Before the Independent Hearing Panel
Appointed by the Southland Regional Council

Under	the Resource Management Act 1991 (**RMA**)
In the matter of	an application by **South Port NZ Limited** to dredge parts of the Bluff Harbour

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Supplementary statement of evidence of Bryony Miller

7 July 2022

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Qualifications and experience

1 My name is Bryony Miller.

2 I have prepared a statement of evidence dated 29 March 2022. My qualifications and experience are set out in that statement. I confirm that this supplementary evidence is also prepared in accordance with the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2014.

3 This statement addresses:

(a) The rationale for the proposed turbidity trigger levels for the South Port Capital Dredging soft sediment dredging programme.

(b) The methodology used to calculate the proposed turbidity trigger levels.

(c) The proposed consent condition to monitor turbidity in the Bluff Harbour during the dredging programme.

4 This supplementary statement of evidence provides a summary of Attachment 1 – Turbidity technical memorandum which is, on occasion, referred to for further information.

Turbidity Trigger Rationale

5 A technical memorandum was prepared for South Port NZ Ltd (South Port) (Attachment 1). It supports a tiered turbidity trigger levels regime to monitor part of the capital dredging programme proposed by South Port: specifically, the dredging of soft sediments in the berths and swinging basin. This activity is further outlined in Section 3.2.2 of the Adaptive Marine Management Plan (AMMP[1]) and Section 3 of the Marine Assessment of Environmental Effects (Marine AEE[2]).

6 This additional information has been sought by the Independent Commissioners hearing the South Port resource consent application.

7 This proposed monitoring regime requires consideration as this component of the proposed dredging could result in losses of fine sediment beyond the

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[1] Miller, B. 2022. South Port Capital Dredging Adaptive Marine Management Plan. Prepared for South Port NZ Ltd. e3Scientific Report No. 20041.2

[2] Miller, B. & Davis, G. 2021. South Port Capital Dredging Assessment of Marine Environmental Effects. Prepared for South Port NZ Ltd. e3Scientific Report No. 20041.1

immediate works area from fine sediment being disturbed or discharged from the dredging. This sediment could theoretically interact with sensitive ecology beyond the works area were it to cause increased sedimentation and/or reduced light penetration. In this case the specific resource of interest is seagrass and consequential effects such as smothering and reduced photosynthetic light have been considered.

8 A sensitive ecological receptor-based approach was proposed to manage the dredging in Bluff Harbour. It was initially intended to use measurements of turbidity and water clarity (by secchi disk) to generate a locally calibrated correlation between these metrics which would serve to provide a practical means of assessing changes in the 'light regime' at the seagrass beds. One month of calibrated turbidity:water clarity data was considered necessary to assess this relationship, however, due to failures of the initial turbidity loggers over the first 3 weeks and the time sensitivity nature of the project, a modified approach was taken. This similar approach adopted still allows for site specific tiered trigger levels to be defined based on the natural turbidity range experienced by seagrass in Bluff Harbour.

9 At this point, this adapted approach does not allow for direct correlation between local turbidity levels and water clarity. However, it utilises the range of turbidity levels clearly reflecting a harbour environment which sustains seagrass beds within the area. This approach is based on ensuring that seagrass beds are not exposed to turbidity levels which lie outside their natural environmental regime as a consequence of the dredging. As is discussed in the associated reports (AMMP[3]; Marine AEE[4]) these tiered turbidity trigger levels provide a final adaptive strategy to allow for dredge operators real-time management.

10 As detailed at the hearing, there are several factors which either avoid or significantly mitigate against the risk of any dredging associated adverse effects on seagrass. These factors provide an important context within which to view the proposed monitoring. These factors include:

(a) All dredging will occur within the seagrass' senescent period, i.e., outside of the seagrass growing (and flowering) season.

(b) A short dredging period (<7 days) for the sediments of interest (silts).

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[3] See [1].

[4] See [2].

(c) The small fraction of sediment likely to be lost/discharged from the TSHD operation due to operational constraints such as no jetting and no overflow.

(d) All sediment of interest (silts) from the berths will be dredged on an outgoing tide.

(e) Harbour tidal currents will convey disturbed sediment up and down the harbour more or less unidirectionally but have no direct pathway across the harbour to where the nearest (Tiwai wharf) seagrass beds are located.

(f) The distance between the dredging and the nearest seagrass bed being approximately 700 m which will result in very large factors of dilution and dispersion of sediment which might conceivably reach the seagrass.

(g) The discontinuous nature of the dredging (and deposition) operating through different tidal cycles which will ensure there is no significant increase in concentration of suspended sediment beyond the dredging zone (and mixing zone).

11 Notwithstanding the small, and in my opinion, remote risk to seagrass, a monitoring programme for turbidity was suggested by the applicant to provide a means of verifying the predicted absence of significantly changed water clarity conditions within the closest seagrass beds. Natural ranges in turbidity provide a useful (and commonly used) proxy for assessing such changes in areas which already support subtidal seagrass beds. Turbidity and its limitations are discussed in detail within the associated supporting reports (AMMP[5]; Marine AEE[6]).

12 The first and foremost management strategy, whereby all dredging will occur within the seagrass' senescent period, i.e., outside of the seagrass growing (and flowering) season, is of particular importance as seagrass studies have found there to be a clear light dependent effect on seagrass morphometrics during seagrass growing seasons, but **no effect** during

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[5] See [1].

[6] See [2].

senescent periods (Chartrand et al., 2016[7]; Turner & Schwarz, 2006[8]). Based on this alone, there is no expectation that the proposed one week of silt dredging will have any adverse impacts on the seagrass.

13 In addition, all silts from the berths will be dredged on an outgoing tide, and this will effectively prevent higher and longer turbidity values and silt sedimentation within seagrass beds. Seagrass metric monitoring assessments pre-, during and post-dredging will also provide evidence of this.

Turbidity Trigger Methodology

Field Data Collection

14 Turbidity was chosen as an easily measured proxy for potential changes in the harbour suspended sediment regime at the seagrass beds. As there is virtually no background turbidity data in Bluff Harbour, data was collected to provide some local reference data.

15 Three EXO3 Sonde sensor loggers (turbidity loggers) were deployed between 16 May and 3 June 2022, following technical issues with the previous EXO3 Sonde which was deployed between 20 April 2022 and 13 May 2022. The data collected during this earlier time period had a number of reliability issues which effectively rendered it unsuitable for use.

16 The three turbidity loggers deployed on 16 May were located at three sites proposed to be monitored during the dredging activity. These are the Tiwai Wharf seagrass bed, Rabbit Island seagrass bed and the Disposal site for the dredged material (Figure 1). Turbidity (NTU), pH, temperature, dissolved oxygen and conductivity values were recorded at each location every 2 minutes for the 15-day period. Each turbidity logger was secured to capture turbidity values at approximately 1 m above the seabed (Figure 2), therefore, reflecting the conditions at the seagrass beds.

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[7] Chartrand, K. M., Bryant, C. V., Carter, A. B., Ralph, P. J., & Rasheed, M. A. (2016). Light thresholds to prevent dredging impacts on the great barrier reef seagrass, Zostera muelleri ssp. capricorni. In Frontiers in Marine Science (Vol. 3, Issue JUL). https://doi.org/10.3389/fmars.2016.00106.

[8] Turner, S., & Schwarz, A. M. (2006). Management and conservation of seagrass in New Zealand: An introduction. Science for Conservation, 264, 1–90.

Figure 1: Turbidity logger deployment sites with finer sediment berth zones (in blue) and Disposal site (orange).

Figure 2: Turbidity logger deployment set-up.

17 Wind (speed, direction and run) data were collected from the nearby Cliflo NIWA site at Tiwai Point and tide data was recorded from the Bluff Tide Beacon over this time period to allow for turbidity and associated weather condition interpretation. Rainfall data was not considered relevant as Bluff Harbour has minimal influence from stormwater run-off and has no riverine inputs.

Data Analysis

18 The two-minute interval data collected was initially aggregated in pivot tables into hourly and daily averages. Standard deviations were calculated for each of these averages, and the maximum and minimum turbidity values within each averaging period were also identified (see Attachment 1). This

information allowed for the identification and removal of outlier data points, which reduced the random spread of data points to a more relevant range. Outliers were high turbidity spikes, often in the hundreds, which did not have incremental increases or decreases associated with them and were likely a result of algal fouling.

19 Outliers were identified and removed from each dataset using the interquartile range calculated in the statistical software “R”. Recorded values were identified as outliers if it was 1.5 times the interquartile range greater than the 99th percentile or 1.5 times the interquartile range less than the 25th percentile. The number of outlier data points removed from the dataset via this method were 4 of 8863 data points at Tiwai Wharf site (0.05%), 41 of 9706 at Rabbit Island site (0.4%) and 51 of 9938 at Disposal site (0.5%). The Disposal site experienced the highest number of large biofouling spikes likely due to its’ position near rocky reef and kelp habitats.

20 A selection of days with high average turbidity across the 15-day sampling period were selected from each of the three sites (Figure 3, Figure 4 & Figure 5) (see Figures 3, 4 and 5 within Attachment 1 for full selection of days). Turbidity (NTU) (in 2-min intervals) for each day was plotted with depth (recorded from the logger) and tidal movements to assess the effect of depth and tides on natural turbidity (NTU) values.

21 Tiwai Wharf and Rabbit Island sites showed an obvious relationship between tidal height and NTU, although this was less apparent on 25 May at the Tiwai Wharf site (Figures 3 & 4 in Attachment 1). NTU can be highly variable over short periods suggesting an active near seabed environment in terms of natural fine sediment plumes. Where the tidal velocity is waning, such as near the slack low tide, NTU values are at their highest and the opposite occurs as tidal velocity increases. The Disposal site shows a highly dynamic environment dominated by wave action and with little tidal influence (see Figure 5 in Attachment 1).

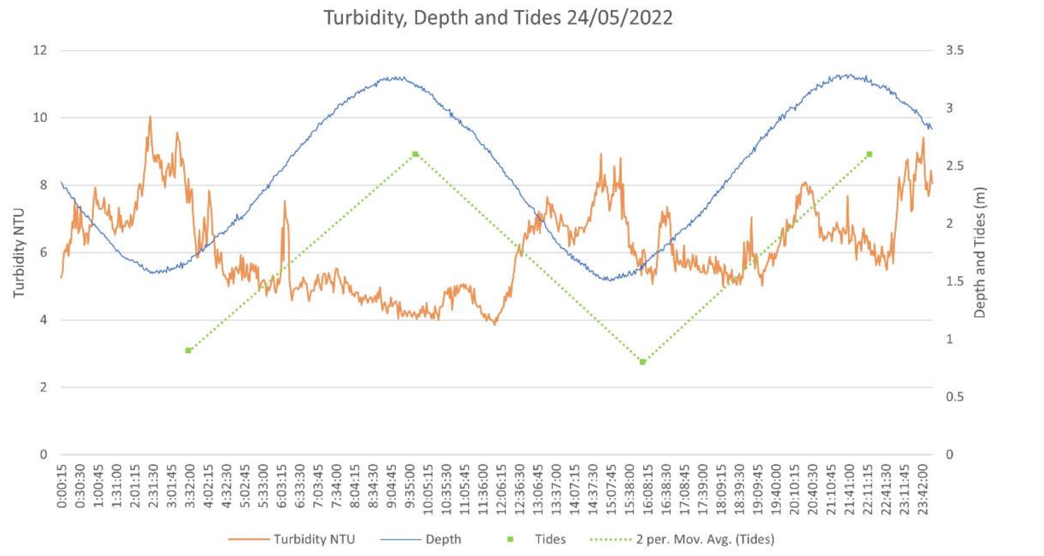

Figure 3: Tiwai Wharf seagrass site turbidity (NTU), tidal range/depth (m) and tidal cycle.

Figure 4: Rabbit Island seagrass site turbidity (NTU) and tidal cycle (m) 2. Please note; loggers did not record tidal range/depth at this site.

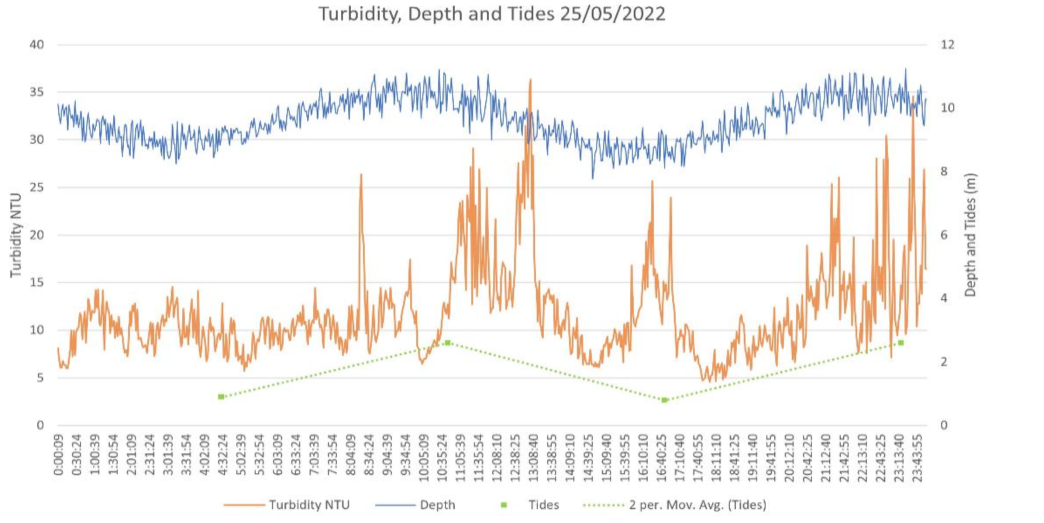

Figure 5: Disposal site turbidity (NTU), tidal range/depth (m) and tidal cycle.

22 Daily wind speed (knts), wind run (km), and maximum wind speed (knts) were plotted for both the turbidity data 15-day sampling period (16 - 30 May) and for the larger proposed dredging window 1 March – 30 September (data from 2021) (Figure 6 and Figure 7). This was assessed in order to provide a brief wind range association between the discrete data collected in May 2022 and that expected within the wider dredging window of March to September. Similar wind conditions occurred several times in the 2021 weather record for Bluff, and slightly more extreme weather occurred only once. To the extent that turbidity levels at the seagrass beds may be influenced by the prevailing wind speed and direction, which is likely at times, the conditions experienced during the turbidity meter deployment period in this study are likely to be conservative and within the natural range documented in the harbour.

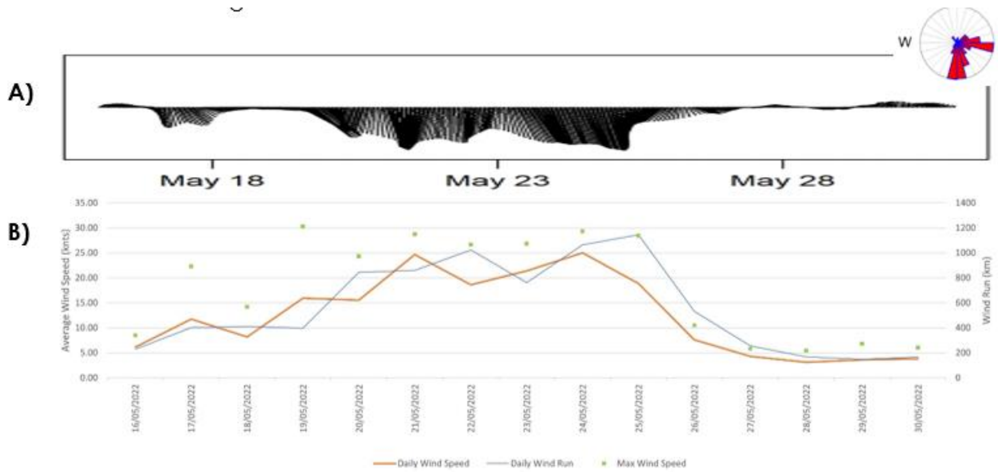

Figure 6: A) Wind direction and speed; B) Daily averaged wind speed (knts), wind run (km) and maximum wind speed (knts) in Bluff Harbour between 16 and 30 May 2022 (data from Tiwai Station, NIWA).

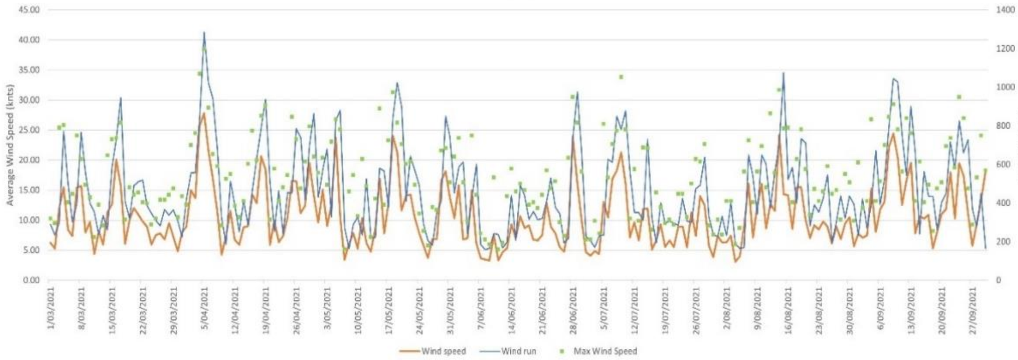

Figure 7: Daily averaged wind speed (knts), wind run (km) and maximum wind speed (knts) in Bluff Harbour between March and September 2021. (data from Tiwai Station, NIWA).

Development of Turbidity Triggers

23 The turbidity data collected from Bluff Harbour is provided in Attachment 1 and ranged from:

(a) Tiwai Wharf seagrass site: 0.9 NTU on the 17 May to 14.6 NTU on 19 May.

(b) Rabbit Island seagrass site: 0.9 NTU on 17 May to 24 NTU on 25 May.

(c) Disposal site: 0.8 NTU on 17 May to 41 NTU on 26 May.

24 During the 15-day data collection window hourly wind strength ranged from 1.4 knts to 30.3 knts and the daily averaged wind run was 148 km to 1144 km. Tidal range varied between 0.5 m and 2.9 m. NTU values were most variable during the days with the highest wind strength and run and strong tidal influence remained evident throughout the period.

25 Three levels or tiers are proposed for the South Port dredging: Tiers 1 and 2 are for South Port internal use and provide early-warning mechanisms of elevated turbidity to allow for adaptive dredge management. Tier 3 provides a Compliance status trigger during dredging and allows for a compliance feedback loop for the consenting authority. These tiers were assessed using the collected turbidity data within Bluff Harbour in May 2022. This approach is similar to and follows that used for the Lyttleton Capital Dredging which was a significantly larger dredging programme (Fox, 2018[9]).

26 Daily average (24-hour) Tier 1 and 2 turbidity triggers and Tier 3 compliance limit were calculated from the reference turbidity data at each site over the 15-day period as the 80th, 95th, and 99th percentiles, respectively (Table 1). A daily average (24-hr) period was considered more applicable than a 6-hourly average due to the strong tidal influence on NTU values and is also more practicable for data collation during working hours. The 6-hr and 12-hr averages do not afford greater protection to seagrass beds than a 24-hr average, which still maintains the natural variance in which seagrass beds currently experience.

27 These daily average tiers are proposed to be utilised during the dredging of the Berth sites (see Figure 1) where finer sediments occur. Given the very

[9] Fox, D. R. (2018). Turbidity Triggers for Lyttleton Port Company's Channel Deepening Project (Environment Canterbury Certified). April.

short duration of the dredging (~7 days) of the finer sediments of interest, the frequency of exceedance was not considered.

28 A rolling weekly average compliance limit (Tier 3) is proposed for the remainder of the dredging locations where coarser natural sands predominate. The rolling average weekly Tier 3 compliance limit was based on the weekly 99th percentile (Table 2).

29 This methodology ensures that even if the 'environmental limit' (Tier 3 compliance level) is breached, the seagrass beds, and more generally, marine ecosystem, is very unlikely to have experienced short-term conditions significantly different from those which it experiences and evidently thrives, in the natural flux of environmental conditions.

30 As seagrass beds were present at both Tiwai Wharf and Rabbit Island sites it was considered appropriate to utilise the site with the higher turbidity percentiles for compliance limits. This still ensures the limits lie within the natural range of conditions experienced in Bluff Harbour.

31 The tiered consent limits for the Port Otago Ltd capital dredging project, based on 6-hour averaged data, were also examined for comparison purposes. The South Port values provided in Table 1 are similar, although lower, to the Port Otago seagrass NTU ranges for each tier.

Table 1: Average daily turbidity (NTU) values for each site over a 24-hr period.

Site	Tier 1	Tier 2	Tier 3 Compliance Trigger
Tiwai Wharf seagrass	6 NTU	8 NTU	10 NTU
Rabbit Island seagrass	7 NTU	13 NTU	17 NTU
Disposal	9 NTU	17 NTU	24 NTU

Turbidity values for Tiers 1 and 2 are early-warning triggers for South Port use only

Table 2: Average rolling weekly turbidity (NTU) values for each site over a 7-day period.

Site	Tier 3 Compliance Trigger
Tiwai Wharf seagrass	8 NTU
Rabbit Island seagrass	8 NTU
Disposal	12 NTU

32 Figure 8 within Attachment 1 of this supplementary evidence provides the graphed daily NTU averages and maximums with the 80th, 95th and 99th percentile daily averages for reference for each site. Tiwai Wharf site is presented in Figure 8 below for reference.

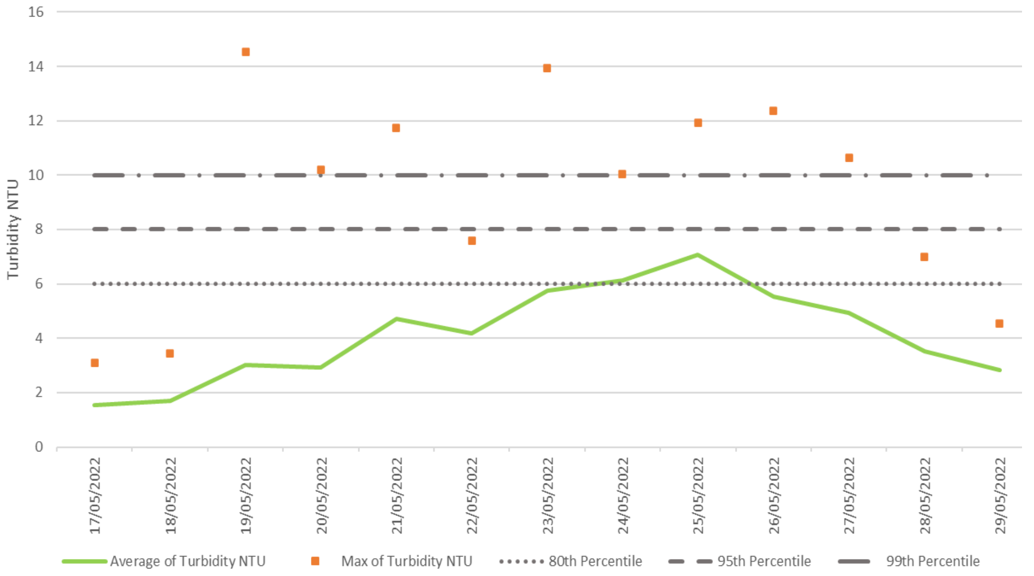

Figure 8: Tiwai wharf seagrass site daily turbidity (NTU) average and maximum with 80th, 95th and 99th percentile daily average levels.

33 Based on the above management strategies and collected data, a turbidity tiered trigger consent condition was developed. This is provided on page 18 of the Attachment 1 Technical memo.

Conclusion

34 This supplementary evidence and attached technical memo (Attachment 1) provides an overview of the methods employed to derive turbidity limits for the South Port Capital dredging project. This method identifies the typical turbidity range expected in the Bluff Harbour. The assumption that under its natural environmental regime, seagrass is exposed to a wide range of turbidity values, is verified by the data collected.

35 The objective of the turbidity tiers and trigger levels is ultimately to prevent adverse effects on seagrass. This is avoided by ensuring that high turbidity in the upper end of the natural range does not persist for a sustained period. It should not be concluded from a short-term exceedance of a trigger, including a Tier 3 threshold, that there has been an adverse effect on seagrass. Only that the risk has increased and a feedback loop into the management of the dredging might be warranted. Monitoring of the Tier 1 and Tier 2 thresholds by South Port during the dredging, should provide ample opportunity for encroachment into the Tier 3 range to be avoided.

36 Tidal cycles play a significant role in the natural turbidity ranges observed within Bluff Harbour as is evidenced in the turbidity data set compiled alongside tidal range and phase. It is therefore considered an appropriate management tool to utilise the tides to assist with the management of turbidity within the tier levels. This will be achieved by dredging the finer sediments from the Berths during an outgoing tide only.

37 Utilising the 99th percentile as the compliance turbidity tier (Tier 3) has been accepted by consenting authorities for other capital dredging programmes (Port Lyttleton and Port Otago) which represented significantly larger scale and higher risks to the environment.

38 The data set percentiles used to define the tiered trigger levels have been calculated from 15-days of turbidity data. When contributing environmental characteristics (i.e., wind run and speed) from this 15-day period were qualitatively examined next to the larger March to September period for which historical data is available, similar environmental characteristics were found. From this it has been concluded that the 15-day data set is representative and likely slightly conservative. Therefore, it is an appropriate basis from which to calculate the tiered trigger levels.

39 Given that the dredging of the predominantly silty material is estimated to be completed in ~7 days, this data set represents double the timeframe required to complete this component.

40 In conclusion, the described rationale, methodology and data analysis have developed a set of turbidity trigger levels which are considered to be conservative. Applying this regime of turbidity thresholds to the monitoring and management of the dredging will protect the most sensitive ecological receptor in the harbour, which is considered to be seagrass, and therefore more generally also the other ecologically important environments in and around Bluff Harbour. Moreover, they provide a mechanism not only for early-warning triggers which allow for adaptive management by the dredge operator but also provide a clear compliance threshold in the unlikely event such should such be required.

Bryony Miller

7 July 2022

Appendix 1: Turbidity technical memorandum