BEFORE THE HEARING COMMISSIONERS

NAPIER

IN THE MATTER	of the Resource Management Act 1991 (the Act)
AND	
IN THE MATTER	of applications by Port of Napier Limited to undertake wharf expansion, associated capital and maintenance dredging, disposal of dredged material within the coastal marine area, and occupation of the coastal marine areafor existing port activities and the proposed new wharf

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STATEMENT OF EVIDENCE OF BENJAMIN GRAHAM WILLIAMS

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INTRODUCTION

Qualifications and experience

1. My name is Benjamin Graham Williams. I am a Senior Coastal Engineer at Advisian, in which capacity I have been employed since 2014.

2. I have a BSc (Hons) in Geological Oceanography from Bangor University in the UK. I have an MSc (distinction) in Applied Marine Science and a PhD in Coastal Engineering from Plymouth University (UK).

3. I have over 15 years' experience in measurement, analysis and simulation of dynamic processes within the coastal environment with specific reference to oceanography, coastal engineering and port developments. My project experience ranges across the UK, Europe, UAE, US, Canada, Malaysia, Singapore, Papua New Guinea, Australia and New Zealand.

4. I am a regular contributor to engineering literature and have authored peer-reviewed scientific publications within academic journals and conference proceedings. I have presented at international conferences in Australia, New Zealand, US, China, Malaysia, UK and Europe. I am a corporate member of PIANC through my employer.

5. I have taught aspects of Coastal Engineering courses at the undergraduate and post-graduate level. I was recently coastal engineering Discipline Expert for Engineers Australia during the accreditation of BEng (Hons) Coastal Systems Engineering degree course at Southern Cross University, NSW.

6. My work history is as follows:

   2014 – Present, Senior Coastal Engineer, Advisian;

   2012 – 2014, Senior Project Coastal Modelling Engineer, Cardno;

   2010 – 2011, Research Engineer, Plymouth University Enterprise Ltd;

   2008 – 2012, Research Candidate in Coastal Dynamics, Plymouth University (UK);

   2003 – 2009, Coastal Modeller, Halcrow (UK);

2000 – 2001, Marine Geophysicist, Svitzer (UK).

Involvement in project

7. I have been involved with various projects for Napier Port since January 2015. These have focussed on understanding hydrodynamic, sediment transport and geomorphological processes occurring within and around Napier Port and within Hawke's Bay generally.

8. During this time I have worked closely with Mr Chris Adamantidis, who is also providing evidence in relation to Advisian's input into the project, including some of the areas I worked closely on. I am familiar with the reports prepared by Advisian which form part of the project documentation.

9. I was also involved in the expert caucusing that took place on 20 July 2018 in my capacity as a coastal engineer with involvement in the coastal process investigations, data collection, and numerical modelling for the project.

Expert Witness Code of Conduct

10. I have been provided with a copy of the Code of Conduct for Expert Witnesses contained in the Environment Court's Practice Note dated 1 December 2014. I have read and agree to comply with that Code. This evidence is within my area of expertise, except where I state that I am relying upon the specified evidence of another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

Purpose and scope of evidence

11. This evidence summarises the aspects of the work which I was involved in and the main findings of that work.

12. I have led the following aspects of the studies that have been carried out in support of the Resource Consent Applications:

    (a) Design of field measurement campaigns and the analysis of the data that informed the coastal process studies and the development and calibration of the numerical models.

    (b) The Coastal Process Assessment. This is the subject of the report in Appendix D, Volume 3, of the resource consent application documentation.

(c) The Post Disposal Fate of Sediments Assessment. This is the subject of the report in Appendix F, Volume 3, of the resource consent application documentation.

13. The purpose of the Coastal Process Studies (Appendix D) was to review historical and recent data of wind, waves, currents, bathymetry and sediments, including data collected to support the Resource Consent Applications, and on the basis of that data to develop and benchmark the performance of numerical wave model systems.

14. The calibrated model systems were then applied to determine changes in wave refraction patterns by the proposed dredging project, with associated changes on wave-driven sediment transport and impacts on trends in shoreline change, as evidenced by relative change to nearshore wave height and incidence angle.

15. The calibrated models were also applied to optimise the navigation channel footprint, in order to minimise its impact on wave refraction patterns to the west of the Port. The Coastal Process Studies also presented a detailed assessment of impact to surfing amenity, undertaken by my colleague, Chris Adamantidis and described in his evidence.

16. The Coastal Process Assessment culminated with a conceptual model of sediment transport pathways that I developed on the basis of available historical and measured field data, simulated wave refraction patterns, known coastal sediment transport processes specific to Napier, and observations of current speed and direction at various locations to the west of the Port.

17. The assessment of Post Disposal Fate of Sediments (Appendix F) complements and develops further upon this work by directly estimating sandy sediment mobility due to the joint action of waves and wind-driven currents. This was achieved through a combination of ‘data-driven’ (empirical) and ‘model driven’ (numerical) approaches.

18. Site-specific wave and current data were used to assess sediment mobility and the most likely direction in which the sand would be transported at Westshore, the Port entrance, and the offshore disposal site. These data were used to ‘reality check’ spatial patterns of sediment transport pathways in the wider marine environment, derived using the calibrated wave and 3D hydrodynamic model. The site-specific data give an indication of the natural variability in

relative sediment transport magnitude and direction at each location, whilst the patterns derived from the numerical simulations infer the expected mean direction 'over the long term' (inter-annual to decadal).

19. An assessment was also undertaken of potential morphological consequences to Marine Parade Beach by placement of dredge spoil material at the offshore disposal site.

20. Lastly, the report also presented an assessment of the potential, during very extreme conditions (that is, using conservative assumptions), for sandy and silty material disposed of at the offshore site to be transported towards Pania Reef.

21. The evidence below addresses separately the following specific topics that were raised in various submissions:

    (a) Deposition of dredged material close to Westshore

    (b) Implications of wind speeds on sediment transport

    (c) Suitability of energetic wind speeds as a method for determining sediment pathways

    (d) Effectiveness of recent deposition of maintenance dredged material

    (e) Impacts of Inshore Deposition on Pania Reef.

    I also provide commentary on some matters in the section 42A report and its attachments.

22. My evidence draws upon the work described briefly in paragraphs 12 to 20, plus analysis of additional data collected since the Resource Consent Applications were lodged, to support my conclusions.

Summary of conclusions

23. Based on the outcome of the calibration and validation of the various numerical models used to assess wave refraction, hydrodynamic currents and sediment transport patterns against measured field data, and the extent of available data used to assess the effects of the project, I consider that the coastal process studies as presented in Appendix D and Appendix F of the resource consent application documentation are sound and, where applicable, in accordance with industry best practice.

24. I consider also that the results of the modelling and field data analysis can be relied upon for assessing the spatial impact of the proposed dredging on wave refraction, sediment transport pathways and coastline response.

RESPONSE TO MATTERS RAISED IN SECTION 42A REPORT

25. The conclusion of the Section 42A report raises three matters to be addressed within the evidence. I respond to the last two of these, which address coastal processes.

Adequacy of Scientific Evidence Prepared.

26. The Section 42A conclusion contains the statement that the evidence must address the "concerns of a number of submitters who among others, need faith in the scientific evidence presented." In the equivalent paragraph within the Summary of Approach to Recommendation (page 5), the word "confidence" is used instead of "faith".

27. I refer to the Statements of Evidence (Coastal Processes) by HBRC advisers and experts, Mr Richard Reinen-Hamill and Dr Terry Hume, appended to the Section 42A Report, who found the technical assessment reports and modelling studies carried out to support the application to be comprehensive and to a high standard.

28. I further refer to the Joint Witness Statement appended to the Section 42A Report. The Expert Witnesses agreed that:

    (a) The hydrodynamic model behaviour is consistent with measurements of current speeds and direction

    (b) There is broad agreement that the modelling and results fit the 'framework' and observations of past studies.

29. During the Expert Witness caucusing on the 20th July, Mr Reinen-Hamill noted an apparent 'anomaly' in one Appendix F Figure 6-7, with westerly winds ('coming from') resulting in north-westerly ('going to') transport of silt from the offshore disposal ground.

30. On 26th July and after the Expert Witnesses caucusing, I sent further information to Dr Terry Hume, Professor Peter Cowell and Mr Richard Reinen-Hamill to address this issue.

31. In summary this information showed that the simulated current directions during the storm event are in line with

normal expectations, being largely eastward in the surface layer although also controlled by the local geometry of the coastline and sea floor bathymetric features. In the lower part of the water column, including at the proposed offshore disposal ground south of the Port, there is a 'return flow' during the westerly storm event that transports suspended sediment in the opposite direction to the wind. This 'return flow' is also controlled by local coastline geometry and bathymetric features. This behaviour is consistent with the oceanographic phenomena of 'upwelling' under the presence of an offshore wind.

32. The silt re-suspended by wave and current action at the offshore disposal ground is at first largely contained within the bottom layer and therefore travels within the direction of this return flow. Turbulent mixing over time and space distributes this material vertically through the water column as well as to the wider marine environment, where it is transported by the local current speed and direction experienced at a particular location and depth.

Nourishment of Westshore Beach

33. I refer to the third conclusion of the Section 42A report, which explores the possibility of "nourishment of Westshore Beach… to mitigate an effect in relation to the activities proposed".

34. Page 30 of the Section 42A Report references that it would be an "appropriate use" of dredged material if "suitable material" was utilised. No definition of "suitable material" is given within the Section 42A Report, but a definition is given within the Coastal Engineering literature.

35. I quote the guidance of the National Research Council (1995)[1]

"It is essential that material obtained from the sea be located a sufficient distance from offshore that the sand placed in conjunction with the nourishment will not be carried back in to the borrow areas. …

The most important borrow material characteristic is the sediment grain size. Borrow material grain size matching the native material is synonymous with quality. A candidate

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[1] National Research Council(1995): Beach Nourishment and Protection. Washington, DC: The National Academies Press. pg 97:

> *borrow area may be considered unacceptable if the clay and silt fraction exceeds a certain percentage. …*
>
> *Fine material also adversely affects project performance. Early projects constructed without regard for grain size performed relatively poorly."*

36. Dean (2003)[2] defines 'fine' as fine relative to the receiving material.

37. I know of no established in-situ method applicable to spoil material within a dredge hopper for processing sand such that one retains just the portion of the particle size distribution that matches or is coarser than the native sandy material at the receiving site. A methodology for in-situ sediment sorting within a dredge hopper appears to be under development by USACE[3][4] but this method is still at the early research stage.

38. Further commentary on the use of dredge spoil material at Westshore is provided in my Response to Matters Raised in Submissions, below.

RESPONSE TO MATTERS RAISED IN SUBMISSIONS

39. In this section of my evidence I respond to some of the comments and claims in the various submissions. As a number of submissions raise similar matters, I have grouped them and addressed them as issues.

Deposition of dredged material close to Westshore

40. The submission of Chris Hart (Submission 2) and a number of other submissions[5] request that sand-sized sediment excavated during capital and maintenance dredging operations by the Port be deposited within area 'RExt'.

41. The submission states: *"I will support the application for the proposed new wharf, provided the sand material which is dredged from the new deep water channel be deposited (in the water) in and around Westshore beach providing*

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[2] Beach Nourishment, Theory and Practice. World Scientific. pg 78

[3] http://rsm.usace.army.mil/techtransfer/FY18/RSM-IPR-May2018/briefs/32_2018_ERDC_BOEM_SAJ_SedimentSorting-Brutsche.pdf

[4] https://www.boem.gov/Marine-Minerals-Presenations-McCoy/

[5] E.g. Submitters David Ship (Submission 6), Stephen Loughlin (Submission 13), Dorothy Pilkington (Submission 22), and Richard Karn (Submission 34).

further protection from coastal erosion. And that sand material from future dredging activities in regard to maintenance of the channels be deposited (in the water) in and around Westshore beach".

42. The evidence of Michel de Vos and Dr Martin Single also addresses some aspects of this issue. I understand that Napier Port has not ruled out the future availability of suitable material for coastal protection. I address some key considerations in relation to suitability of material.

43. The use of suitable material in various forms of protection from coastal erosion processes is accepted coastal engineering practice, as provided in both the Shore Protection Manual (1984) and the Coastal Engineering Manual (2003)[6]. However, there are a number of considerations and limitations for renourishment projects. My comments refer to placement of dredged material in area RExt[7].

44. The likely longevity of material placed at a particular location can be inferred from:

1) Hydrodynamic conditions: that is, if wind and wave conditions at RExt disposal ground are of sufficient magnitude to mobilise sediments. If wave activity is able to suspend sand, it will move in the direction of any current in the overlying water column and disperse to the wider marine environment.

2) Compatibility of 'borrow' and 'receiving' material: that is, how similar the particle size distribution of the dredged sand is compared to the "native" material at 'RExt'. If dredge sand is finer than the "native" material it will be preferentially eroded ('winnowed') and will not remain at the deposition site.

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[6] Specific sections of these reports which have been referred to are, Shore Protection Manual 1984 (pg 30/556), and Coastal Engineering Manual 2003 Chap 111-1 (pg 13/45); Chap V-4-1-e (pg 30/113).

[7] Which of the Port holds current consents for disposal of dredging material, subject to some limitations.

Hydrodynamic Conditions

45. Figure 1 shows the amount of time per year wave and current conditions will exceed that required to mobilise different sizes of sediment at RExt. This has been calculated by combining wave and current data recorded close to area RExt, for a period of 6 weeks.

46. Figure 1 suggests that sand grains with diameters between 0.1mm and 0.3mm will be mobile for roughly 12% of the year. Once suspended, sediment will move in the direction of the current roses presented in Figure 2. That is, for the majority of the time, the finer sand size sediments (and any finer material) will move southward and eastward along the coast.

47. The presence of a net eastward current adjacent to the Port has been confirmed by additional ADCP[8] deployments at 'Pilot Buoy' (the channel fairway) for May – December 2016, and September 2017 – May 2018. That is, for more than one year. The results of these current measurements are shown in Figure 3.

48. Additional measurements of current speed and direction within area RExt have been collected for September to November 2017, and April to June 2018. Some results are shown in Figure 4. Current direction is variable, as would be expected in an environment with variable wind, waves and currents. However the presence of a net south-east current is still visible in the data, which corroborates the ADCP results given in Figure 2 and Figure 3. These measurements can be compared with the sediment transport pathways obtained from the numerical simulations (Figure 5).

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[8] An acoustic Doppler current profiler

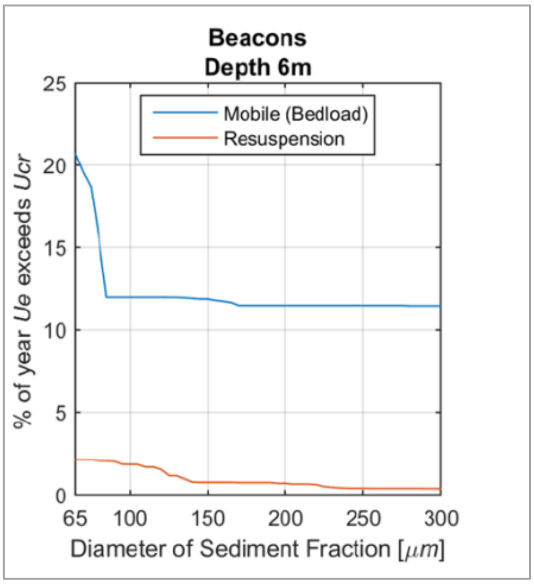

Figure 1: Sediment Mobility Estimate for ADCP deployment 'Beacons', in 6m water depth just north of area RExt.

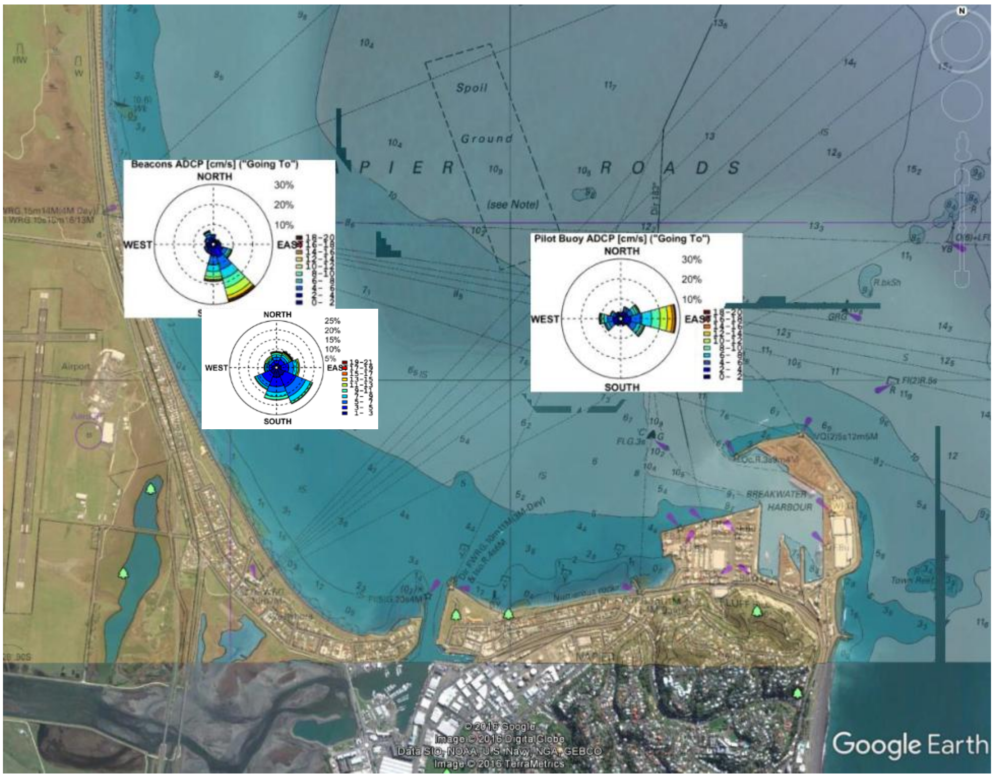

Figure 2: Current measurements between Westshore and Napier Port. Directions are 'going to'.

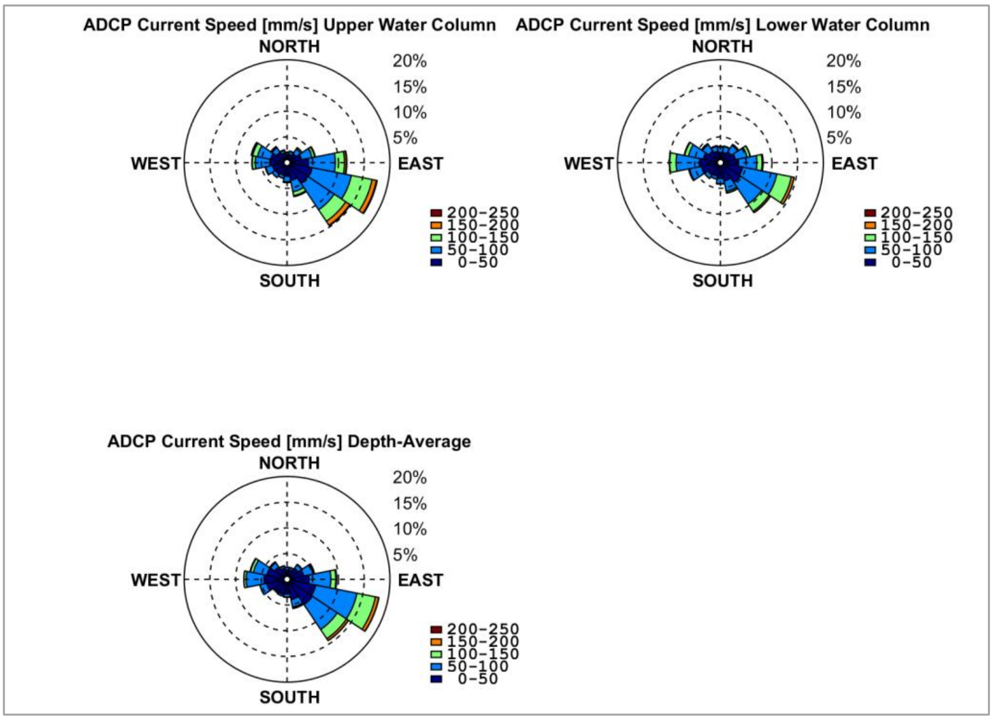

Figure 3: Current roses at 'Pilot Buoy', based on ADCP measurements for May – December 2016, and September 2017 – May 2018 (total 15 months of data). Currents are 'going to'.

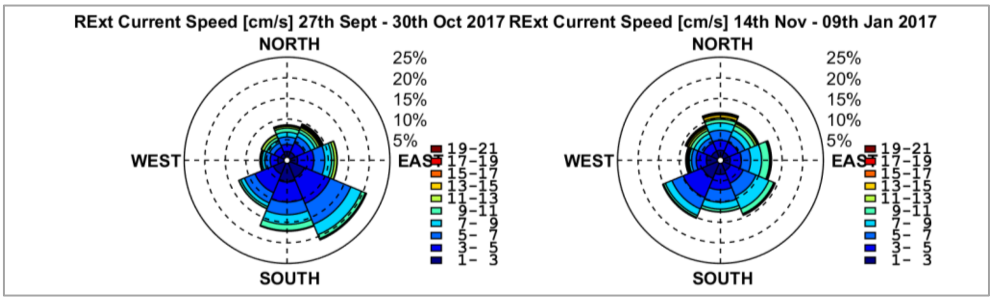

Figure 4: Current speed and direction measured by Marotte current meter deployed at RExt between September 2017 and January 2018. Currents are 'going to'.

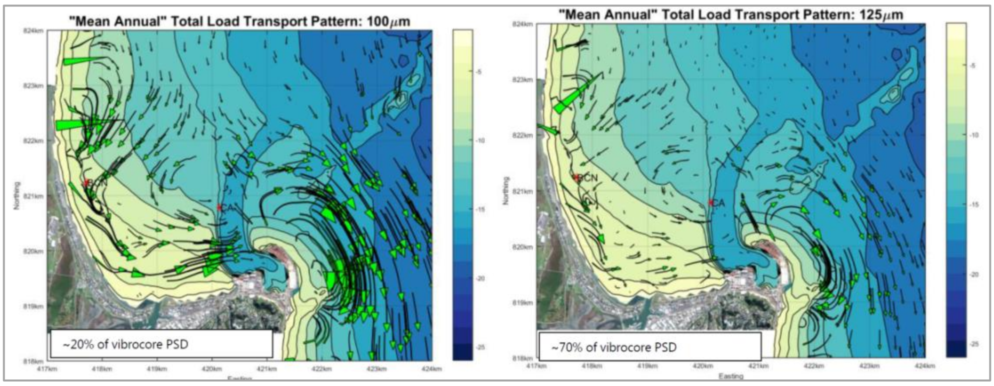

Figure 5: Simulated 'mean' sediment transport pathways for fine sand.

Compatibility of dredged and native sediments

49. The compatibility of sediments is based on the concept of 'replacing like with like'. That is, the more similar the new material (i.e. the material available from dredging) is to the native material (i.e. in-situ sediment composing the sea floor within area RExt), the more natural the beach and inshore response.

50. The similarity of the sediments is calculated using 'Graphic Phi moments' of new and native material. This means that the median particle diameter and degree of sorting of the two sediments are compared with each other.

51. The potential longevity of nourishment is estimated by the 'Overfill Ratio'. This is calculated from the Graphical Phi moments, and represents how much additional sediment is required to maintain the desired volume of nourishment, based on ambient sediment transport rates.

- Overfill Ratio RA< 1: The new material is coarser than the native material. It is more resistant to erosion by ambient hydrodynamic conditions and will tend to remain in place for longer than the native sandy material.

- Overfill Ratio RA= 1: The new and native sediments are perfectly compatible. The longevity of the nourishment is determined by the sediment transport rates of the native material.

- Overfill Ratio RA = 2: The new material is finer than the native material, and is preferentially eroded by ambient hydrodynamic conditions. Double the amount of sediment is required to maintain the design nourishment volume over the design period.

- Overfill Ratio RA = 3: Triple the amount of sediment is required to maintain the design nourishment volume over the design period.

- Etc.

52. Figure 6 shows the calculated Overfill Ratio for nourishment at Westshore, using sand dredged during various stages of the Project. The Particle Size Distribution (PSD) of dredged

sediments has been obtained from borehole data corresponding to the various dredge levels. These are compared to the PSD of two sea floor sediment samples obtained from area RExt close to Westshore, at two different water depths (samples GS3, GS4; Figure 7).

53. Mr Richard Karn in his evidence provided sediment grain size curves for an additional location within RExt, opposite the surf club in approximately 1m water depth at low tide. This location is to the north of samples GS3 and GS4, and is in a shallower water depth. The median grain size (D_{50}) of this sample is approximately 0.14mm. This D50 is essentially the same as that measured for samples GS3 and GS4, and therefore the conclusions drawn in Paragraph 54 will also apply to this location.

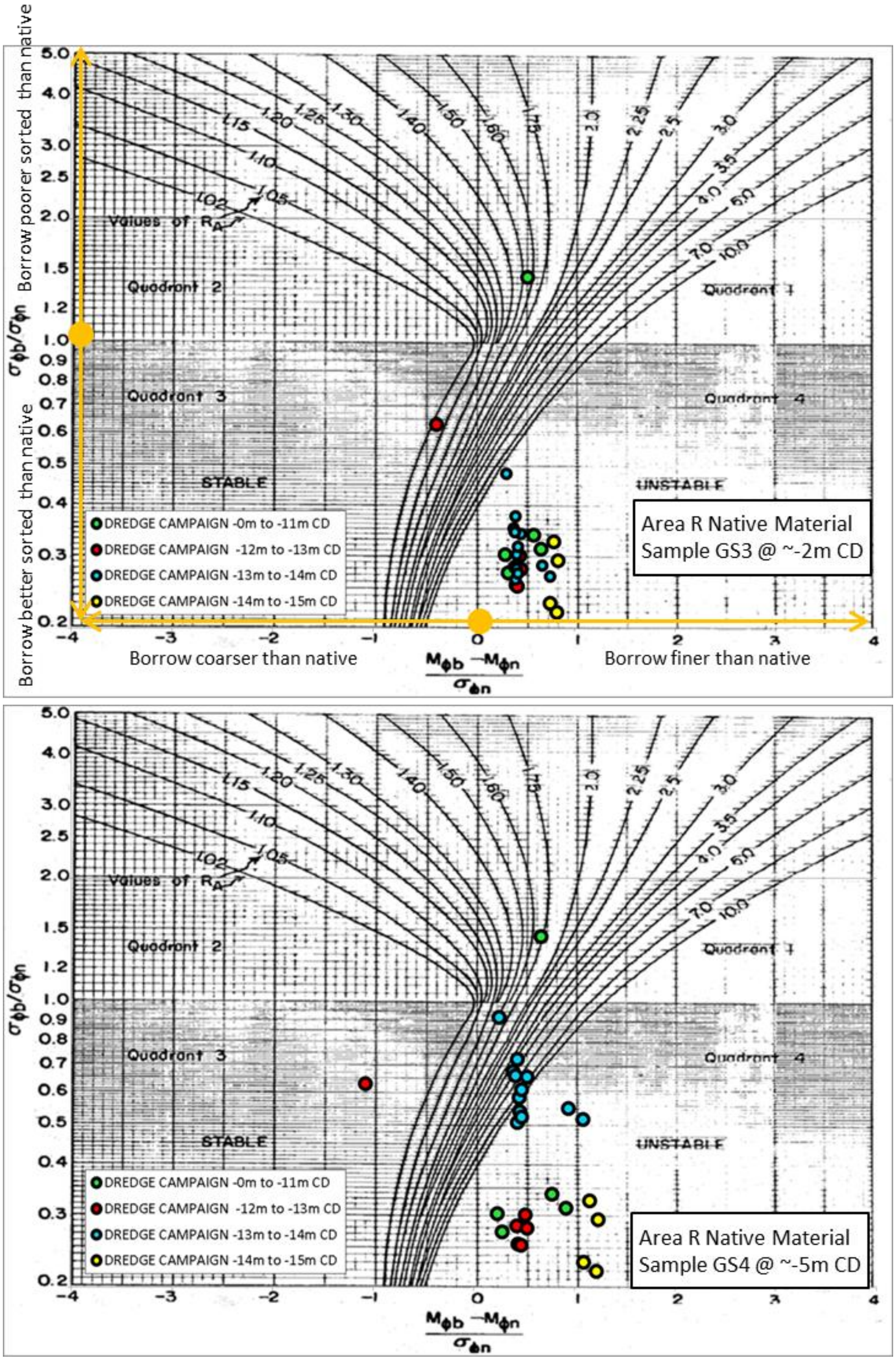

Figure 6: Calculated Overfill Ratio for nourishment of the sea floor at Westshore within area RExt (samples ‘GS3’ and ‘GS4’), using sand dredged from the Port navigation channel.

Results

54. The key results are:

- Using sand obtained by maintenance or capital dredging for nourishment within area RExt at about 2m below Lowest Astronomical Tide (LAT) (sample GS3) results in an Overfill Ratio that, in general, greatly exceeds 10.

- Using sand obtained by maintenance or capital dredging to nourishment within area RExt at about 5m below LAT (sample GS4) results in an Overfill Ratio that mostly exceeds 5 and generally exceeds 10.

- The most frequent quadrant for the Graphic Phi Means analysis between dredged and native sediment at RExt is Quadrant 4 (unstable). From Figure 8, this corresponds to dredge material being finer and better sorted than native beach material. Fill loss cannot be reliably predicted, but will probably be large over the long term.

- This means that the longevity of the nourishment cannot be reliably calculated, but does clearly show that the dredged sediments are finer than the native sediments and would not remain in place for long. This suggests that the majority of the material (fine sand) obtained from maintenance and capital dredging is unsuitable for protection from coastal erosion.

- Measurements of waves and currents between Westshore and the Port show that most dredged material deposited within area RExt will be mobile. Although measured current speed and direction shows natural variation, the presence of a clear net south-east and east current means that sediment placed within RExt will, over time, tend to move towards the Port to be deposited within the deeper waters of the navigation channel and berth pocket.

55. Long-term measurements (order of months to one year) of current speed and direction at several locations between the Port and RExt have confirmed the initial findings, which were based on one or two months of data.

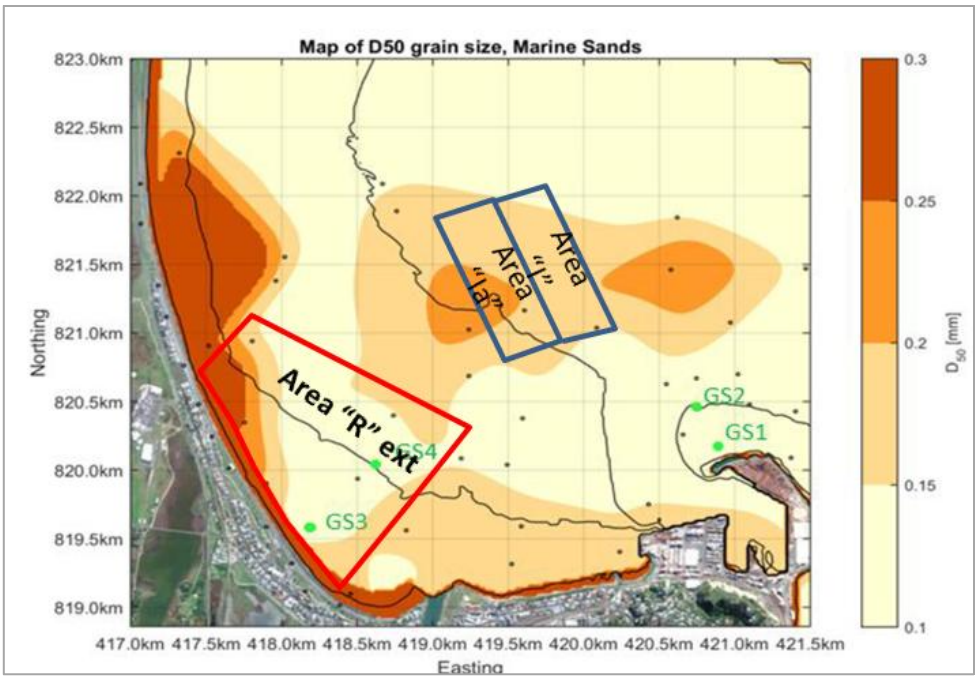

Figure 7: Location of sea floor sediment samples GS3 and GS4 within RExt.

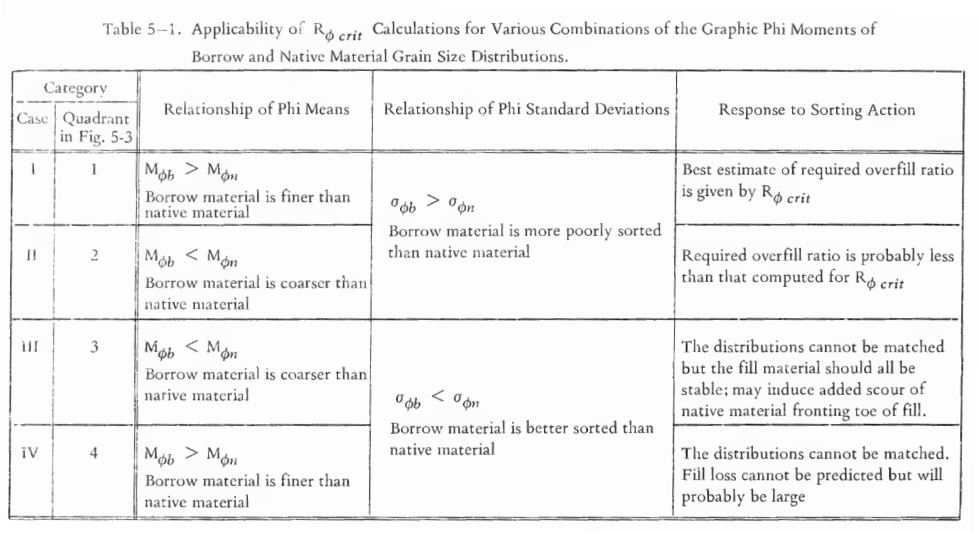

Table 5–1. Applicability of $R_{\phi\ crit}$ Calculations for Various Combinations of the Graphic Phi Moments of Borrow and Native Material Grain Size Distributions.

Category		Relationship of Phi Means	Relationship of Phi Standard Deviations	Response to Sorting Action
Case	Quadrant in Fig. 5-3			
I	1	$M_{\phi b} > M_{\phi n}$ Borrow material is finer than native material	$\sigma_{\phi b} > \sigma_{\phi n}$ Borrow material is more poorly sorted than native material	Best estimate of required overfill ratio is given by $R_{\phi\ crit}$
II	2	$M_{\phi b} < M_{\phi n}$ Borrow material is coarser than native material		Required overfill ratio is probably less than that computed for $R_{\phi\ crit}$
III	3	$M_{\phi b} < M_{\phi n}$ Borrow material is coarser than native material	$\sigma_{\phi b} < \sigma_{\phi n}$ Borrow material is better sorted than native material	The distributions cannot be matched but the fill material should all be stable; may induce added scour of native material fronting toe of fill.
IV	4	$M_{\phi b} > M_{\phi n}$ Borrow material is finer than native material		The distributions cannot be matched. Fill loss cannot be predicted but will probably be large

Figure 8: Response to Sorting Action for Quadrants shown in Graphic Phi analysis within Figure 7[9]

56. In some circumstances, dredged material may be found to be suitable for inshore placement. Based on accepted definition of "suitable" for the specific purpose of coastal protection (as defined below), such material would ideally consist primarily of sand-sized material of median grain size equal to or larger than of the native sediment. That is, larger than about 0.15mm, with limited finer material.

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[9] Shore Protection Manual, 1984,

57. The Coastal Engineering Manual[10] states that for native beach material with composite median diameter between 0.15 and 0.2 mm, borrow material can be considered compatible if its composite median diameter is within plus or minus 0.01 mm of the native diameter. For native beach material with a composite median diameter of less than 0.15 mm (such as that measured in the sub-littoral zone within disposal area RExt), use of material at least as coarse as the native beach is recommended.

58. It should be borne in mind that the sandy sediments dredged from the navigation channel and existing natively within the sub-littoral zone of disposal area RExt are ephemeral in nature, being the product of local Graywacke rocks that are broken down by abrasion within the littoral and sub-littoral zone. This abrasion is continuous over the lifespan of the sediment until it returns to the clays and fine particles that were originally laid down via turbidity currents occurring in deep water over geologic time.

59. Therefore in addition to the expected movement and sorting of sediments by waves and currents, there will also be a gradual (but unquantified) loss of the coarser nourishment material as it continues to break down in the marine environment.

Implication of Wind Speeds on Sediment Transport

60. The submission of Jenny Dunningham (Submission 3) and a number of others[11] addresses the validity of the modelling outcomes related to the movement of material deposited near to Westshore (and specifically at 'RExt').

61. Jenny Dunningham states: *"We understand that there is some concern about tidal and wind direction forces moving the sand away from Westshore, and perhaps affecting Te Pania reef to the south, but the evidence does not support this concern, and from simple local knowledge, concern about strong westerlies for hours on end at a certain strength is unfounded."*

62. With regards to occurrence of Westerly and North-Westerly winds, Figure 9 shows annual and seasonal wind roses

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[10] Coastal Engineering Manual (2003), Chapter V, Page V-4-25

[11] E.g. Submissions by Denis Pilkington (Submission 12) and Richard Karn (Submission 34).

derived from ten years of data collected by Napier Port anemometer. Westerly and North-Westerly winds are observed, and correspond to 23% and 13% of the wind record, respectively.

63. Figure 10 shows that both Westerly and North-Westerly winds result in sand transport away from Westshore and towards the Port and dredge navigation channel.

64. Table 1 summarises the key wind speed-duration statistics (in m/s) for Westerly and North-Westerly winds, measured at Napier Port anemometer for the period January 2004 to May 2018. The data has been converted to 'hourly average' values prior to calculating the statistics.

65. The presence of strong westerly winds (strong breeze or greater) is observed within the wind climate and can be sustained over periods of several hours.

Table 1: Summary wind event duration statistics, calculated for Westerly and North-Westerly wind, using hourly averaged data measured at Napier Port anemometer for period January 2004 – May 2018.

Sector	**West**		
Duration	**1 - 5 hours**	**6 - 11 hours**	**12 - 24+ hours**
Moderate Breeze (5.5 - 7.9 m/s)	Roughly once per day, on average	Roughly once per week, on average	Roughly once every two weeks, on average
Fresh Breeze (8- 10.7 m/s)	Roughly once every two days, on average	Roughly once every two weeks, on average	Roughly once every two months, on average
Strong Breeze (10.8- 13.8 m/s)	Roughly once every four days, on average	Roughly once every two months, on average	Roughly once every three years, on average
Moderate Gale (13.9 - 17.1 m/s)	Roughly once every 1.5 months, on average	Roughly once every seven years, on average	-
Sector	**North – West**		
Moderate Breeze (5.5 - 7.9 m/s)	Roughly once per day, on average	Roughly once per week, on average	Roughly once every month, on average
Fresh Breeze (8- 10.7 m/s)	Roughly once every two days, on average	Roughly once every three weeks, on average	Roughly once every six months, on average
Strong Breeze (10.8- 13.8 m/s)	Roughly once every week, on average	Roughly once every six months, on average	Roughly once every five years, on average
Moderate Gale (13.9 - 17.1 m/s)	Roughly once every three months, on average	-	-

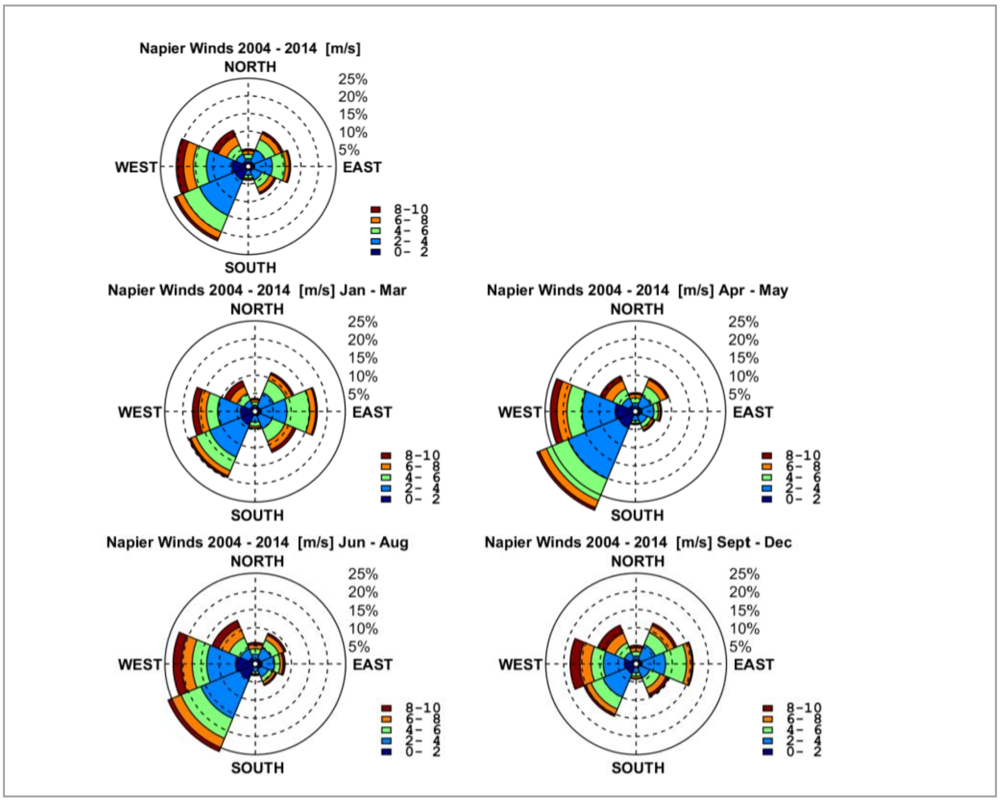


Figure 9: Annual Average and Seasonal Average Wind Roses, Napier Port Anemometer for period 2004 – 2014.

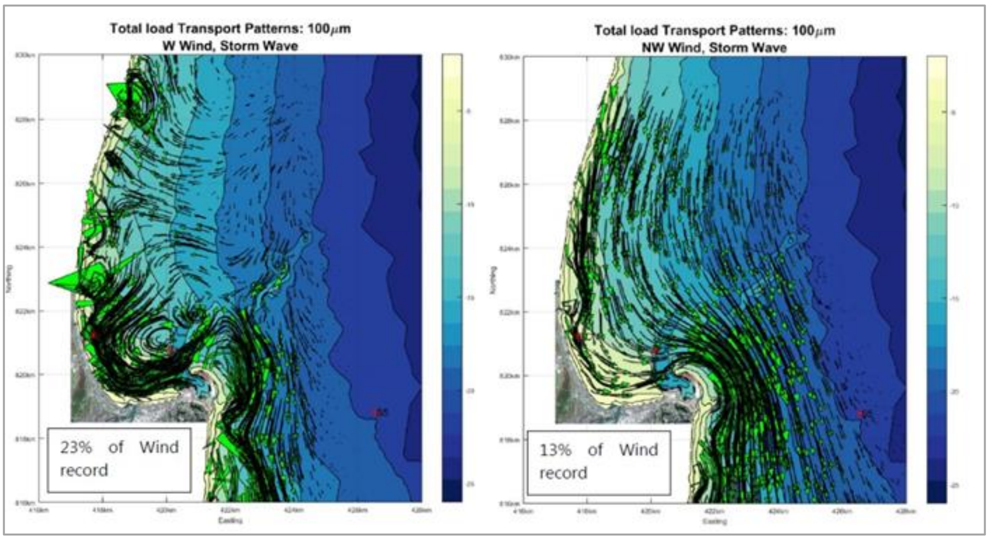


Figure 10: Sediment Transport Patterns for Westerly and North-Westerly Wind.

Suitability of energetic wind speeds as a method for determining sediment pathways

66. In a related matter, the submission of Richard Karn questions the validity of the sediment transport pathways, stating:

> *"[The] current vector diagrams were generated using 'energetic wind speeds' that only occur for 24 hours per year, the equivalent of 1 day per year (0.27% of the year). …*
>
> *Because only 2 12 hour periods can fit in to one 24 hour period, the maximum number of 12 hour numerical simulation periods that can be achieved each year is 2. This shows how extreme the numerical data from this numerical simulation is. It is representative of only 2 extreme wind events per year, occurring for 12 continuous hours."*

67. The issue of wind speed, direction, occurrence interval and duration has not played any part in assessing the erosion of sediments at Westshore. The ability of waves and currents to move sandy sediments, of a particular grain size distribution and at a particular location, has been assessed purely on the basis of site-specific measured wave and current observations.

68. Once sediments have been mobilized by ambient wave and current conditions, the 3D simulations estimate the most likely direction in which sediments would move "over the long term" (inter-annual to decadal). The sediment transport vectors provided by the 3D model are relative magnitudes. That is, the relative scale is preserved between simulation results for different sediment fractions and wind sectors. There is no quantitative prediction inferred from the 3D simulation results.

69. In undertaking the specific numerical simulations referred to by Mr Karn the wind speed units were mis-interpreted, causing a wind speed measured in knots to be applied in the model as a value interpreted as meters per second. The effect of this mis-interpretation is that the wind speeds applied to the model are more severe than the 24-hour non-exceedance wind speed, but are still wind speeds that have been measured at the anemometer.

70. What matters in the 3D simulation results is that the relative strength in wind speed is preserved between sectors, at a particular recurrence interval (that is, percentile wind speed). A high wind speed percentile was deliberately chosen across the octants, as the model 'spins up' to achieve quasi-steady-state much more quickly than if some mean value is used. As the suspension and deposition of sandy material reacts more-or-less instantaneously to the ambient wave and current climate, there is no requirement

that there be a link between wind speed and duration to a simulated current pattern - only that reasonably steady-state conditions are achieved.

71. A high percentile (rather than the mean) wind speed is appropriate to derive sand-sized sediment transport pathways (pattern) within Hawke Bay because, for a particular sediment diameter, the carrying capacity of the water column is roughly proportional to the current speed raised to the power of three. This means that if you double the current speed, the amount of sediment it can carry increases by a factor of 8. This means that, over the long term, sediment transport patterns tend to be determined by relatively infrequent events (such as storms).

72. The vectors in the transport pattern then must be scaled down appropriately to represent 'mean' or 'long term' conditions. In our case, the simulations are required only to assess long-term sediment transport pathways – that is, the directionality not the magnitude. The scale factor is therefore determined by the relative occurrence of each wind sector applied to the model.

73. In all such simulations that use a subset of the full environmental forcing to determine the overall sediment transport pattern, a 'reality-check' must be undertaken against site-specific data. For the simulations of sediment transport patterns around Napier Port, the 'reality check' is benchmarking the weighted simulation results against measured current meter data at several locations around the Port. The current data, measured by ADCP and tilt-drag current meter over a period of months to a year, including both summer and winter seasons, clearly show the presence of a net residual current, with directions that very strongly corroborate the sediment transport patterns determined from the 3D simulations, at multiple locations.

74. I can further say that the current roses determined from each location are a very good indicator of the mean sediment transport direction (and variation around the mean direction) because the current roses have been assessed for sediment transport using the Van Rijn sediment transport algorithm that combines the full range of waves and currents measured at the sites. These showed that, exterior to the surf zone, the current direction generally determines the direction in which sediment will move.

75. An additional, independent benchmarking of the long-term directionality inferred from the 3D non-cohesive sediment transport simulations is provided by depth-averaged hydrodynamic simulations of wind-induced current speed and direction undertaken by Worley Parsons in 2005 (Appendix D, Figure 8-7). These consider a uniform wind speed (9 m/s), for the six main wind directions (SW, W, NW, NE, E, SE). Table 2 shows the relative contribution of these sectors to the long-term wind climate, of which the SW, W and NW sectors clearly dominate. The current vectors clearly show the same overall directionality as measured by the ADCP and current meter, and also inferred by the 3D non-cohesive sediment transport simulations.

76. The conceptual sediment transport pathways as shown in Appendix D, Fig. 8-7 are derived from all available information – wave refraction patterns from the calibrated wave refraction model, the current data measured at multiple locations around Napier Port, the sediment transport roses assessed directly from the combination of wave and current meter data, the 3D sediment transport simulations, (Appendix F, Figure 5-8) and the hydrodynamic results also shown in Appendix D Figure 8-7.

77. In summary, the mean sand transport directions as inferred from the 3D simulations are robust, as they are 'reality checked' by multiple lines of evidence that each independently verify the model results and all infer the same conceptual picture.

Table 2: Wind Occurrence Frequency for Winds at Napier Port Anemometer, Jan 2004 – May 2018. Data averaged to hourly values from 1-minute wind speeds.

Sector	Total ≥1 m/s	% of wind record
N	6339	5.8%
NE	12168	11.1%
E	13390	12.2%
SE	8829	8.1%
S	4349	4.0%
SW	25190	23.0%
W	24766	22.6%
NW	14344	13.1%
	Total years:	**12.5**

Effectiveness of Recent Deposition of Maintenance Dredged Material

78. The submission of Denis Pilkington (Submission 12) describes on-going erosion processes at Westshore, and suggests that

recent deposition of dredged material adjacent to Westshore Surf Club has had a beneficial impact to beach volume by mitigating coastal erosion.

79. The submission states: "*Recent aerial photographs show that the wavebreak line has moved out in this area and measurements by the Hawke's Bay Regional Council show that the water has become shallower off this section of the beach. The Regional Council's sieve analysis of the sea bed show that the sea floor in this area is sand rather than silt*".

80. Mr Pilkington claims that the proposed capital dredging programme could make a major contribution to amelioration of the effects of erosion at Westshore Beach.

81. The submission of Richard Karn (Submission 34) makes similar points, but adds further detail. The submission presents an analysis of available beach profile data and bathymetry data pertaining to the shore adjacent to the Surf Club, which is at the southern limit of disposal area 'RExt'. This is then compared with satellite imagery showing shoreline position with time, and Particle Size Distribution (PSD) results from beach sediments collected in February 2018.

82. My earlier evidence has addressed various aspects relating to deposition of dredged material in general terms (see paragraphs 40 to 59).

83. Advisian was requested to undertake a review of the information in Mr Karn's submission, particularly in the light of the hydrodynamic model developed for the wider area. This analysis is presented below.

Interpretation of beach profile data

84. Figure 11 shows beach profile data measured adjacent to the Surf Club, for years 2016, 2017 and 2018, as provided by Mr Karn. The following aspects are noted:

- Beach profiles 2016-09 and 2017-08 show erosion of the upper beach profile (above y= 9m, on the graph in Mr Karn's evidence).

- Between 2017-08 and 2018-01, beach nourishment occurred on the upper profile to increase resilience against wave overtopping and 'storm bite'. The nourishment added volume to the upper beach and reshaped the crest where erosion had taken place.

(This process is shown in the picture dated 31st Oct 2017 on page 1 of Mr Karn's submission).

- Between 2018-01 and 2018-04 the upper beach face remains relatively stable. Some material removed from the beach crest is redistributed amongst the upper beach profile.

- The lower beach profile (below y = 9m, on the graph in Mr Karn's submission) shows relatively little change for the periods 2016-08 to 2017-08, and 2018-01 to 2018-04. Between 2017-08 and 2018-01, the lower beach profile between 60m and 80m distance from the surf club shows a vertical accretion of approximately 1m.

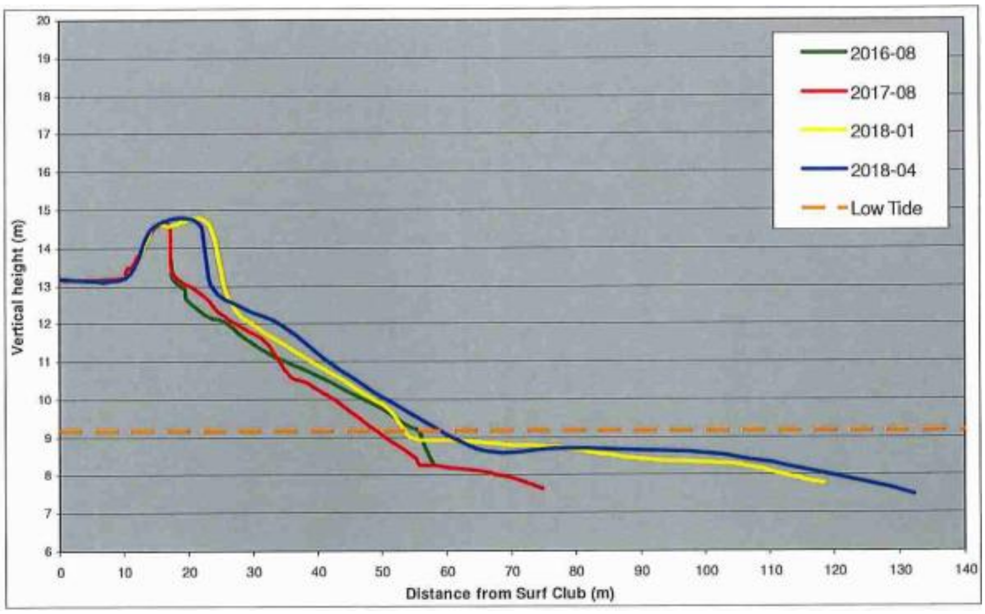


Figure 11: Beach profile measurements provided within Submission 34.

85. In my opinion, the change in lower beach profile between August 2017 and January 2018 will be in part attributable to natural variations in beach alignment due to e.g. seasonal fluctuations of incident wave height and direction.

86. It is also conceivable that the changes in the lower beach profile may be due in part to the sand deposition that took place within area 'RExt' between October and November 2017. The aspect that requires further investigation is not that sand placed upon the lower beach face will add volume to the beach profile, but how long the sand will remain in place and its effectiveness as a coastal protection measure.

Interpretation of bathymetric survey data

87. Figure 12 shows an analysis of bed level change (that is, erosion and accretion) at RExt between September 2017 and May 2018. The analysis has been completed by comparing bathymetric surveys undertaken in September 2017, January 2018 and May 2018.

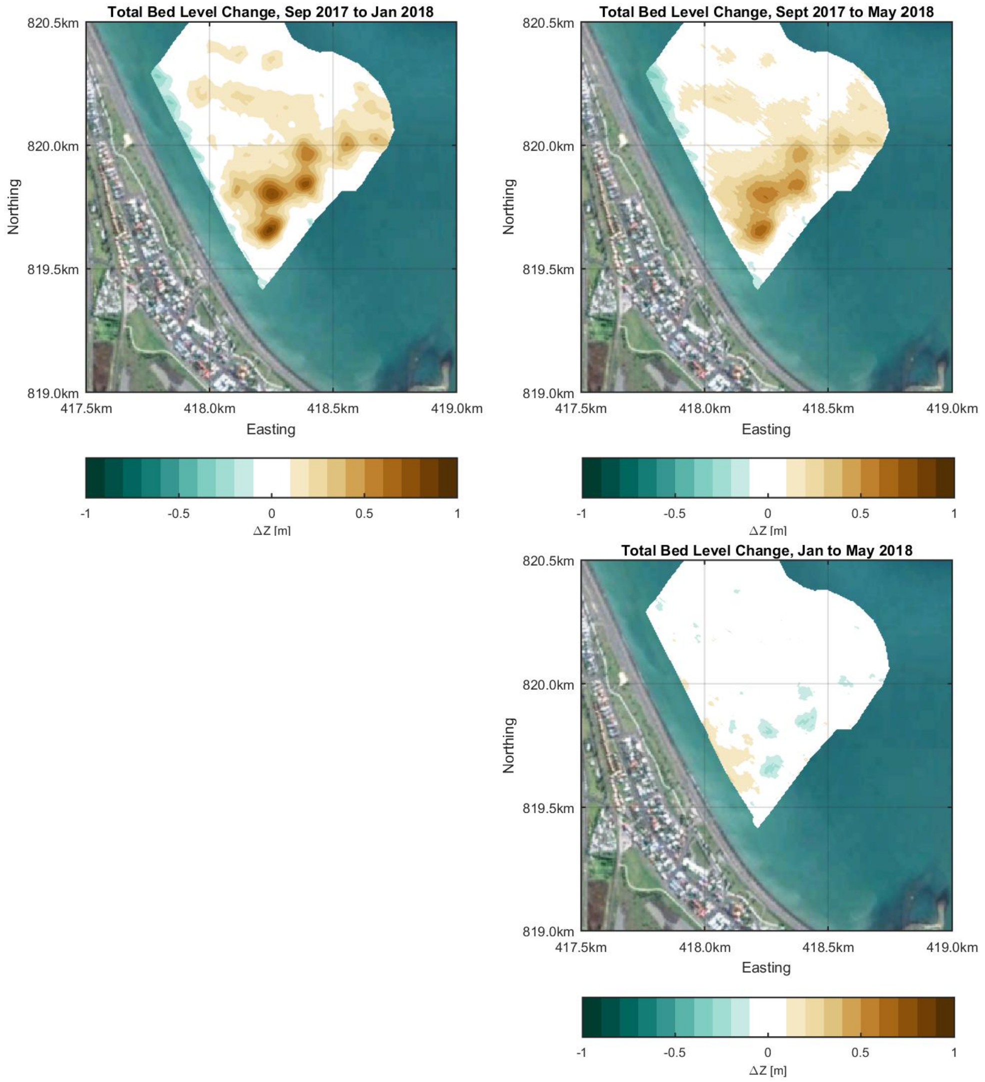
88. The locations of sediment deposition are clearly visible in the survey data. The following observations can be made:

- The shore nourishment has largely remained in place between October 2017 and May 2018.

- Some material has clearly dispersed between October 2017 and May 2018.

- Comparing surveys in January 2018 and May 2018 suggests that some sediment lost from the nourishment has moved on-shore. This corroborates beach profile data shown in Figure 11.

- It is also possible, based on current observations presented earlier in Figure 2 of this evidence, that sediment also is lost to the south and south-east of the survey area. This loss cannot be quantified.



Total Bed Level Change, Sep 2017 to Jan 2018

Total Bed Level Change, Sept 2017 to May 2018

Total Bed Level Change, Jan to May 2018

Figure 12: Analysis of bed level change around southern extent of disposal ground RExt. Upper left: Sept Positive ΔZ corresponds to accretion, negative ΔZ to erosion.

Shore Nourishment Longevity

89. As noted earlier, the longevity (or 'stability') of a particular deposition event can be estimated from:

a) *Hydrodynamic conditions*. That is, if incident wind and wave conditions are of sufficient magnitude to mobilise sediment over time. If wave activity is able to suspend material, it will move in the direction of any current in the overlying water column, dispersing to the wider marine environment.

b) *Sedimentological compatibility*. That is, how similar the particle size distribution of the new material (from the dredge in the activity) is compared to the 'native' material in the receiving environment. As noted earlier, if dredged material is finer than the native beach material it will be preferentially eroded ('winnowed') at a higher rate.

90. The consequences of hydrodynamic and sedimentological conditions at Westshore are discussed below, with implications for sandy sediment deposited at area RExt.

Hydrodynamic Conditions October 2017 – May 2018

91. Figure 13 shows a time series of wave conditions (height, period and direction) measured at the Triaxys wave buoy maintained by Napier Port. In the upper panel the wave height for disposal area 'RExt-O6' (418300E, 819800N) is shown in blue, produced from Advisian's calibrated wave refraction model.

92. The lower panel shows the cumulative sediment transport at Ext-O6, calculated using a simple general formulae for sand transport (Van Rijn, 2017)[12]. The cumulative transport has been normalised to show results as a fractional value in the range 0 to 1 for the period 1st October 2017 to 25th May 2018, and is valid for fine to medium sand (0.1 – 0.2 mm).

93. The following observations are made on the basis of the wave and sediment transport time series:

- Wave conditions at RExt-O6 can be segregated to 'calm' and 'storm' conditions using a threshold wave height of 1.0m. 'Calm' conditions exist for up to three months (12 weeks), whereas 'Storm' conditions last for the order of one to two days.

- For Hm0 <1.0m little (but not zero) sediment transport was observed. This is interpreted as periods where beach accretion would be expected, with waves gradually 'pushing' sediment on-shore to eventually weld with the beach face.

- Four storm events are recognised where wave Hm0 exceeded 1.0m. These storm events are always associated with significant sediment transport and are interpreted as periods where wave stirring is sufficient

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[12] Van Rijn, L. (2017). Simple general formulae for sand transport in rivers, estuaries and coastal waters. http://www.leovanrijn-sediment.com/papers/Formulaesandtransport.pdf

to entrain sediment to the water column, whereupon the sand will move in the direction of any net current.

- Of the four storm events observed, two (Jan and May 2018) involved significantly more sediment mobility, due to a combination of storm duration and offshore wave conditions approaching from almost due East, to which Westshore is relatively exposed.

94. As noted earlier, the presence of a net eastward current adjacent to the Port has been confirmed by additional ADCP deployments at 'Pilot Buoy' (the channel fairway) for May – December 2016, and September 2017 – May 2018 (that is, for a total of more than one year). The results of these current measurements were shown in Figure 2. These measurements compare well with sediment transport pathways obtained from numerical simulations (shown earlier in Figure 5).

How typical was the Oct 2017 – May 2018 wave climate for assessing sediment mobility at Westshore?

95. The wave climate at Napier is known to be seasonal, with generally larger mean wave height in winter relative to summer. Stronger storms can occur from June through to September.

96. Figure 14 shows the simulated winter wave climate at RExt-O6 for three 'typical' years (2011, 2014, 2015). Storm events as defined by Hm0>1.0m are marked in red.

97. It is evident from Figure 14 that:

- The frequency of occurrence of storm events with Hm0 >1.0m during the winter period is between 3 and 4 times that observed for the summer 2017 – 2018 season.

- The duration of storm events with Hm0>1.0m are generally longer (sometimes much longer) than those observed for the summer 2017 – 2018 season.

98. These observations show that sediment mobility at RExt is, in general, greater than that which has been experienced between the October 2017 maintenance dredging campaign and May 2018.

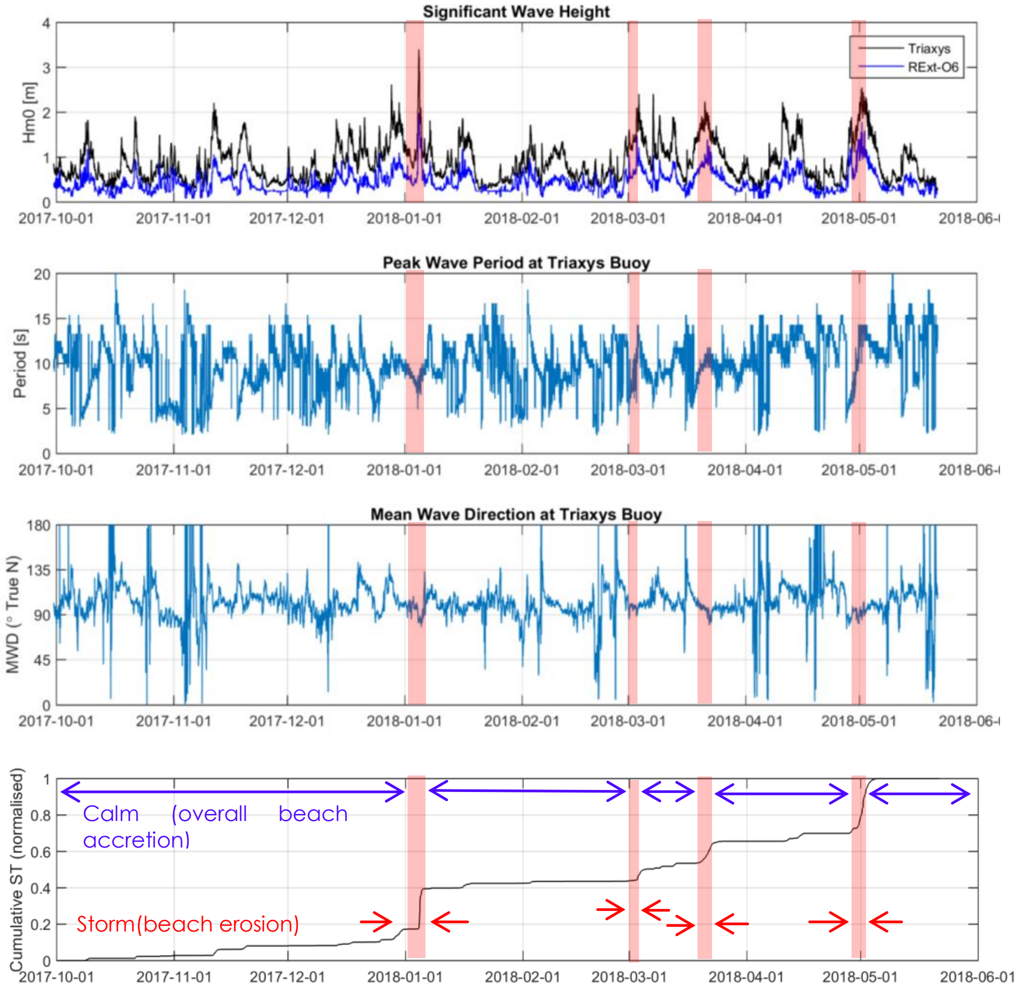

Figure 13: Top 3 panels- Time series of wave height, period and direction since 1st October 2017. Lower panel – Cumulative sediment transport (normalised) calculated between 1st Oct 2017 and 24th May 2018, based on the wave climate at RExt-O6.

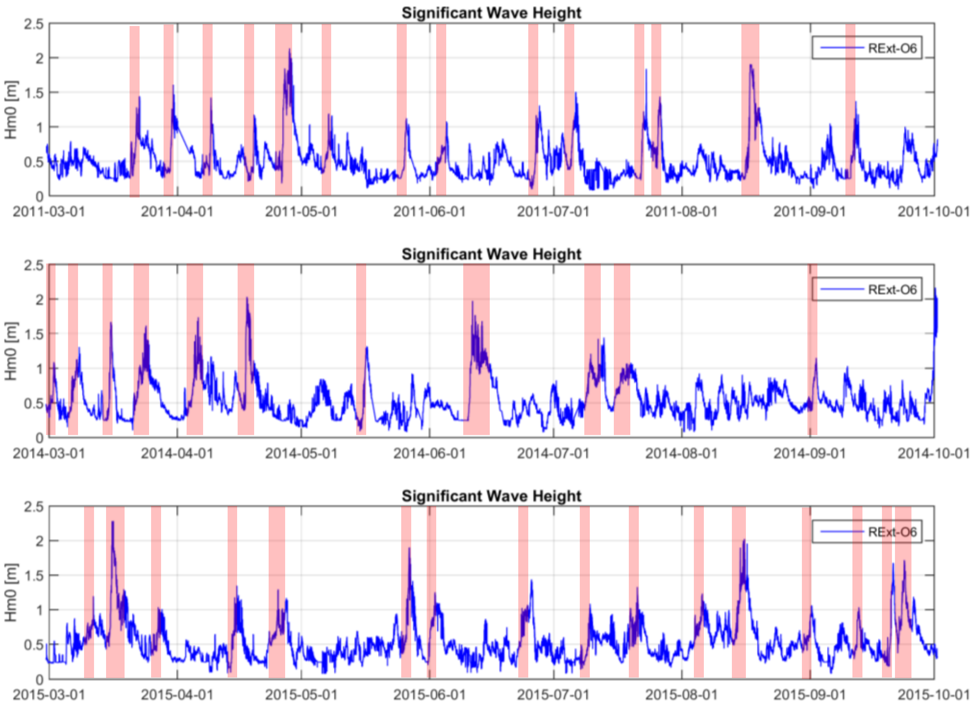

Figure 14: Typical Winter Wave Climates at RExt-O6

Compatibility of dredged and native sediments

99. I have addressed compatibility of sediments earlier in paragraphs 49 to 59 of this evidence. This will also have a bearing on the suitability and duration of material in the receiving environment.

Summary

100. The key points of this analysis in response to these submissions may be summarised as follows:

- Established coastal engineering methods comparing suitability of dredged material shows that it will be generally incompatible. Therefore it is expected that much of the material, particularly the fine sand placed on the lower shore will be lost over time.

- The dispersion of fine sandy material to the wider marine environment is a function of incident wave forcing. Storm events of sufficient magnitude are required to entrain sediment to the water column, where it can be reworked by shore-parallel currents that persist around RExt, driven primarily by wind.

- Analysis of the wave climate since the maintenance dredging campaign has shown that wave conditions have been mostly calm punctuated by occasional brief storms. This is typical of summer conditions, and suggests that not much wave energy has yet been available to move sediment from where it was deposited during the 2017 maintenance dredging campaign.

- Analysis of bed level changes at RExt between September 2017 and May 2018 corroborate this picture. The sediment deposited at RExt has largely stayed in place. Some material has moved onshore, which would be expected during largely calm conditions.

- Analysis of the wave records during the winter season over multiple years shows that, over a 6 month period, some 10 to 16 storm events of significance for sub-tidal sediment transport would normally be encountered. This compares with the two significant storm events recorded between October 2017 and May 2018.

- This lack of wave energy may explain why the October dredge deposition at RExt has largely remained in-situ. It would be expected that this will start to disperse more rapidly during winter, as storm intensity and frequency increases.

Impacts of Inshore Deposition on Pania Reef

101. The submission of Dorothy Pilkington (Submission 22) highlights residual uncertainty over the eventual fate of sediment disposed of at Westshore. Addressing the "anecdotal evidence" of a gradual increase in sedimentation over the past three decades on the Pania Reef, she considers that this cannot be attributed to *"the very recent depositing of sand from dredging in the near shore at Westshore"*.

102. The full dredge disposal records were provided to HBRC by Napier Port on 3rd July 2018 in response to informal queries. These date back to 1973 and indicate a range of locations in the general vicinity of Westshore.

103. The basis for the conclusion that there may be a link between increased turbidity at Pania Reef and the disposal of dredged material is set out earlier in this evidence,

including in response to other submissions – see paragraphs 44 to 47.

104. As the dredge sediments are much finer than the native material, it would not be expected that the fine sand and finer material disposal in these areas would remain in place after a limited number of significant storm events. That is, the longevity of nourishment by dredged material would be severely limited, which would not remain in place over successive storm events. The shallower the disposal depth the greater the risk of fine material moving into suspension for transport by currents. However even the 10 m depth would result in disturbance at times shown by our earlier 2005 modelling and our analysis of bed shear stress in 10m water depth[13] (Figure 15).

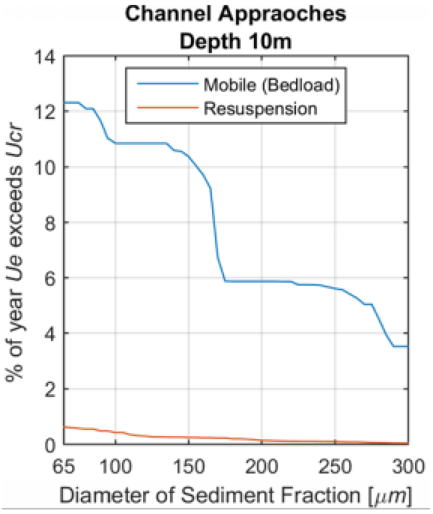

Figure 15: Sediment Mobility Estimate for ADCP deployment 'Channel Approaches', in 10m water depth just south of disposal area IA

105. With regards to potential transport of fine material from the former disposal areas and also RExt to Pania Reef, turbidity buoy measurements as reported by Cawthron and cross-referenced against river discharge data for southern Hawke's Bay indicate that fine sediment discharged from rivers (and therefore coastal areas) can be transported eastward over Pania Reef. This is consistent with plume turbidity behaviour visible in satellite imagery, and also corroborates with results of numerical simulations of dredge plume behaviour (as discussed in the evidence of Chris Adamantidis). There is therefore no reason to doubt the findings of these studies.

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[13] Also Figure 5-1 of Appendix F, Volume 3 of the resource consent application

CONCLUSIONS AND RECOMMENDATIONS

106. Based on the analysis of measured data and the results of the calibrated numerical model systems of coastal processes, I consider that the coastal studies presented in Appendix D and F of Volume 3 of the resource consent application documentation are sound and in accordance with industry good or best practice.

107. Review of the coastal studies by the Council's expert advisors have found them to be of a high standard. There is broad agreement that the modelling and results fit the 'framework' and observations of past studies.

108. On the balance of available hydrodynamic and sedimentological evidence presented and discussed within this Statement, I do not consider there is any credible basis for the proposition that dredge material placed within disposal area RExt will meet commonly accepted criteria of "suitable" nourishment material for the specific purposes of coastal protection from on-going, long-term erosion issues at Westshore.

109. My opinion therefore is that the applicant could not comply with the 'provide suitable beach material' conditions[14] if sediments obtained from capital or maintenance dredging of Napier Port are to be used for this purpose.

110. This opinion is formed on basis of:

    (a) accepted coastal engineering criteria for assessing the suitability of dredged material; and

    (b) the uncertainty of established methods relating to the in-situ treatment of dredged sand within a dredge hopper to retain just the portion of the particle size distribution that matches or is coarser than the native sandy material at the receiving site.

Benjamin Graham Williams

6 August 2018

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[14] Condition 17 of the Draft Conditions of Consent CL180010E and CL180010E, and Condition 18 of the Draft Conditions of Consent CL180009E.