Before Hearing Commissioners
at Christchurch

under: the Resource Management Act 1991

in the matter of: applications CRC172455, CRC172522, CRC172456, and CRC172523 to undertake channel deepening dredging and maintenance dredging in Lyttelton Harbour

and

in the matter of: **Lyttelton Port Company Limited**
Applicant

Summary and response evidence of Gary Charles Teear (marine physical environment)

Dated: 1 May 2017

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SUMMARY AND RESPONSE EVIDENCE OF GARY CHARLES TEEAR

INTRODUCTION

1 My name is Gary Charles Teear.

2 I prepared evidence dated 28 March 2017 for Lyttelton Port Company Limited (*LPC*) in relation to its applications for resource consent to undertake works known as the Channel Deepening Project (*CDP*).

3 My qualifications and experience are as outlined in that evidence.

SCOPE OF EVIDENCE

4 This evidence consists of a summary of my evidence as filed.

PART 1: SUMMARY OF EVIDENCE

5 My evidence presents a summary of the marine physical environment in Lyttelton Harbour and Pegasus Bay as well as a brief summary of the empirical data collection work that OCEL has undertaken over the last 25 years. It has also drawn on earlier work and studies to establish a historical context. It complements the more recent numerical modelling work by MetOcean Solutions Limited (*MetOcean*), as detailed in the evidence of **Brett Beamsley**.

Lyttelton Harbour and Pegasus Bay

6 Lyttelton Harbour is the eroded caldera remnant of an extinct volcano. In its natural condition the seabed in the Harbour is unusually flat which is indicative of a fluid seabed condition in high energy events.

7 Pegasus Bay is a relatively shallow embayment north of, and in the lee of, Banks Peninsula and is part of the continental shelf which is relatively narrow off the end of the east tip of Banks Peninsula but extends directly north of the peninsula in the shape of a banner bank. This is historic evidence of the transport of sediment north past the Peninsula by the north setting flood tide which is the stronger of the two tidal currents past Banks Peninsula.

8 The fine sediments forming the seabeds of both the Harbour and Pegasus Bay are predominantly (60%) silt size, primarily derived from the loess silt that mantles Banks Peninsula.

Empirical and Computer Modelling Work

9 Over the last 25 years, OCEL has undertaken empirical data collection as part of studies on the Harbour tidal regime, wave

environment, seabed geotechnics and vessel handling/motion studies.

10 The MetOcean models of tidal currents and wave energy, as described in the evidence of **Brett Beamsley**, have been fine-tuned as a result of observations and now fully replicate measured currents and waves for the existing Harbour configuration.

11 Both the empirical data undertaken by OCEL and the numerical modelling approach undertaken by MetOcean are symbiotic and the work to date has enabled a close to complete understanding of the Harbour and coastal environment.

DREDGE SPOIL

12 OCEL undertook practical test disposal trials of hopper/loads dredged material during maintenance dredging campaigns both inside and out of the Harbour Heads.

13 Work carried out in 2003 inside the Harbour gave quite clear results showing a turbid plume of 2 to 3 m thickness away from the drop zone and a bottom layer of suspended sediment visible up to 1.5 m above the seabed.

14 Tracking the leading edge of the plume indicated that the material dumped by the dredge could travel some 300 m from the drop zone in a period of approximately 40 minutes following the time of the disposal.

15 The results of the 2007/2008 work which were undertaken outside of and at the entrance to the Harbour were not as clear. It proved difficult to track the plume because of relatively high levels of ambient or natural background turbidity.

16 At the offshore disposal location the plume cloud moved south east, roughly parallel to the line of the coast, consistent with an ebbing tide. At depth a plume footprint approximately 200 m wide was observed before it became indistinguishable from the natural background.

17 My evidence also included details on the nature dredge spoil – although specifics on the nature of the material to be dredged is described in evidence of **Michael Page**.

TURBIDITY

18 Turbidity is a natural background phenomenon that occurs in most bodies of water. The coastal waters of Pegasus Bay and Lyttelton Harbour exhibit high natural variability in their characteristic

properties. The natural condition for the Harbour, exposed as it is to swell wave action, is to have fine sediment in close to permanent suspension.

19 The turbidity depth profiles from turbidity measurement undertaken by OCEL typically show a hockey stick profile with turbidity increasing close to the seabed. This hockey stick turbidity profile (as well as my own observations while diving both in and outside the Harbour) show a fluid mud layer at the seabed is a constant of the subsea environment at certain locations in the deeper areas of the channel and offshore.

ENVIRONMENTAL FACTORS INFLUENCING SEDIMENT MOVEMENT

20 The primary influences on sedimentation and channel siltation within and outside the Harbour are the waves and tidal currents. The wave climates within and outside the Harbour are relatively benign compared to elsewhere on the New Zealand coastline.

21 Waves within Pegasus Bay generally fall into two categories, locally derived wind generated short period waves (typically 3 to 5 seconds period) and longer period swell waves (typically 8 to 20 seconds period) from more distant storms in the southern ocean which refract around Banks Peninsula.

22 Swell waves in excess of 1 m significant wave height and 10 – 12 second period can disturb and entrain sediment over the full extent of the Harbour inlet and outside it, including the proposed dump location. The locally generated wind waves with a 3-6 second period cannot entrain sediment and have minimal effect on Harbour siltation other than at the Head of the Harbour.

TIDAL CURRENTS

23 OCEL has undertaken a number of investigations of tidal currents in Lyttelton Harbour over many years both for vessel handling studies and sediment transport work. OCEL studies in 2000, 2003 and 2007/2008 have used an Acoustic Doppler Current Profiler (*ADCP*) in both the mobile and static modes.

24 The work undertaken in 2003 using the ADCP in the mobile mode identified the tidal circulation patterns in the outer Harbour and in particular the development and persistence of the vortex that forms inside Godley Head on the incoming tide. This work gave the first detailed picture of tidal circulation in the outer Harbour confirming the previously known asymmetry of the tidal flow.

25 The finding of a net flow out on the north side of the Harbour supported the proposal to dispose of dredged material on that side in an effort to increase wave refraction effects and thereby reduce wave energy progressing up the Harbour.

TIDAL COMPARTMENTS

26 The relatively low tidal current speeds (1 knot maximum) means that tidal excursion distances on a tide are limited – typically of the order of 3.5 km maximum meaning it takes several tidal cycles for water in the Upper Harbour to leave the Harbour system. Therefore sediment entrained into suspension either by wave action or dredging activity in the outer Harbour cannot reach the Upper Harbour in one tidal cycle.

27 To illustrate this a self-tracking buoy was released in Governors Bay on the north side of the Upper Harbour and tracked for two days, during which time it did not leave the Upper Harbour.

28 The implications of a relatively long dwell time or changeover time in the Upper Harbour are reflected in the fact sediment accumulation has continued to occur over the last 50 years.

SEDIMENTATION AND CHANNEL SILTATION

29 Sedimentation is the conversion of discrete soil particles in a suspension into loose sediment. From a comparative study of hydrographic charts and dredging records over time it is apparent that the Harbour is in a state of quasi-stability in terms of net sedimentation.

30 The major sedimentary process within the Harbour is the maintenance dredging program which removes in the order of 1 million tonnes per year from the navigation channel.

31 The navigation channel tends to act as a sediment trap because it is deeper than the natural bed levels. This tendency is reinforced by density differences.

32 The CDP will not change the amount of siltation experienced along the length of the existing channel it is just extending and deepening the sediment trap. The extra volume of sediment that needs to be removed as part of the maintenance dredging will most likely be less than proportionate to the increase in channel length.

SEDIMENT TREND ANALYSIS (STA)

33 OCEL undertook sediment trend analysis (*STA*) work in outer Lyttelton Harbour in order to identify sources and sinks of sediment

and to generate maps of the pathways, sediment types and transport environments. Particularly, this was undertaken with respect to dispersion of deposited dredge spoil and potentially channel infilling.

34 300 sediment grab samples were collected from the outer Harbour in August 2012. Size analysis of these samples showed that mud (silt and clay <63 µm) dominated the study area with decreasing amounts of sandy mud, muddy sand and sand respectively.

35 The STA work showed that the processes of mass wasting on the steep hillsides surrounding the outer Harbour supplies much of the sediment that enters the shoreline waters. Highly dynamic processes transport these sediments westward on the south side and eastwards on the north side. The material shown being transported north in the direction of Taylors Mistake is sand only.

36 At the same time finer material is driven from each side towards the middle and the channel where seaward transport continues into Pegasus Bay. In addition material is also derived from dredged material disposed of on the north side of the Harbour.

37 In conclusion, my evidence deems the two offshore disposal locations suitable for the disposal of both the channel deepening material and the subsequent maintenance dredging material from the deepened channel. The environmental impact will be minimal as the extra turbidity created by the dumping of the sediment will be masked by the existing natural background. The dredge spoil will be dispersed offshore along the coast but not along the shoreline and there is no direct tidal current path to take the dumped re-suspended sediment into either Port Levy or Taylors Mistake or any of the other Banks Peninsula inlets.

Dated: 1 May 2017

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Gary Teear