BEFORE THE INDEPENDENT HEARINGS PANELS APPOINTED TO HEAR AND MAKE RECOMMENDATIONS ON SUBMISSIONS AND FURTHER SUBMISSIONS ON PROPOSED PLAN CHANGE 1 TO THE NATURAL RESOURCES PLAN FOR THE WELLINGTON REGION

UNDER	the Resource Management Act 1991 (the Act)
AND	
IN THE MATTER	of Hearing of Submissions and Further Submissions on Proposed Plan Change 1 to the Natural Resources Plan for the Wellington Region under Schedule 1 of the Act

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STATEMENT OF EVIDENCE OF AMANDA ELIZABETH VALOIS

ON BEHALF OF GREATER WELLINGTON REGIONAL COUNCIL

TECHNICAL EVIDENCE – REVISION OF BASELINE STATE AND ATTRIBUTE BANDS FOR SUSPENDED FINE SEDIMENT IN LIGHT OF NATURALLY OCCURING PROCESSES

HEARING STREAM 2 – OBJECTIVES

28 FEBRUARY 2025

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INTRODUCTION

1 My full name is Amanda Elizabeth Valois. I am a Freshwater Scientist and Team Leader of the Monitoring Water team at Greater Wellington Regional Council (**the Council**).

2 I have prepared this statement of evidence on behalf of the Council in respect of technical matters arising from the submissions and further submissions Proposed Plan Change 1 to the Natural Resources Plan for the Wellington Region (**PC1**).

3 This statement of evidence relates to the matters in the Section 42A Report – Objectives and specifically to the application of setting objectives for suspended fine sediment in the Mangaroa River, as set out in Objective WH.O9 of PC1. This evidence specifically relates to the revision of sediment load reductions for the Mangaroa River part-Freshwater Management Unit as set out in paragraphs 30 to 33 of the Statement of Evidence (Clarity) of James Blyth and in paragraphs 147-148 and 209 of the Statement of Evidence of Dr Michael John Crawshaw Greer.

QUALIFICATIONS AND EXPERIENCE

4 I hold a Bachelor of Science and a Master of Science from Laurentian University (Canada) and a PhD from the University of Otago. I am a member of the New Zealand Freshwater Sciences Society and a co-convenor of the Surface Water Integrated Management (**SWIM**) Special Interest Group. I have published 14 peer-reviewed articles on a range of freshwater science topics covering ecology, water quality and modelling, including studies on visual clarity.

5 I have 18 years' experience in the field of water quality and ecology, working in both Canada and New Zealand. I have had roles within universities, governments, and a Crown research institute (**NIWA**). My experience overseas centred on aquatic ecology and the application of multivariate statistics and modelling in aquatic ecosystem health studies. At NIWA, I have led several studies on estimating contaminant loads (e.g. *E. coli*, sediment, microplastics) in rivers. I was a Senior Freshwater Scientist at the Council, providing water quality expertise and advice for Whaitua Te Whanganui-a-Tara and Te Awarua-o-Porirua Whaitua processes. I am currently the Team Leader for the Monitoring Water team at the Council, leading the collection of water quality and ecology data from rivers and lakes from across the region.

CODE OF CONDUCT

6 I have read the Code of Conduct for Expert Witnesses set out in the Environment Court's Practice Note 2023 (Part 9). I have complied with the Code of Conduct in preparing this evidence. My experience and qualifications are set out above. Except where I state I rely on the evidence of another person, I confirm that the issues addressed in this evidence are within my area of expertise, and I have not omitted to consider material facts known to me that might alter or detract from my expressed opinions.

SCOPE OF EVIDENCE

7 My evidence addresses the impact of naturally occurring processes on interpreting the National Policy Statement for Freshwater Management (**NPS-FM**) 2020 national bottom line (**NBL**) for suspended fine sediment (as indicated by visual clarity) and subsequent limit setting on resource use. An example of this is naturally coloured brown-water in some streams due to high concentrations of coloured dissolved organic matter.

8 In their submission the Wellington Branch of New Zealand Farm Forestry Association (**NZFFA**) correctly identify that the suspended fine sediment TAS for the Te Awa Kairangi rural streams and rural mainstems Freshwater Management Unit (**part-FMU**) does not account for the naturally occurring processes of high coloured dissolved organic matter (**CDOM**) in the Mangaroa River. This part-FMU is in Whaitua Te Whanganui-a-Tara. Other sites were examined for potential impacts of high CDOM on visual clarity (e.g. Black Creek in the Wainuiomata urban streams part-FMU) but no sources of CDOM were evident.

9 My evidence provides an overview of coloured dissolved organic matter in streams, how CDOM impacts measurements of visual clarity and therefore estimates of suspended sediment concentrations, and how CDOM may influence the interpretation of NPS-FM 2020 attribute state for suspended fine sediment in the Mangaroa River.

10 This evidence is limited to technical matters and I do not provide recommendations on matters of policy.

BACKGROUND AND CONTEXT

11 Clause 3.32 of the NPS-FM 2020 states that if all or part of a waterbody is affected by naturally occurring processes that mean that the current state is below the national bottom line, and a target attribute at or above the national bottom line cannot be achieved, the regional council may set a target attribute state that is below the national

bottom line (but must still set the target attribute state to achieve an improved attribute state to the extent practicably given the naturally occurring processes).

12 Suspended fine sediment (as measured by visual clarity or turbidity converted to visual clarity), is one of the 22 compulsory attributes in the in the NPS-FM 2020 and is associated with the Ecosystem health compulsory value. Visual clarity measurements are influenced by a number of naturally occurring processes outlined in the notes to Table 8 of the NPS-FM 2020, including naturally highly coloured brown-water streams.

13 Visual clarity is a measure of the horizontal viewing distance (measured in metres) of a black disc through the water column. Visual clarity measurements are inversely related to suspended fine sediment concentrations / total suspended solids and therefore provide an indirect measure of these concentrations (Depree 2017). Although suspended fine sediment concentrations are generally the dominant light attenuating constituent in rivers, visual clarity is also indicative of other river constituents.

14 CDOM and phytoplankton are the other two main light attenuating constituents influencing visual clarity measurements (Davies-Colley et al. 1993). Phytoplankton concentrations are typically a dominant contributor to visual clarity in lakes and lake-fed rivers (Vant 2015). Therefore, visual clarity in these systems is largely an indicator of phytoplankton levels.

15 CDOM is the optically measurable component of dissolved organic matter and is primarily leached from decaying matter. CDOM is generally low in rivers, contributing very little to visual clarity (Vant 2015). However, rivers draining catchments dominated by wetlands are the exception (Davies-Colley and Nagels 2008).

16 Understanding the role of constituents other than sediment in influencing visual clarity measurements is important because the broad goal of sediment management is to limit discharges or loads in rivers, as much as possible, to achieve freshwater objectives. In rivers in which CDOM concentrations are significant contributors to low visual clarity, this should be accounted for in any load limits.

17 The Mangaroa peatland is found in the Mangaroa River catchment. The Mangaroa river is stained brown from the water with high concentrations of CDOM draining the peatland. This colouring is due to the fact that CDOM most strongly absorbs light in the blue to ultraviolet spectrum (~300-500 nm) resulting in the water appearing brown/yellow brown. The Mangaroa River at Te Marua site is a Council State of the Environment river site in

Suspended Sediment Class 3. The national bottom line for visual clarity for this sediment class is 2.22 m. The 5-year median for visual clarity at this site between 2012 and 2017 was 1.5 m resulting in a baseline state of D for this attribute.

18 As the Mangaroa River contains high amounts of CDOM, visual clarity is lower than would be expected from sediment concentrations alone due to the impact of CDOM on light attenuation. However, it is not known how much this naturally occurring process influences visual clarity measurements or how accurately visual clarity measurements can be used to estimate sediment concentrations in this system. To address this, monitoring and assessment of the impact of CDOM on visual clarity in the Mangaroa River has been undertaken (see paragraph 19 to 24).

ASSESSING IMPACT OF COLOURED DISSOLVED ORGANIC MATTER ON VISUAL CLARITY IN THE MANGAROA RIVER

19 To understand the impact of CDOM concentrations on visual clarity measurements, CDOM must be measured at the same time as measuring visual clarity. To measure CDOM, water samples are analysed at the lab via spectrometry and measured as absorptivity at different wavelengths (440 nm and 780nm, A440 and A780 in Equation 1). The absorbance can be then converted to the absorption coefficient (g440) of the sample using Equation 1 as presented by Davies-Colley and Vant 1987 and outlined in Neefjes 2015. The absorption coefficient (g440) is used as an indication of CDOM.

20 Equation 1.

$$g440 = \frac{\ln(10)\left(A440 - \frac{780}{440}\right)A780}{y}$$

21 CDOM is not routinely measured as part of the Council's State of the Environment (**SOE**) river monitoring so additional CDOM samples were collected from the Mangaroa River at Te Marua (concurrently with visual clarity, Total Suspended Solids (**TSS**), and Suspended Sediment Concentration (**SSC**)) between June 2023 and December 2024 (9 samples). Visual clarity measurements were converted to the beam attenuation coefficient (**c**) – the fraction of light that disappears per meter of path length (Davies-Colley 1988, as outlined in Verburg 2011). This is presented in Equation 2.

22 Equation 2.

$$c = \frac{4.8}{visual\ clarity}$$

23 The contribution of CDOM to the beam attenuation coefficient (**cy**) was calculated using Equation 3 as presented by Vant and Davies-Colley (1984) and outlined in Vant (2015). The ratio of cy/c provides an estimate of the relative contribution of CDOM to beam attenuation and has been presented in Table 1 for the nine measurements in Mangaroa River. The original (non-colour adjusted visual clarity measurements) are also presented.

24 Equation 3.

$$cy = \frac{g440}{c}$$

Table 1. The percent contribution of CDOM and sediment to visual clarity across the nine samples collected in the Mangaroa River at Te Marua site. The contribution due to phytoplankton is assumed to be negligible. The adjusted visual clarity in the absence of CDOM ($Clarity_{adj}$) is presented.

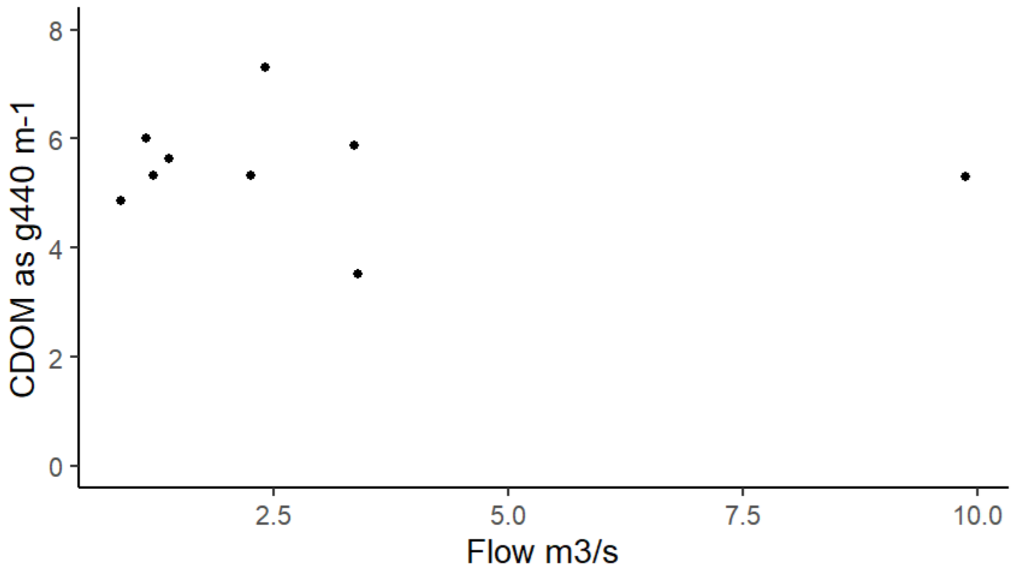
Sample	Field measurements			Beam attenuation	CDOM	Contribution of CDOM to beam c	Contribution (%)		Adjusted visual clarity/NBL
	Clarity (m)	TSS (mg/L)	Flow (m^3/s)	c (m^{-1})	g440 (m^{-1})	cy (m^{-1})	CDOM	Sediment	$Clarity_{adj}$ (m)
1	1.19	2.3	2.26	4.03	5.32	0.69	17	83	1.43
2	0.15	52	9.88	32.00	5.30	0.69	2	98	0.15
3	1.60	2.3	1.23	3.00	5.32	0.69	23	77	2.08
4	1.84	1.2	1.39	2.61	5.63	0.73	28	72	2.56
5	1.33	2.9	2.42	3.60	7.31	0.95	26	74	1.81
6	1.86	2.7	1.15	2.57	6.01	0.78	30	70	2.68
7	1.56	1.9	3.36	3.06	5.87	0.76	25	75	2.09
8	1.91	0.3	0.88	2.52	4.87	0.63	25	75	2.54
9	0.40	24.4	3.4	12.00	3.52	0.46	4	96	0.41
Baseline	**1.5**	**N/A**		**3.2**	**5.46 (± 0.34)[1]**	**0.71 (± 0.04)[1]**	**22 (±1)**	**78 (±1)**	**1.93 (1.89 - 1.96)**
NBL	**2.22**			**2.16**			**33 (±2)**	**67 (±2)**	**1.67 (1.65 - 1.70)**

[1] **Mean and standard error of samples 1 to 9.**

25 In most rivers, CDOM concentrations increase with flow (Smith et al. 1997, Neefjes 2015). However, CDOM may also increase more rapidly during the rising limb of the hydrograph, depending on the relationship between near-stream sources (which display an early storm response) and wider catchment sources (which are reflected in the falling limb of the hydrograph) (Hood et al. 2006). In the Mangaroa River, the amount of CDOM shows no relationship to flow and appears to be relatively constant across a range of flows (Figure 1). More samples during higher flows will be required to confirm this assumption.

26 Because the contribution of CDOM to beam attenuation remained relatively constant (cy = 0.45 - 0.95), the relative contribution of CDOM to beam attenuation at high flows was very small (2-4% - Table 1). These results demonstrate that at high flow, when the majority of sediment is being delivered to the river, the contribution of CDOM is negligible.

Figure 1. CDOM concentrations (as the absorption coefficient at 440 nm) versus flow in the Mangaroa River at Te Marua



POTENTIAL APPROACH FOR SETTING VISUAL CLARITY TARGETS FOR THE MANGAROA RIVER THAT ACCOUNT FOR THE IMPACT OF CDOM

27 Given that CDOM concentrations are expected to stay constant across a range of flows, the simplest way forward to set TAS that account for this naturally occurring process would be to adjust the National Bottom Line for this site (currently 2.22 m) by the average concentration of CDOM (0.71 m^{-1}) using Equation 4. This results in a corrected Site Specific Bottom Line of 1.67 m.

28 Equation 4.

$$BL\,adj = \frac{4.8}{c_{NBL} + \mu cy}$$

Where:

c_{NBL} = the beam attenuation coefficient of the national bottom line for visual clarity (2.16 m^{-1})

µcy = the mean contribution of CDOM to the beam attenuation coefficient (0.71 m^{-1})

29 The other option would be to collect CDOM samples with each visual clarity measurement and correct each individual visual clarity measurement by the contribution of CDOM using Equation 3. The median of five years of visual clarity measurements (corrected for CDOM) would be used to calculate current state and compared to the current National Bottom Line of 2.22 m.

LIMITATIONS AND CAVEATS

30 The estimated contribution of CDOM to visual clarity is based off a small number of samples (9) and will require more sampling to understand the underlying relationship. Although the relationship appears to be linear, only two sample was collected during high sediment concentrations (>20 mg/L). More samples across the range of sediment concentrations would improve the accuracy of the model and verify it meets the assumptions of linearity.

31 The influence of phytoplankton on visual clarity is assumed to be negligible. This is consistent with work by Vant (2015) and Yalden and Elliot (2015) which found no evidence of the impact of phytoplankton on visual clarity in rivers that weren't lake-fed nor hydrolakes.

CONCLUSION

32 The visual clarity of the Mangaroa River is not only an indication of suspended sediment concentrations but also of concentrations of CDOM (coloured dissolved organic matter) originating from the large wetland in the catchment. In the absence of CDOM, visual clarity would be higher, although still below the national bottom line. The contribution of CDOM to visual clarity measurements will impact sediment load estimates, although this impact is expected to be small.

33 I recommend that the National Bottom Line is adjusted for this river to reflect the fact that CDOM concentrations will prevent the high clarity measurements that are predicted for this river class. Further samples (~5-10, particularly samples at high flows as well as very low flows) would ensure an accurate estimate of the average CDOM concentration in this river and verify that no relationship exists between CDOM and flow. The revised visual clarity bottom line was incorporated into load reduction estimates to meet visual clarity targets for the Mangaroa River at Te Marua target attribute site (more detail in James Blyth Statement of Primary Evidence[2]).

DATE: 28 FEBRUARY 2025

DR AMANDA ELIZABETH VALOIS, TEAM LEADER MONITORING WATER, GREATER WELLINGTON REGIONAL COUNCIL

[2] Statement of Evidence of James Blyth on Behalf of Greater Wellington Regional Council (dated 28 February 2025)

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