$$\mathrm{WTA}^* = \begin{cases} \sqrt{\mathrm{VF}} \times \mathrm{WTA} & \text{for SRF} \\ \mathrm{VF} \times \mathrm{WTA} & \text{for non} - \text{SRF} \end{cases}$$

Variation factor (representing precipitation distribution)

Strongly regulated flows

Pfister et al. (2009)

$$\mathrm{WTA}_i = \frac{\sum_j \mathrm{WU}_{ij}}{\mathrm{WA}_i}$$

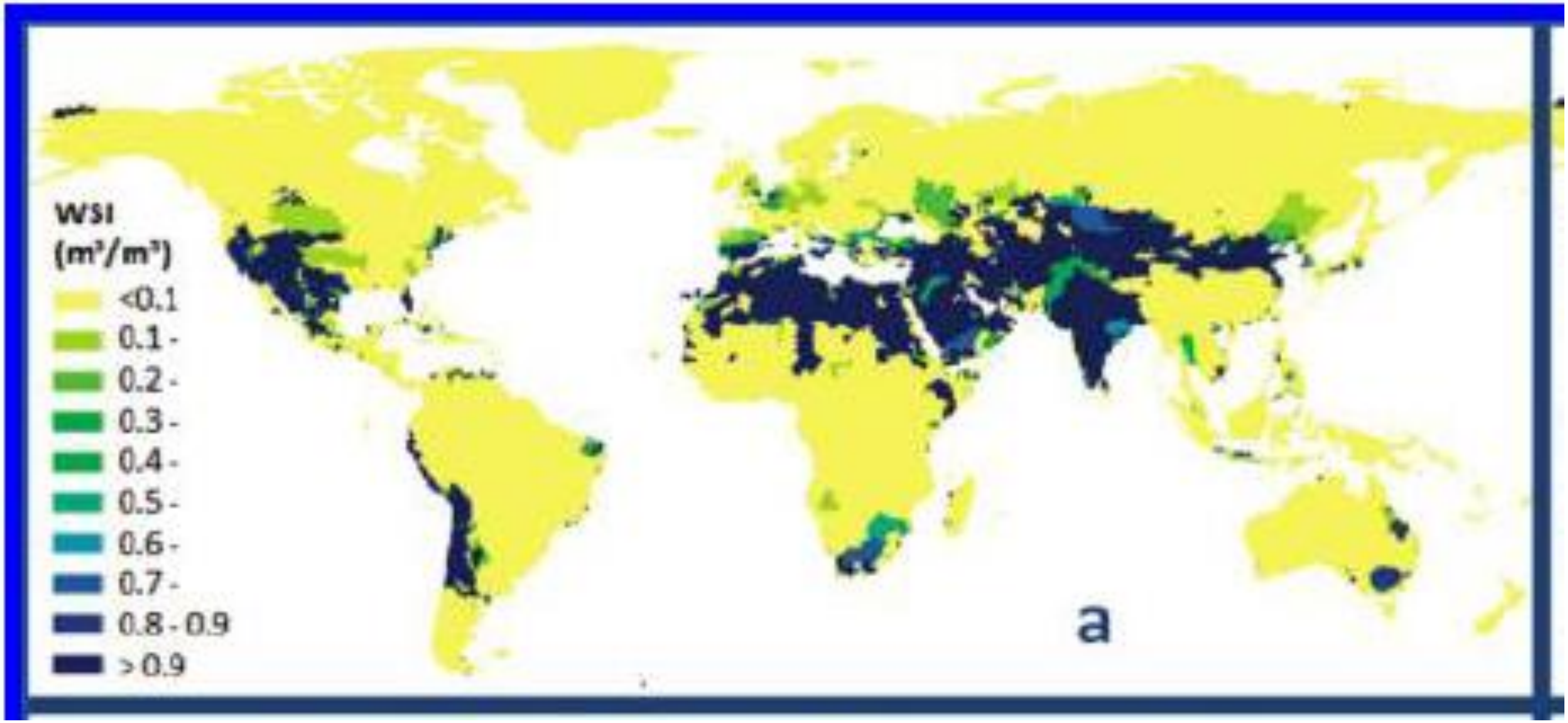
$$\mathrm{WTA}^* = \begin{cases} \sqrt{\mathrm{VF}} \times \mathrm{WTA} & \text{for SRF} \\ \mathrm{VF} \times \mathrm{WTA} & \text{for non} - \text{SRF} \end{cases}$$

$$\mathrm{WSI} = \frac{1}{1 + e^{-6.4 \cdot \mathrm{WTA}^*\left(\frac{1}{0.01} - 1\right)}}$$

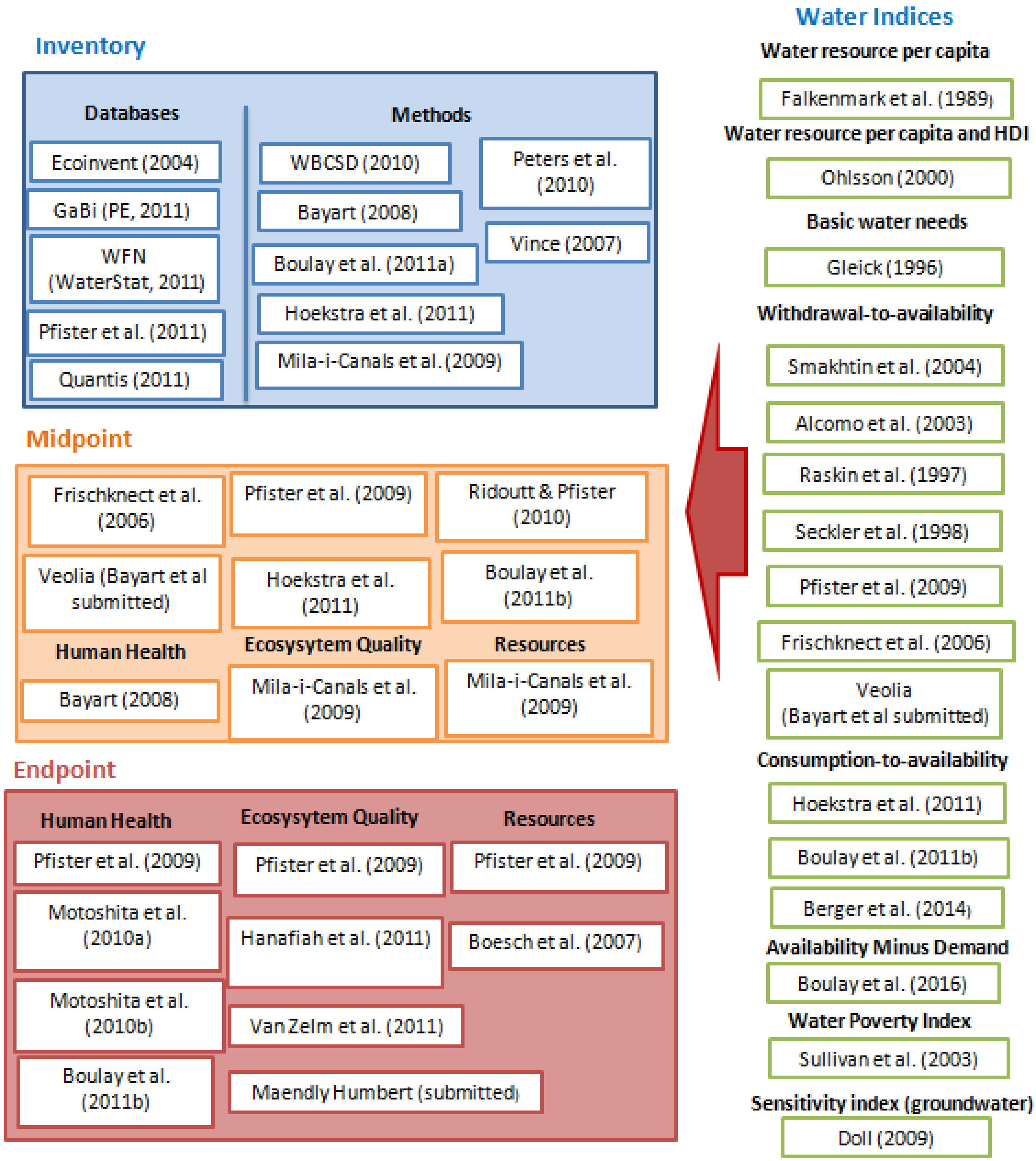
WSI from 0.01 to 1.0

WSI 0.5 is threshold between moderate and severe water stress

Pfister and Ridoutt (2009 ...)



A short history



Source: Kounina et al., 2013, Figure 2

A short history …

Evolution of thinking:

- Withdrawal-to-Availability (WTA) concept … but no accounting for water withdrawn but released into the same watershed
- Consumption-to-Availability (CTA) approaches … but no accounting for water required by ecosystems
- Demand-to-Availability approaches: include ecosystems water requirements (EWR) as well as human water requirements.

Case Study of Concrete

Aims:

- Calculate the water footprint of 1 m^3 concrete produced at 27 batching plants in New Zealand
- Identify the influence on the results of different water footprint methods
- Investigate the influence on the results of geographical scale used in calculating WF characterisation factors

Method:

- Water data provided for 27 batching plants by Allied Concrete (e.g. reticulated water withdrawal), "gate-to-gate" study
- Assessment at three regional scales using four different methods

Flows of water through plant

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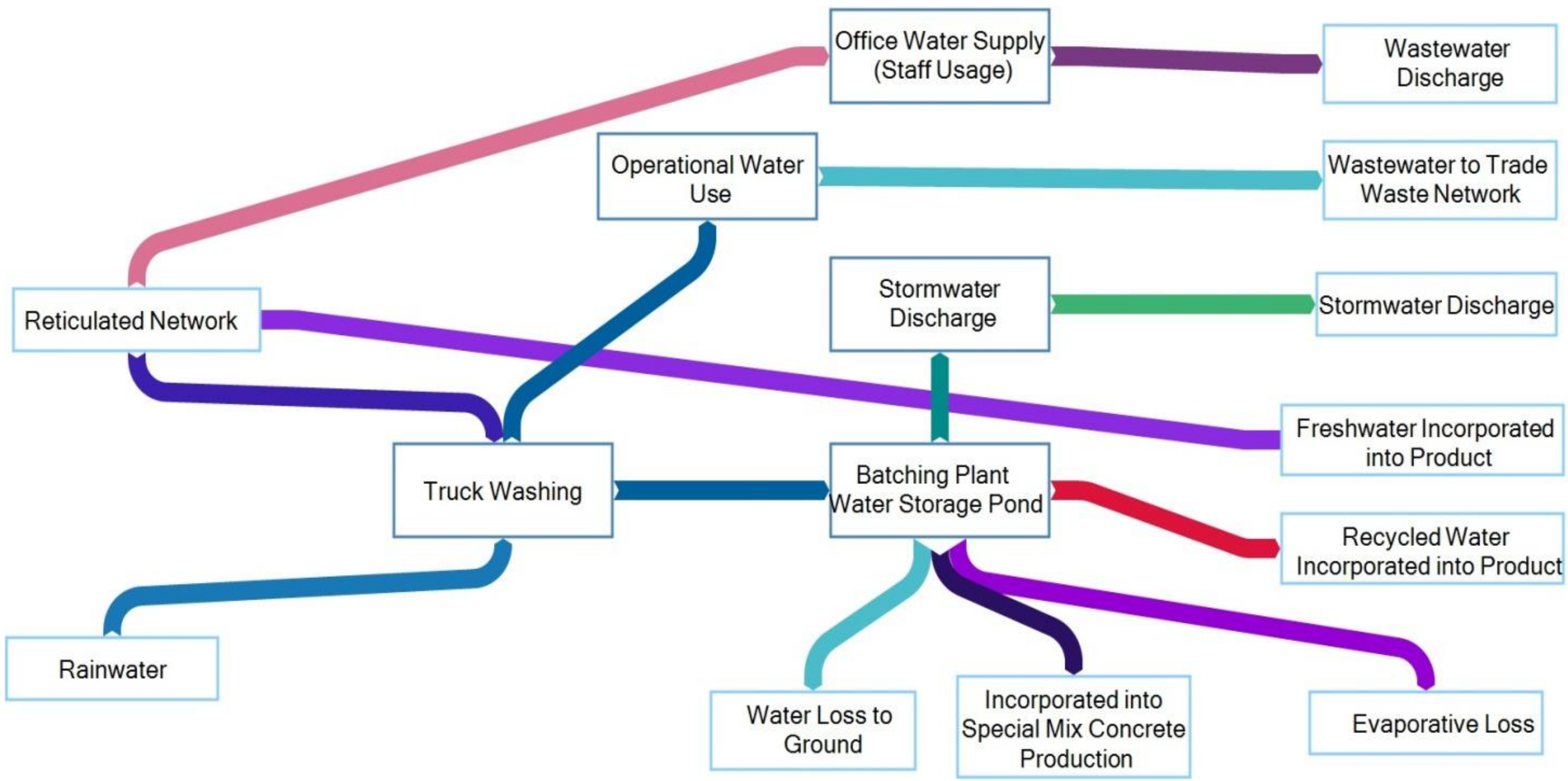
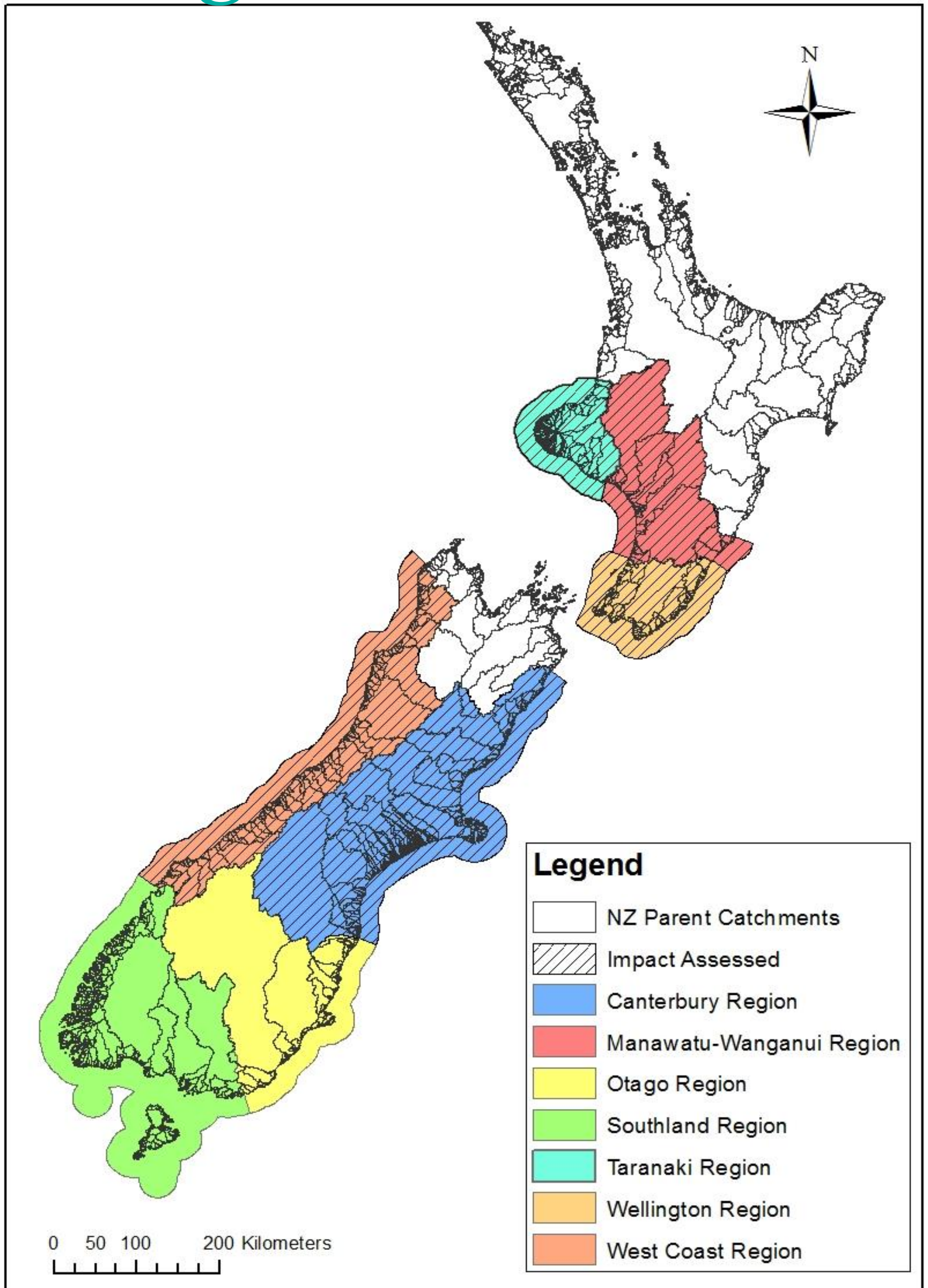
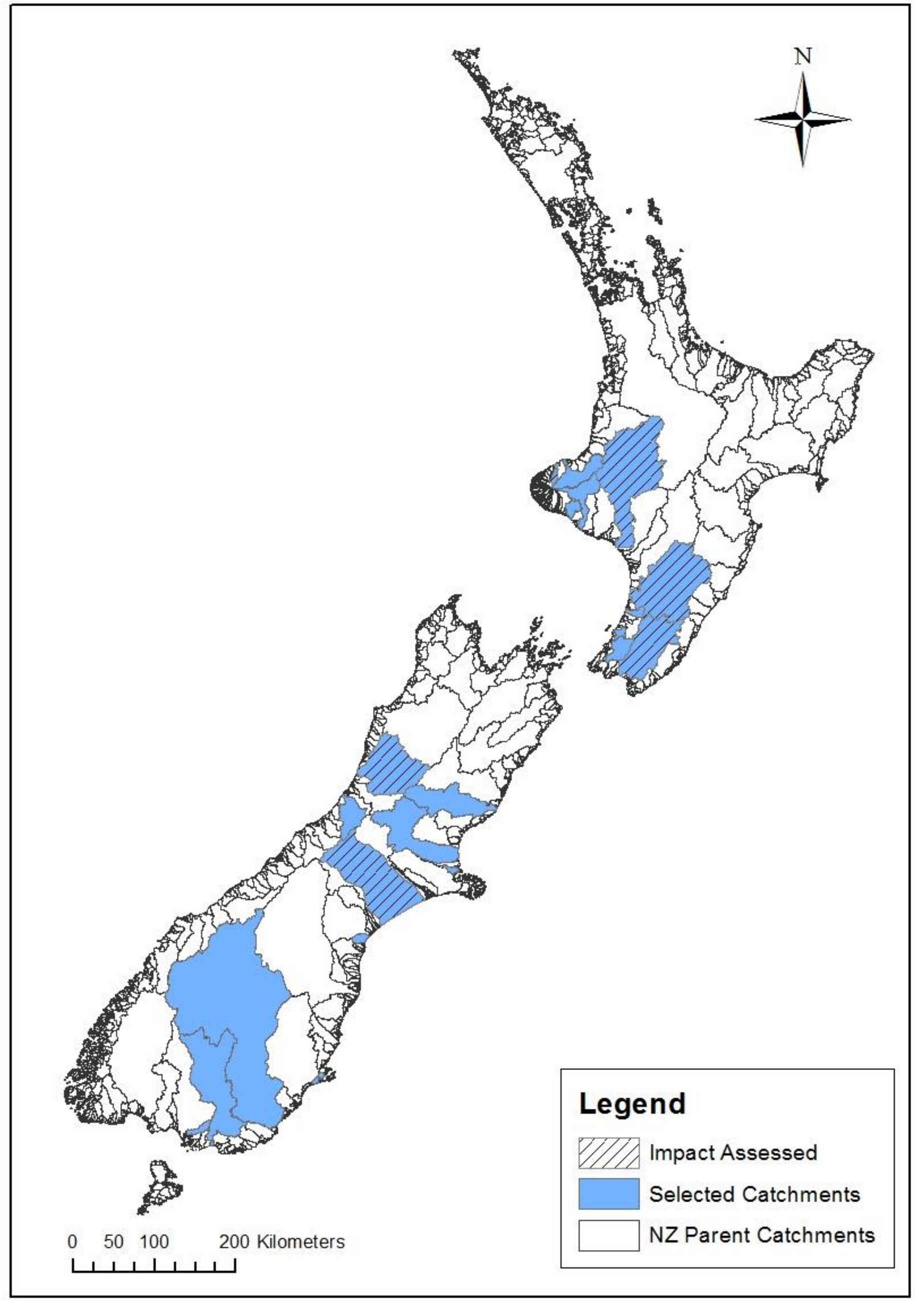


Source: Mellor, 2016

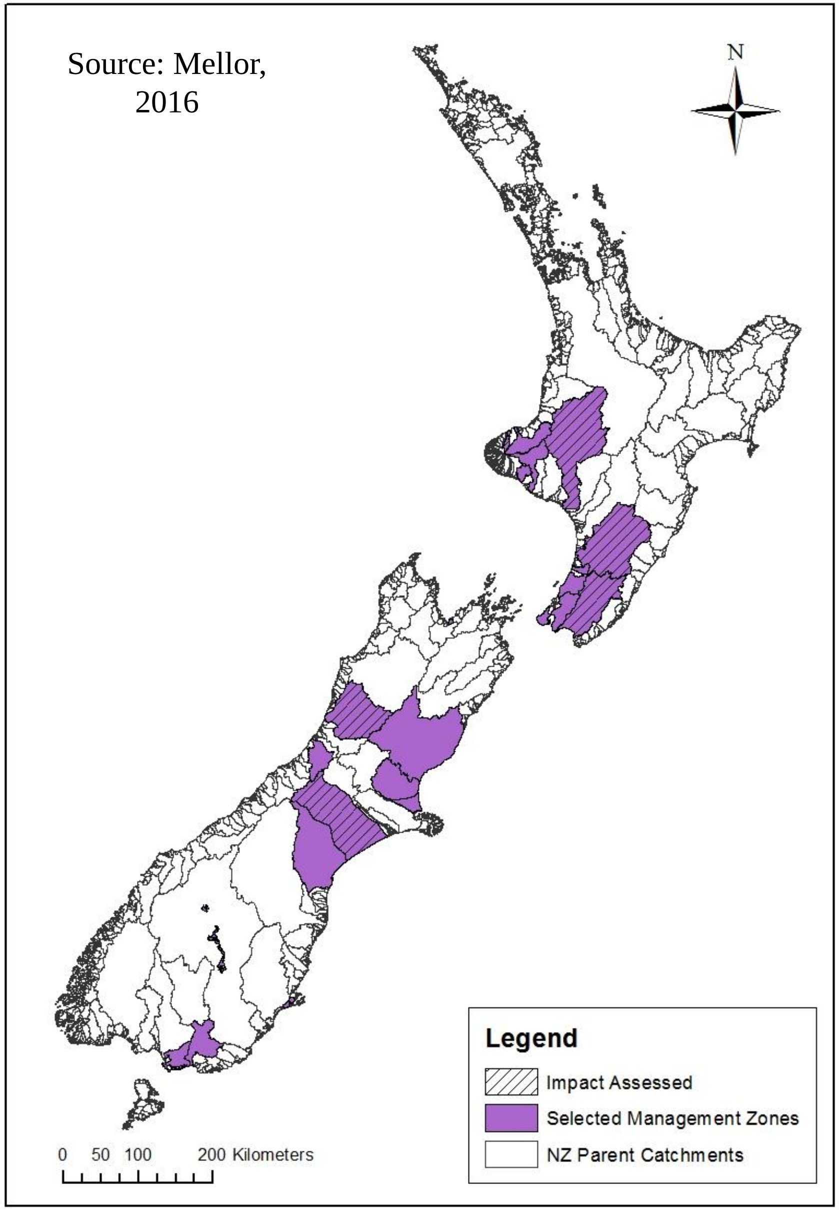
Regional and catchment scales

Source: Mellor, 2016





Freshwater management zones

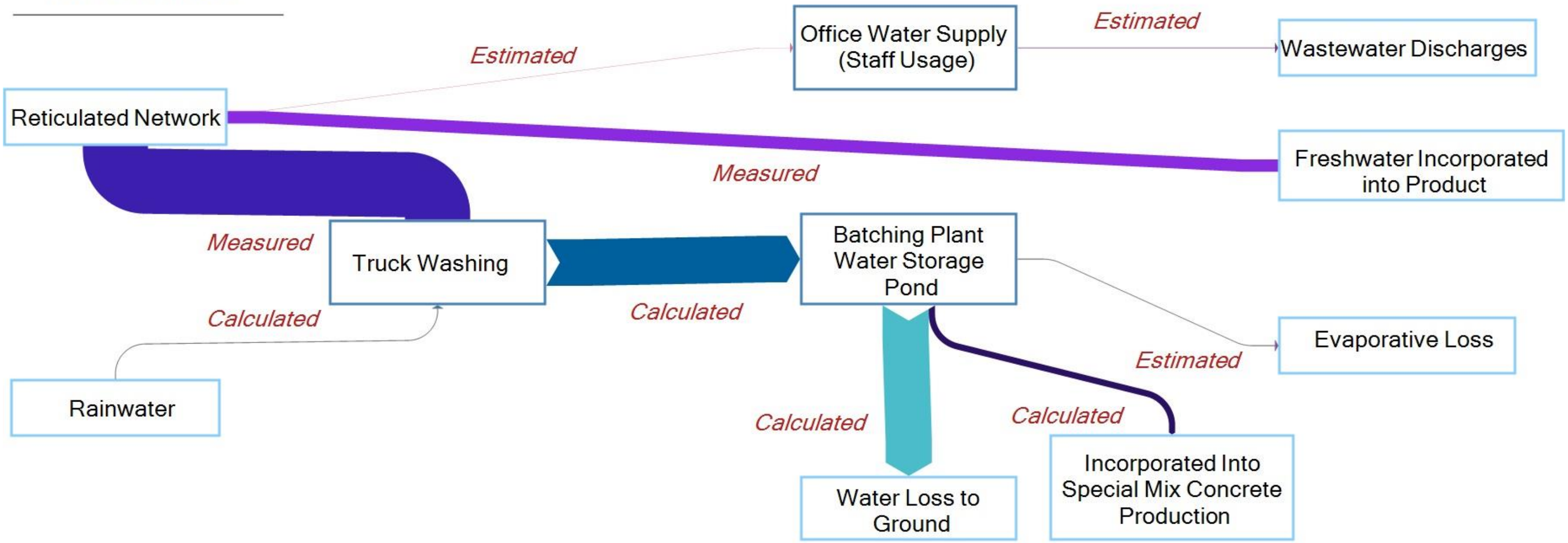


"the water body, multiple water bodies, or any part of a water body determined by the regional council as the appropriate spatial scale for setting freshwater objectives and limits for freshwater accounting and management purposes" (Ministry for the Environment, 2014b, p. 7).

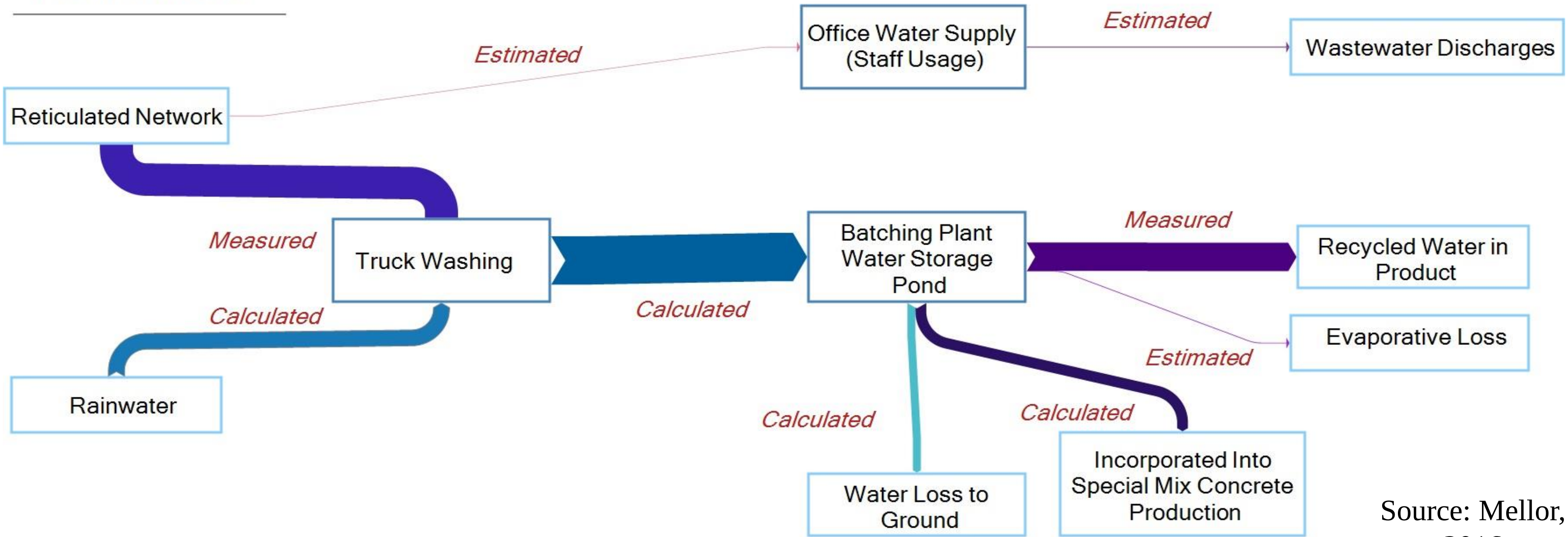
Assessment methods

- WFN volumetric blue water footprint (evaporation from storage ponds, incorporated into product itself, lost return flow i.e. volume of 'wastewater' transported to other batching plants)
- WNF volumetric blue water scarcity index (availability, EFR)
- Pfister et al. Water Stress Index (availability, demand)
- Berger et al. WAVE model (availability, demand, evaporation recycling)
- Boulay et al. AWaRe method (availability, demand, EFR)

Masterton



Ashburton



Source: Mellor, 2016

Volumetric blue water footprint

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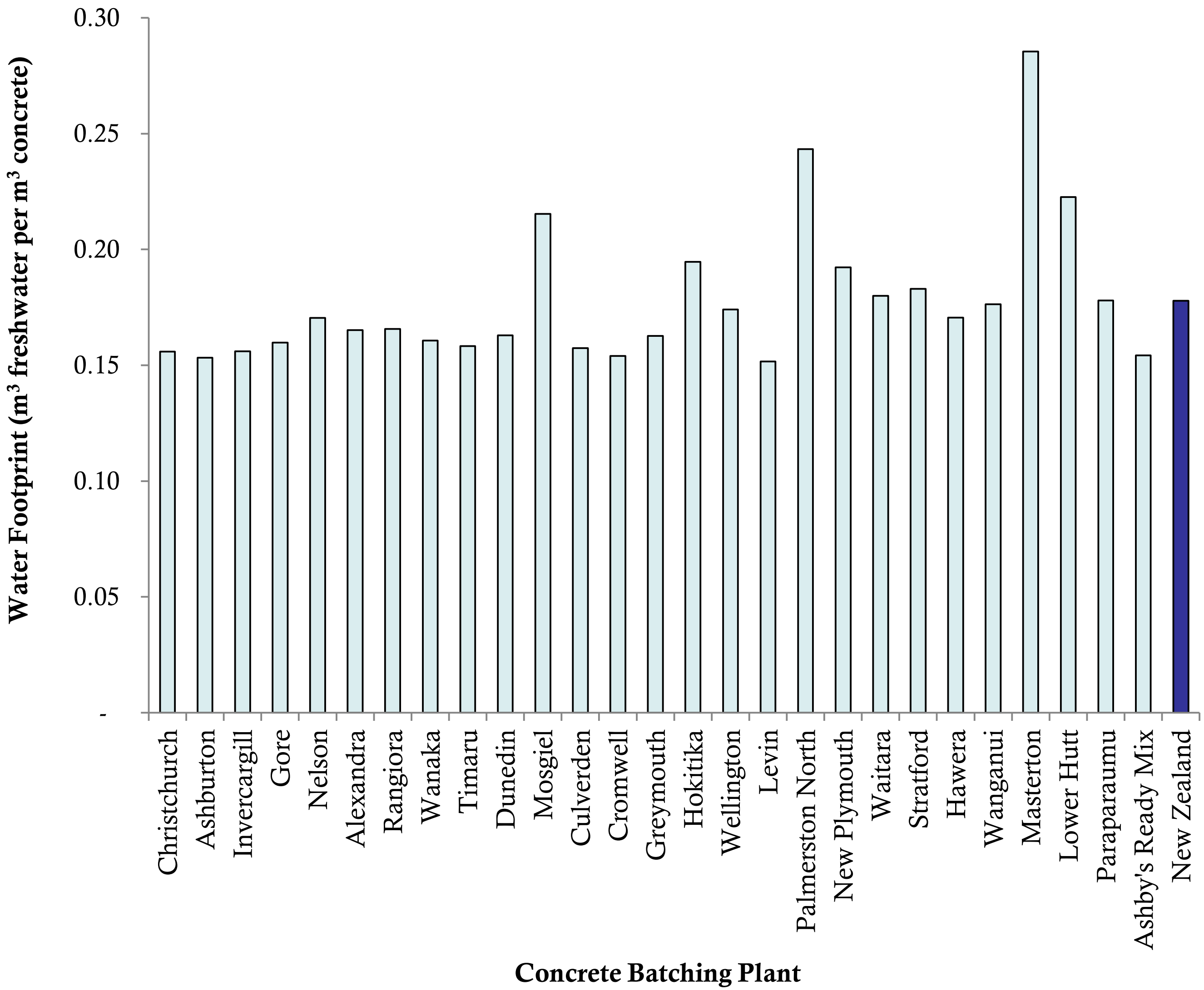
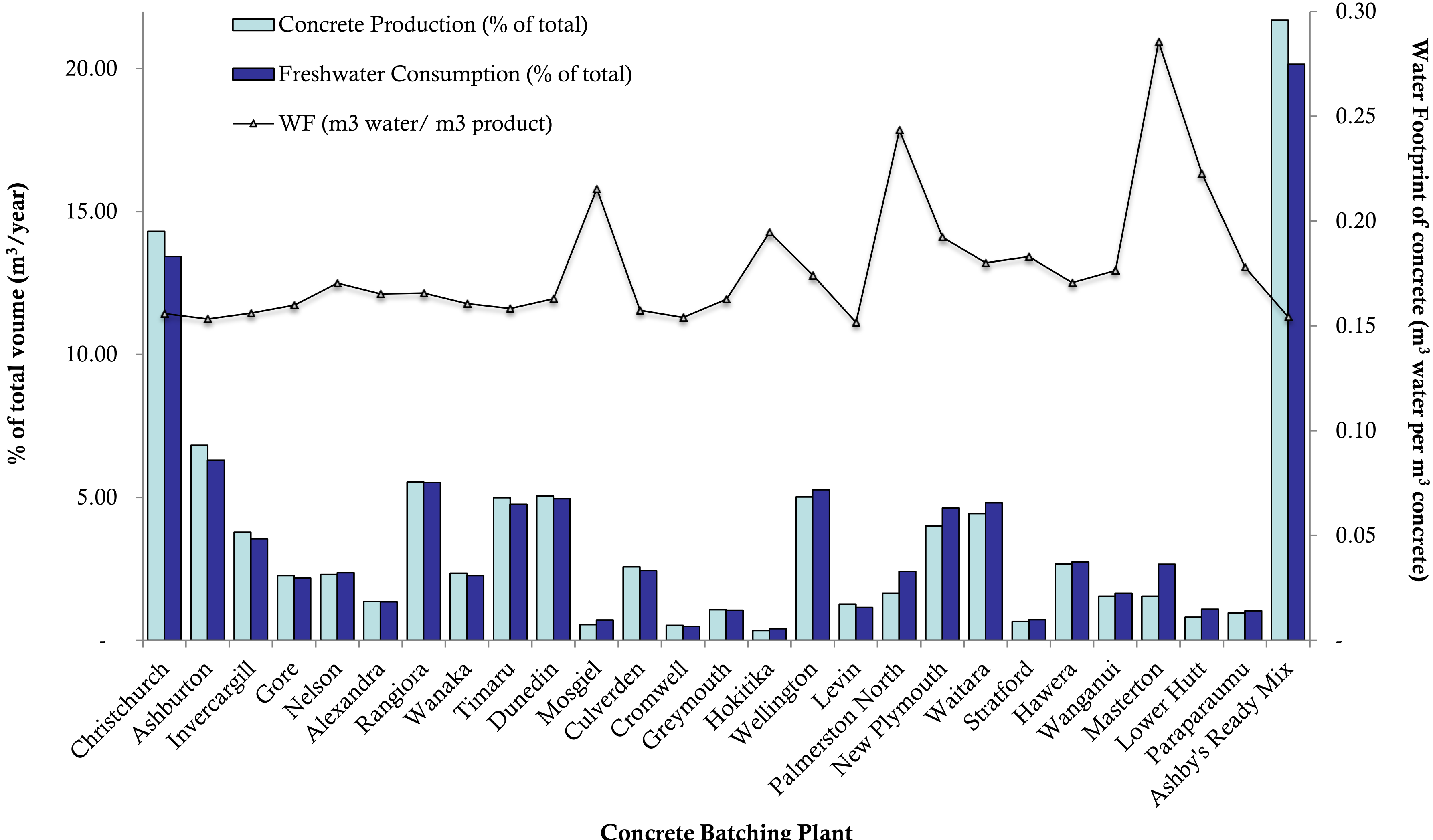


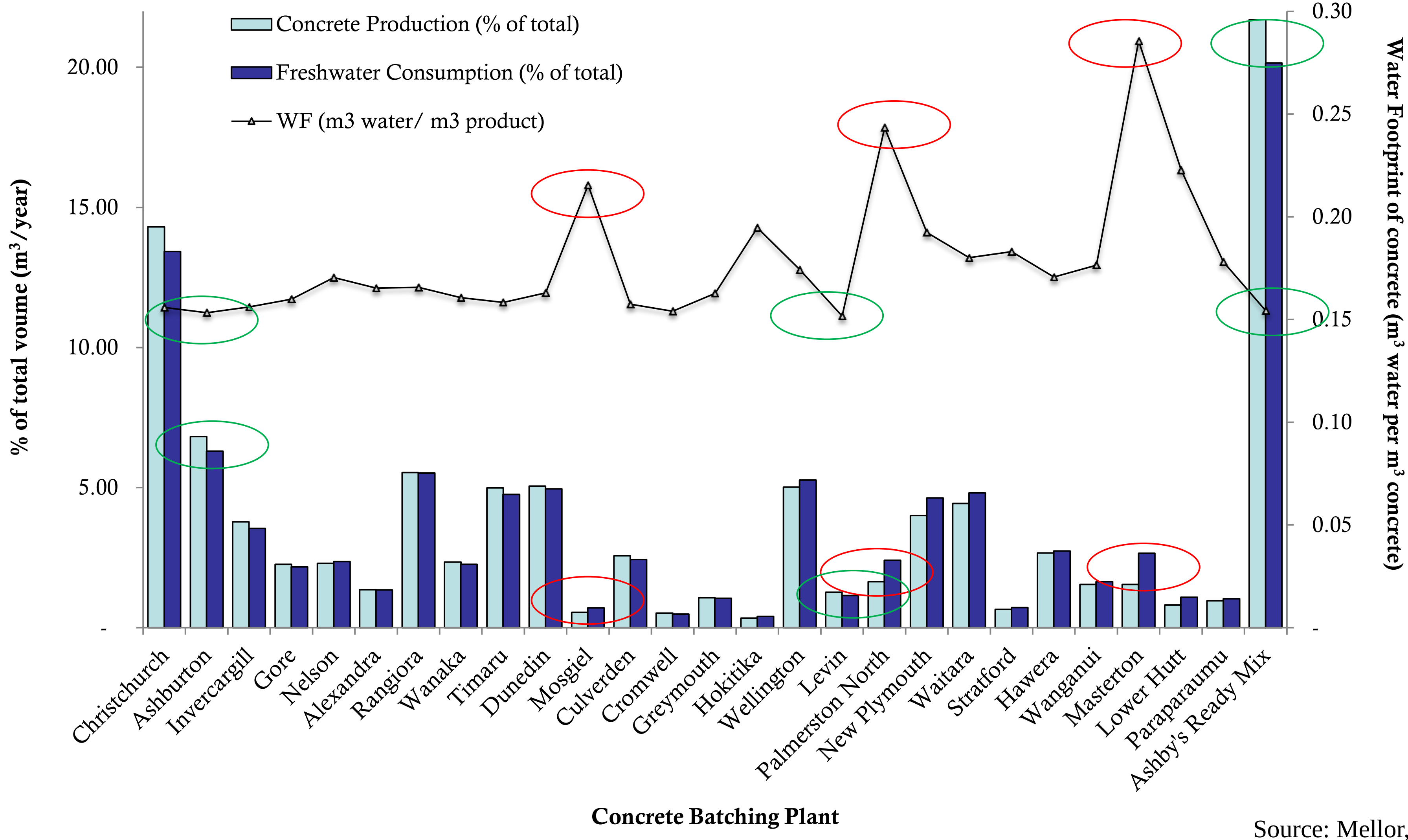
Source: Mellor, 2016

In context of production



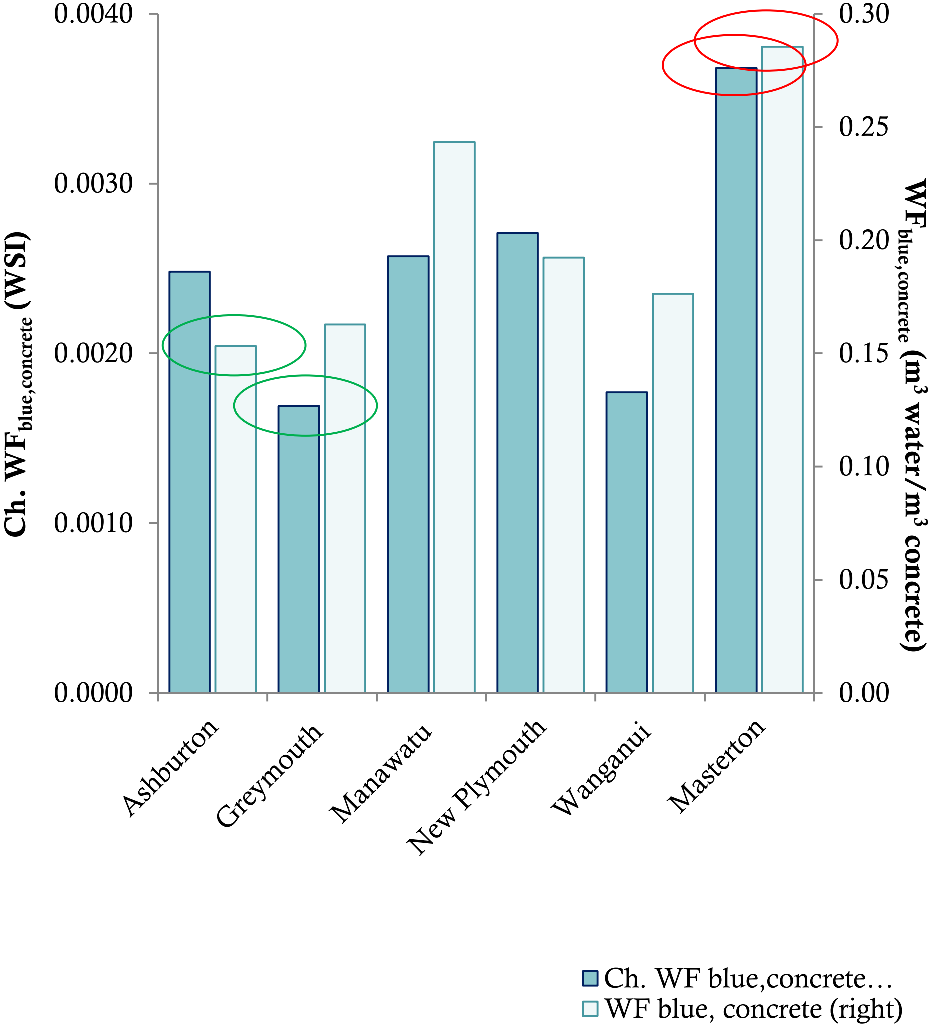
Source: Mellor, 2016

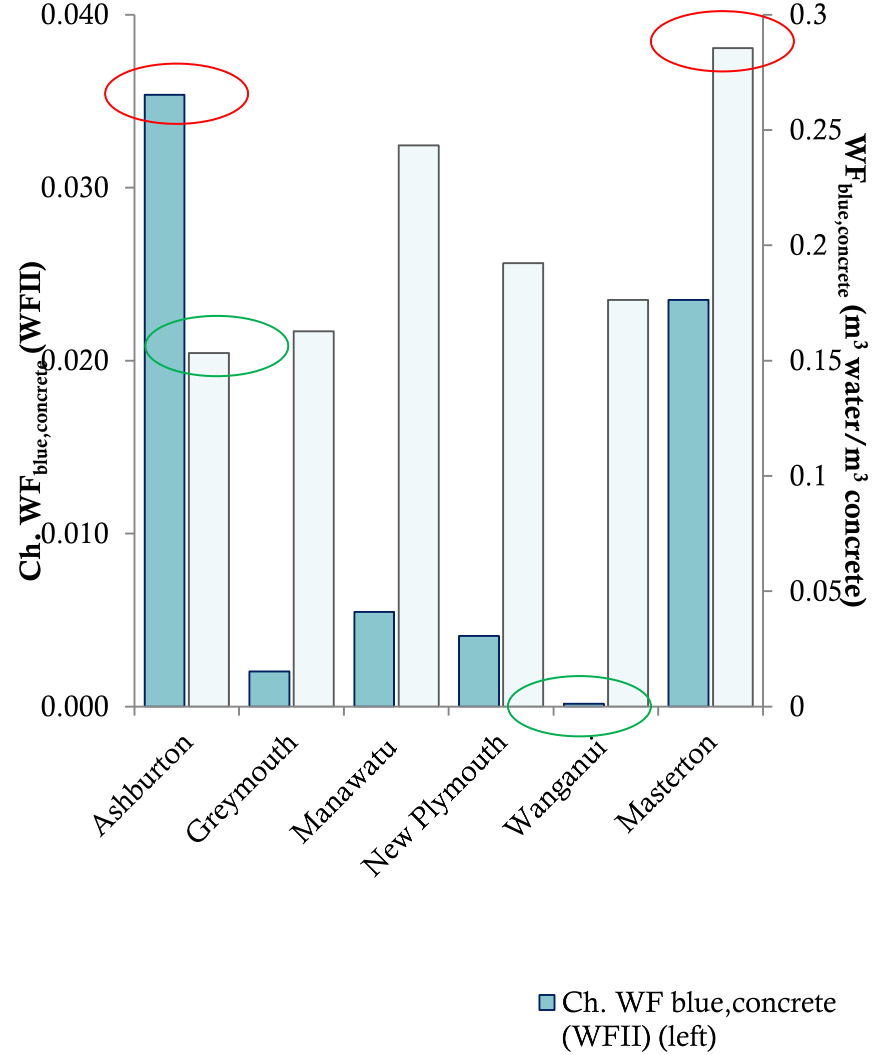
In context of production



Source: Mellor, 2016

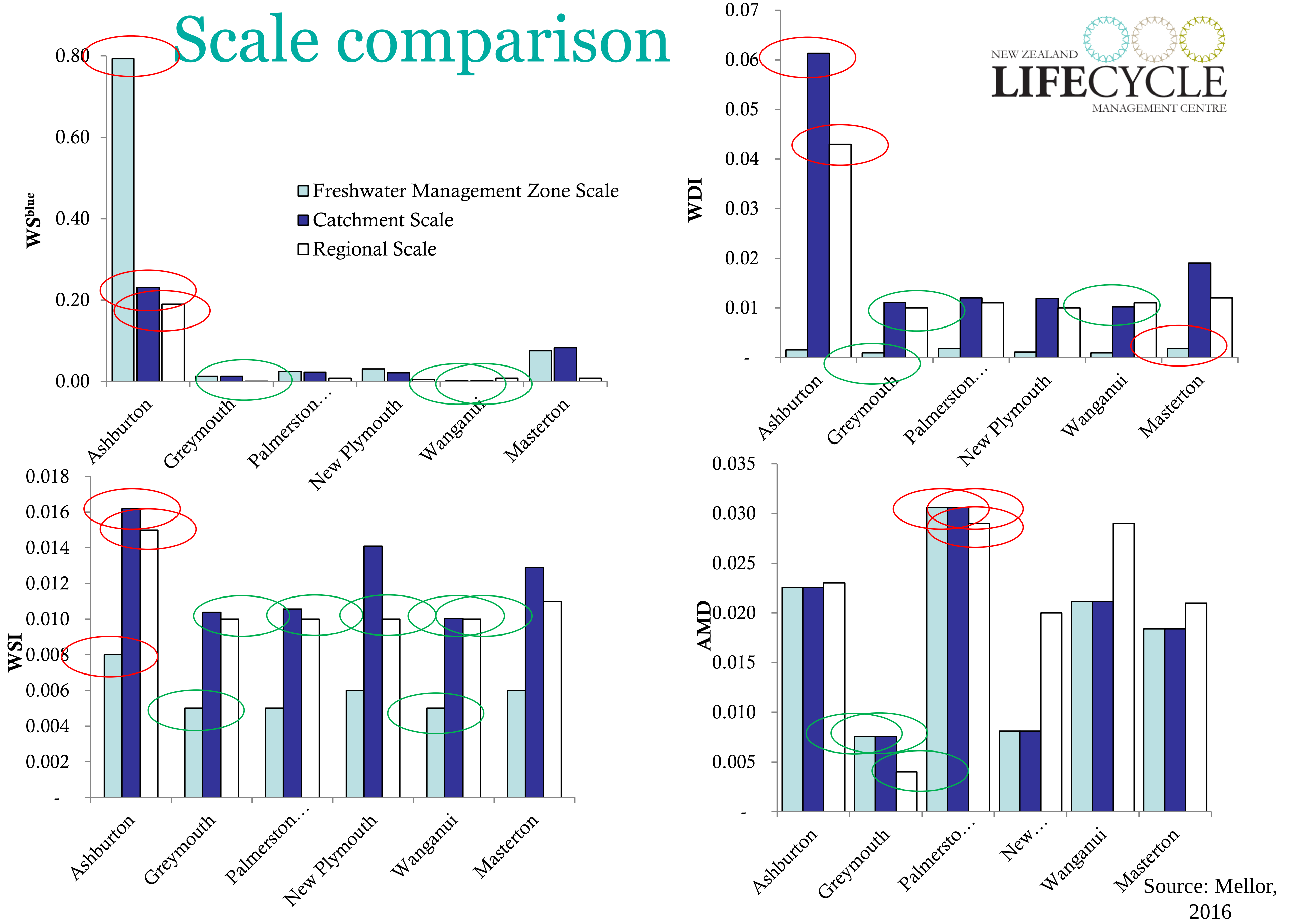
Methods comparison (catchment scale): WSI, AWaRe





Source: Mellor, 2016

Scale comparison



Source: Mellor, 2016

Conclusions

- Water flows provide useful information to support improvements
- Choice of WF method influences results
- Choice of spatial scale has (smaller) influence over results