BEFORE THE HEARINGS PANEL

IN THE MATTER of hearings on submissions concerning the Proposed One Plan notified by the Manawatu-Wanganui Regional Council

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SUPPLEMENTARY EVIDENCE OF MR JOSEPH HAY

FOR THE WATER HEARING

ON BEHALF OF HORIZONS REGIONAL COUNCIL

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1. PART ONE: INTRODUCTION

1. I have prepared this supplementary evidence to address concerns raised by Dr Russell Death in his evidence (presented on behalf of Wellington Fish & Game, and Forest & Bird) regarding Policy 6-18, which addresses supplementary water allocation.

2. Dr Death expressed concerns that "*The policy should also include maintenance of high flows, specify what significant departure is, how natural flow regime is assessed and how a flushing flow is assessed*" (paragraph 52).

3. The amended version of Policy 6-18 presented in Ms Clare Barton's final recommendation to this hearing states that "*In addition to the core allocations set out in Policy 6-16, a supplementary allocation from rivers may be provided:*

a. in circumstances where water is only taken when the river flow is greater than the median flow, and the total amount of water taken by way of a supplementary allocation does not exceed 10% of the natural flow in the river at the time of abstraction, or

b. in circumstances where it can be shown that the supplementary allocation will not:

(i) *increase the frequency or duration of low flows or lead to a significant departure from the natural flow regime, including frequency of flushing flows.*

(ii) *cause any adverse effects on the values of the water body as set out in Schedule B.*

(iii) *limit the ability of anyone to take water under a core allocation*."

4. Obviously, Dr Death's concerns regarding inclusion of maintenance of high flows and flushing flows have already been addressed to some extent by the wording of the latest version of this policy.

5. The key outstanding issues are how the natural flow regime and flushing flows are to be assessed, and how a "significant" departure from the natural flow regime is to be defined.

2. PART TWO: ASSESSING FLOW REGIME AND FLUSHING FLOWS

6. Dr Hayes discussed an earlier wording of Policy 6-18 in his evidence (paragraphs 116-117). He considered that the restriction of supplementary abstraction to ≤10% of the instantaneous flow, at flows above the median (Policy 6-18a), ought to adequately

maintain flushing and channel forming flows. I agree with Dr Hayes. This essentially amounts to a 9:1 flow sharing regime, with the river retaining approximately 90% of the instantaneous flow. This flow sharing regime should maintain adequate flow variability in the mid-to high flow range, in my opinion.

7. With regard to Policy 6-18b, Dr Hayes (paragraph 117) suggested that he would expect "*that a detailed hydrological analysis of effects would be carried out, along with an IFIM* [1] *instream habitat analysis that included a flushing flow analysis (Jowett, Hayes & Duncan 2008)*" to address the effects of such supplementary allocation applications on frequency and duration of low flows and instream values.

8. In his paragraph 51, Dr Death suggested two hydrological assessment methods that could be applied to see that hydrological variability is preserved (IHA; Indicators of Hydrologic Alteration, Richter *et al*., 1996[2], or ELOHA; Ecological Limits Of Hydrologic Alteration, Poff *et al*., 2009, Poff & Zimmerman, 2009)[3].

9. I agree with Dr Death that maintenance of ecologically relevant flow variability is an important consideration with respect to water allocation, and high flow events including flushing flows are of particular relevance when considering supplementary allocation.

10. Biologically important components of the flow regime are discussed in the technical guidelines to the proposed National Environmental Standard (NES)[4] on Ecological Flows and Water Levels (Beca 2008; section 2.2.1), Dr Hayes and I also described these components in Hay & Hayes (2007), and Dr Hayes mentions them at paragraph 60-64 in his evidence in chief. In summary, the key components include:

(i) Large floods, which are responsible for maintaining channel form and large scale sediment transport. Often referred to as channel forming flows. These are likely to be in the order of the mean annual maximum flow. The NES states "*Studies of New Zealand rivers indicate that flows of more than about ten times the mean flow or 40% of the mean annual maximum flow begin to move a substantial portion of the river bed (Clausen and Plew 2004)*"(p8).

(ii) Smaller floods and freshes, which flush fine sediment, periphyton and other aquatic vegetation. Often referred to as flushing flows. The NES suggests "*The magnitude of such flow perturbations is usually about 3–6 times the median flow*

1 Instream Flow Incremental Methodology; described by Dr Hayes in his evidence.
2 In this paragraph Dr Death actually refers to a method he calls HVA (Hydrological Variability Assessment). However, the paper that he cites (Richter *et al*., 1996) introduces a method called the IHA (Indicators of Hydrologic Alteration).
3 These methods are discussed further below (paragraph 12-21), including a summary what each method involves.
4 The NES is discussed further in the evidence of Dr Hayes and Dr Roygard.

(or 3–6 times the low flow in a highly regulated river) (Biggs and Close 1989; Clausen and Biggs 1997)" (p8).

(iii) Low flows, the period of minimum wetted habitat availability, but also potentially of relatively high productivity in the remaining habitat.

(iv) Flow recessions, higher than usual flow in the few days following a flood may offer enhanced recreational opportunity, and increased wetted area during flow recession over longer periods (i.e. weeks) may enhance ecosystem productivity.

(v) Flow variability, at a range of scales. From seasonal variability comprising the annual flow regime to small scale flow variations (which many people consider are an essential element of the regime that should be maintained, avoiding long periods of artificial "flat lining"). In some situations the timing of flow variability may be a critical factor, e.g. to provide a stimulus for fish migrations.

11. As discussed by Dr Hayes (paragraph 69-70) the ecological effects of abstraction depend on the magnitude of abstraction and the resulting degree of hydrological alteration. Water storage schemes (e.g. those involving damming and impoundment or large-scale diversion to an impoundment) have the biggest effects on a river's hydrology and can affect all biologically important components of the flow regime. However, it is difficult to conceive how large channel forming flows are likely to be substantially altered by schemes that do not include large dams.

12. With regard to Policy 6-18b (i), the IHA or ELOHA methods suggested by Dr Death, or the closely related Range of Variability Approach (RVA; Richter *et al*., 1997) provide possible approaches to assessing "significant departure from the natural flow regime".

13. All of these flow regime assessment frameworks are closely aligned with the "natural flow paradigm" (Poff *et al*., 1997). Dr Hayes introduces the RVA and discusses the natural flow paradigm in paragraph 73-74 of his evidence in chief. The implicit assumption in these methods is that the natural flow regime has intrinsic values or important ecological functions that will only be maintained by retaining all elements of the flow regime within their natural range.

14. The IHA is a method for characterising a flow regime based on a set of 32 hydrological parameters (and their associated dispersion measures) derived from the flow record (Richter *et al*., 1996). The RVA turns the IHA into a flow regime assessment tool by assessing the degree of change in the IHA hydrological parameters resulting from an alternative flow regime scenario. The approach allows the user to prescribe an acceptable level of change to any component of the flow regime, based on the "natural"

range of variation in the set of 32 hydrologic parameters derived from the “natural” flow record (Richter *et al.*, 1997). This level of change is usually taken to be one standard deviation, but could be some other multiple of the standard deviation, or a certain inter-percentile range.

15. The ELOHA method is essentially a framework for application of adaptive management principles for developing regionally applicable limits to alteration of flow regimes. It is also strongly aligned with the natural flow paradigm. The starting point for this method is categorising river systems within a region based on their hydrological regimes (potentially using the IHA) and geomorphology. Hypothesised ecological responses to flow regime alteration, based on existing knowledge, are then used as a basis for setting flow regime standards. These hypotheses are tested through monitoring and research to refine the flow standards over time, as knowledge improves. The RVA also incorporates a similar adaptive management approach to refining the analysis based on monitoring results.

16. Both RVA and ELOHA have been proposed in response to perceived lack of adequate knowledge regarding how changes to flow regimes will impact ecosystems (Richter *et al*., 1997, Poff *et al*., 2009). Proponents of these methods suggest that there is sufficient ecological understanding to suggest that changes to the natural flow regime are likely to cause some form of change to ecosystems (Richter *et al*., 1997, Poff *et al*., 2009, Poff & Zimmerman, 2009), although they recognise that there are equivocal results regarding whether particular flow regime changes will necessarily cause negative ecological impacts (Poff & Zimmerman, 2009).

17. The ELOHA has only recently been developed and has not been formally applied yet in New Zealand, as far as I am aware. However, the basic sequence of events is essentially similar to how science has been applied to flow regime setting in New Zealand in many instances (i.e. looking at the existing or natural flow regime and in some cases categorising streams by their flow regime and morphology, comparing with proposed scenarios, hypothesising likely responses to flow change based on existing knowledge and/or modelling, monitoring to assess effects and inform future decision-making; I note though that this last part has not always been done well, or at all).

18. By contrast, the RVA has been around for longer. As pointed out by Dr Hayes (paragraph 73) this method has recently been promoted for use in New Zealand by the Department of Conservation, and more research is needed into its utility for setting ecological flows in New Zealand.

19. I understand that Hawke's Bay Regional Council (HBRC) has recently trialled the RVA to inform setting of "high flow water harvesting takes", i.e. supplementary allocation (Kolt Johnson, Scientist, Hydrology, HBRC, *pers. comm*.). They assessed the degree of hydrological change caused by 16 water harvesting allocation scenarios, based on methods already applied by other regional councils. From these scenarios they selected an allocation approach by attempting to optimise the balance between maximising allowable take and minimising the hydrological effects as defined by the RVA. For the river on which they trialled this method, the allocation method recommended involved limiting the timing of abstraction to periods when the river flow was above the mean flow, and setting a maximum limit on the total abstraction (Harkness & Forbes, 2008).

20. Experience gained by HBRC through this application is informative. Three salient points expressed by Kolt Johnson (*pers. comm*.) were that:

(i) The method relies heavily on having adequate hydrological records (Richter *et al*., 1996 recommend a minimum of 20 years, although these could be synthesised for sites with shorter records);

(ii) Allocation methods without a specified maximum allocation limit are likely to cause substantial hydrological changes (at least if allocation is fully exercised); and

(iii) Deciding how much change is acceptable remains a key issue.

21. This last point relates to Dr Death's concern regarding definition of "*significant departure"* from the natural flow regime. So while the IHA and RVA provide a way to characterise the "natural" flow regime, they do not explicitly provide a definition of what is considered a significant degree of change. This is still up to the user to specify and remains a policy issue, balancing risk of potential adverse effects with values and abstractive water use.

22. Although I agree with the conclusion of Poff & Zimmerman (2009) that there is insufficient ecological understanding to precisely quantify the likely ecological response of a given reduction in flow *a priori*, the biologically important flow components identified above, and in the NES, could provide a starting point for an alternative hydrological approach to assessing the significance of flow regime change caused by supplementary allocation. This approach might focus on ensuring that supplementary allocation does not alter the frequency and timing of flows 3-6 times the median flow, since flows of about this magnitude have been shown to have an important ecological function as flushing flows (Biggs and Close, 1989; Clausen and Biggs, 1997). Even if these flows are reduced in magnitude to some extent, if they are still large enough to register as 3-6 times median flow, then they will presumably still retain their flushing capability. I note

that one of the criteria applied by HBRC in its analysis was that the allocation should not alter the average annual frequency of flows ≥3 times the median flow (the FRE_3) by more than 10%.

23. The NES (p10) also states that "*The frequency of flushing flows may also be affected if the capacity of the diversion is sufficiently large (eg, > 1.5 times the mean flow)*" this would also apply to the cumulative affect of multiple smaller diversions. This statement, and the experience of HBRC with application of the RVA, suggest that a maximum limit to supplementary allocation is advisable.

24. The wording of Policy 6-18b suggests that supplementary takes may be allowed at lower flows, provided that they can meet the criteria set out. If allocation is to be allowed at lower flows and effects assessment is to be based on hydrological methods, I consider that substantial alteration of the median flow should also be avoided. This is based on the rationale discussed by Dr Hayes (paragraphs 43-45) that the median flow is an ecologically relevant flow statistic indicative of productive habitat availability for aquatic macroinvertebrates, which are food for higher trophic levels, including fish and birds.

25. However, as discussed in the NES the level of investigation required should be matched to the relative in-stream values and the level of abstraction pressure (i.e. the degree of hydrological alteration). In cases with high abstraction pressure and/or high in-stream values, more in-depth investigation, including IFIM habitat modelling and flushing flow analysis, are likely to be warranted (as suggested by Dr Hayes, paragraph 117). Flushing flow analysis can provide case-specific guidance on the magnitude of flows required for effective flushing, rather than relying on the 3-6 times median flow rule of thumb developed from research on a range of rivers. And habitat modelling can provide an assessment of the expected magnitude of effects on in-stream habitat.

26. To relate these points back to the concerns raised by Dr Death (as paraphrased in my paragraph 5):
    (i) How are flushing flows to be assessed? – Flushing flows are fairly clearly defined in the NES as flows 3-6 times the median flow. However, a flushing flow analysis could be applied to provide a more case-specific estimate of flushing flow requirements in situations where in-stream values are high and/or abstraction pressure is high. Another option would be to use case-specific empirical data from observations of the flushing effectiveness of naturally occurring flows.
    (ii) How is the natural flow regime to be assessed? – There are several ways that the "natural" flow regime and departures from it can be assessed. However, I do not

hold an opinion on which is likely to be the “best” approach, since they all remain to be tested.

and

(iii) How is a “significant” departure from the natural flow regime to be defined? – Notwithstanding the availability of assessment methods, there remains uncertainty about how much change may be deemed “significant” and is likely to cause a “significant” ecological impact. This is essentially a value judgement, based on the perceived magnitude of potential adverse effects. As with other aspects of the Resource Management Act, it involves definition of what is considered more than a minor effect. As with habitat retention levels for minimum flow setting (discussed by Dr Hayes paragraphs 52-53) this is likely to boil down to balancing risk of adverse effects against values, given the current levels of ecological knowledge.

3. REFERENCE

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