

**BEFORE THE ENVIRONMENT COURT
I MUA I TE KOOTI TAIAO O AOTEAROA**

ENV-2018-AKL-000078

IN THE MATTER of the Resource Management
Act 1991 (**RMA**)

AND

IN THE MATTER of the direct referral of
applications for resource
consent for the necessary
infrastructure and related
activities associated with
holding the America's Cup in
Auckland

BETWEEN **PANUKU DEVELOPMENT
AUCKLAND**

Applicant

AND

AUCKLAND COUNCIL

Regulatory Authority

**EVIDENCE OF CRAIG MICHAEL FITZGERALD ON BEHALF OF
PANUKU DEVELOPMENT AUCKLAND
(NOISE AND VIBRATION)
7 AUGUST 2018**

1. QUALIFICATIONS AND EXPERIENCE

1.1 My full name is Craig Michael Fitzgerald.

1.2 I am an Associate with Marshall Day Acoustics (**MDA**), specialising in environmental noise and vibration assessments, building acoustics and underwater acoustics. I have a Bachelor of Engineering (Mechanical) from the University of Auckland. I am a Chartered Engineer (CEng) registered with the Engineering Council (United Kingdom). I am a Member of the Acoustical Society of New Zealand and the Institute of Acoustics (United Kingdom).

1.3 For the past 12 years I have worked in the field of acoustics in New Zealand and England. I have experience in environmental acoustics for large infrastructure projects, including appearing as an expert witness for Council and Environment Court Hearings, and Environment Court mediation. I also have experience in architectural acoustics, and have provided advice on sound insulation, room acoustics and mechanical services noise. I present an annual acoustics lecture to Building Science students at Victoria University.

1.4 Some of my relevant project experience includes:

- a) Kennedy Point Marina, 2016 – 2018. I prepared the assessment of noise effects of the recently approved marina on Waiheke Island. This involved noise monitoring of the existing environment, modelling of the airborne and underwater noise emissions and preparation of an effects assessment. I presented expert evidence on noise effects at the Council and Environment Court hearings.
- b) City Rail Link (**CRL**), 2012 – 2018. CRL is a new rapid rail project in central Auckland. It is one of the most significant urban infrastructure projects currently undertaken in New Zealand. I was the noise expert for the Notice of Requirement and co-author of the noise and vibration assessment. I presented expert evidence on noise effects at the Council hearing and Environment Court mediation.
- c) Other marine projects include the Rena salvage, wharf extensions for Ports of Auckland and Port Napier, and the Waikawa Marina extension.

1.5 MDA has been engaged by Panuku Development Auckland (**Panuku**) to assess the noise and vibration effects of the applications for the 36th America's Cup regatta including construction of the necessary infrastructure and event activities (**AC36**). I have visited the site and liaised with the relevant team members to ensure my assessment of effects addresses the proposed activities.

1.6 I advise that I have read the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2014 and have complied with it in preparing this evidence. I confirm that the issues addressed in this evidence are within my area of expertise and I have not omitted material facts known to me that might alter or detract from my evidence.

2. SCOPE OF EVIDENCE

2.1 I have been asked to provide evidence in relation to construction noise and vibration, and events noise. This evidence addresses potential airborne noise, underwater noise and vibration from infrastructure construction, such as from earthworks, services, piling activities and base construction. It also addresses potential airborne noise from AC36 events, such as festivals, concerts and live race broadcasts and the operation of syndicate bases. These matters are assessed against the relevant legislation, planning rules and existing environment.

2.2 I authored the Construction Noise and Vibration Assessment¹, draft Construction Noise and Vibration Management Plan (**CNVMP**)² and Events Noise Assessment³ attached to the Resource Consent Application. My colleagues assisted with noise and vibration surveys, preparing modelling information and reviewing of these documents and their conclusions.

2.3 I have participated in discussions with stakeholders, mediation⁴ and expert conferencing. I co-authored the Noise and Vibration Joint Witness Statement dated 25 July 2018 (**JWS**).

¹ CBD Vol A, CB27: MDA report Rp 005 r08 20171213, dated 12 April 2018.

² CDB Vol A, CD28: MDA report Rp 007 r05 20171213, dated 12 April 2018.

³ CBD Vol A, CB29: MDA report Rp 006 r07 20171213, dated 12 April 2018.

⁴ 25 and 26 July 2018. Curt Robinson attended the additional day of mediation on 30 July 2018 in my absence.

2.4 I prepared the Wynyard Edge Alliance (**WEA**) revision of the CNVMP⁵ to reflect the proposed construction methodology in accordance with the proposed conditions of consent (110 – 110D). It is included as **Appendix B** of this evidence.

2.5 My evidence will cover the following matters:

- a) Existing environment;
- b) Construction noise and vibration;
- c) Events noise;
- d) Comments on the Auckland Council Report;
- e) Comments on submissions and matters raised by section 274 parties;
- f) Conclusions.

3. SUMMARY OF EVIDENCE

3.1 I have assessed noise and vibration associated with the construction of AC36 infrastructure, hosting of the AC36 events, and potential legacy activities.

3.2 In relation to construction noise and vibration:

- a) I predict airborne construction noise will generally comply with the relevant project standards. However, I predict that piling and concrete cutting will exceed the limits for brief periods at occupied buildings.
- b) I predict construction vibration will generally comply with the relevant project standards. However, piles driven directly adjacent to the Maritime Museum have the potential to locally exceed the cosmetic building damage vibration limits. Vibration may be perceptible in the wider Project area for brief periods.
- c) I consider the underwater noise effects should be managed by implementing low power or shut down procedures for the piling works when a marine mammal or diver is identified within the Temporary Threshold Shift (**TTS**) zones.

⁵ Wynyard Edge Alliance CNVMP, dated 3 August 2018.

- d) I consider the construction noise and vibration effects will be reasonable provided they are of limited duration and Best Practicable Option (**BPO**) measures are implemented through the draft CNVMP to avoid, remedy and mitigate the noise emissions as far as practicable. This includes the specific measures relating to piling and concrete cutting in the conditions 110 – 110D.

3.3 In relation to AC36 events and potential legacy activities:

- a) AC36 events include a series of public address (**PA**) speakers, syndicate base activities and live music noise events (e.g. opening ceremony).
- b) I consider that all AC36 activities can comply with the proposed operational noise conditions and the associated noise effects are reasonable.
- c) Legacy activities would be assessed on a case by case basis, as required. However, I consider that the applicable noise limits enable a wide range of future activities that would generally not constrain potential legacy activities.

4. RELEVANT FACTS AND CONTEXT

4.1 In this statement of evidence, I do not repeat the project description and refer to the summary of the application in the evidence of Mr Marler (Panuku).

4.2 I will refer to the evidence to Mr Kennedy (Coastal Environment) and Mr Grant (WEA).

5. EXISTING ENVIRONMENT

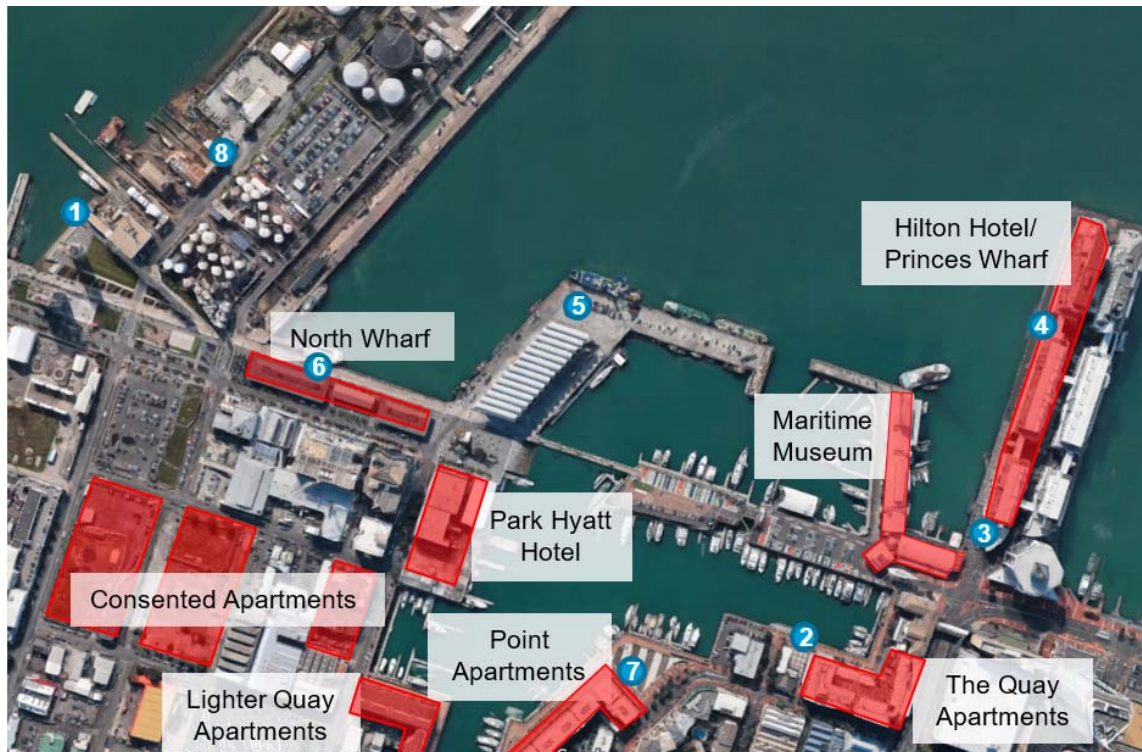
Airborne Noise

5.1 I have undertaken site visits of the project area and inspected inside the Maritime Museum specifically. Surveys of the existing airborne and underwater noise environments were undertaken, primarily by my colleagues at my direction. The surveys are detailed in Section 3 of the construction noise and vibration assessment⁶ and summarised below.

5.2 Airborne noise was measured at eight locations shown overleaf. The results are included in **Appendix A** to this statement of evidence. In summary, the levels during the day and

⁶ CBD Vol A, CB27, page 1719: MDA report Rp 005 r08 20171213, dated 12 April 2018.

evening ranged between 54 and 71 dB L_{Aeq} (15min). The existing airborne noise environment was observed to contain a wide variety of activities, including; marine industrial, commercial establishments such as bars and restaurants, ferry operations, offices, retail shops, residential, commercial and recreational vessel operations, traffic movements and busy public spaces. I also observed that construction noise is a common feature of the general area, including from piling associated with wharf and berth maintenance.



- 5.3 Night-time airborne noise levels were measured at four positions on Tuesday 11 July 2018 from 11.30pm until 4am the following morning. The purpose was to measure a quiet weeknight in winter (i.e. the quietest representative period). In contrast, Friday and Saturday nights in summer are predicted to be louder. This is assumed because bars and restaurants are busier and have open doors and windows in the warmer season. Furthermore, vessel activity increases and cruise ships visit frequently.
- 5.4 The results are included in Appendix A. In summary, the noise levels during the night ranged between 41 and 66 dB L_{Aeq} (15min). The highest levels were measured at Position 3, the southern end of Princes Wharf near Quay Street. The noise levels dropped to 50 – 52 dB L_{Aeq} at position 4, further north on the western side of Princes Wharf. The

existing airborne noise environment was observed to contain noise from music, patrons, pedestrians, road traffic and a tanker. The tanker berthed at Wynyard Wharf was just audible on Princes Wharf. Directly adjacent to the tanker on Brigham Street, it measured 56 dB L_{Aeq} at 60m. By comparison, if a similar sized vessel (e.g. cruise ship) was berthed on Princes Wharf, the noise level at adjacent façades would be up to 60 – 70 dB L_{Aeq} at 10m. This range is supported by further measurements of a cruise ship on Queens Wharf on the afternoon of 13 July 2018. Noise sources included ship ventilation fans and generator, forklift and truck movements (loading/unloading ship) and pedestrian activities.

- 5.5 The relatively high cumulative noise produced by these activities were anticipated for this area, and are reflected in the relevant planning rules. For example, Wynyard Noise Area 1 has a noise limit of 70 decibels applying during the day and night-time periods to accommodate the marine industry, which aligns with the ‘long-term’ daytime construction noise limit in suburban areas. Similarly, no noise limits apply to activities within the Central Wharves Precinct received at Princes Wharf to avoid reverse sensitivity effects of vessels berthed alongside. Elsewhere in the Central Business District (CBD), the Business City Centre Zone noise limits apply (refer exceptions in paragraph 7.2). As a result, new buildings in these areas are required to achieve minimum sound insulation requirements.

Underwater Noise

- 5.6 Underwater noise was measured at three locations shown below. The results are included in Appendix A. In summary, the levels, excluding tidal influences, measured 116 – 124 dB re. 1 $\mu\text{Pa rms}_{(15\text{min})}$. Overall, the existing underwater noise environment is elevated, but typical of a commercial harbour area.



- 5.7 Subsequent to the underwater survey, a suspect performance anomaly was identified in the Mr Styles peer review on behalf of Council. The hydrophone manufacturer reviewed the sensitivity of the hydrophones to examine the calibration and integrity of the equipment used for the survey. The manufacturer concluded⁷ that the equipment was operating within the approved tolerances except for “*a minor deviation in receiving sensitivity in the band 2-4 kHz*”. This potentially elevates the reported levels above by no more than 1 decibel. This is not a significant change to the reported levels and not material to the assessment, conclusions and management measures proposed.
- 5.8 Note that due to variation in both reference pressure level and the properties of the medium (water), the numerical representation of underwater noise levels appear significantly higher than those typical in airborne noise. Furthermore, the characteristics of human hearing are largely irrelevant underwater, so frequency weighted sound descriptors such as dBA are inappropriate. In fact, any weighting system applied is only relevant to the hearing sensitivity of the receiver, which varies widely depending on the species of interest. Therefore, there is no direct relationship between sound levels

⁷ Ocean Instruments NZ Limited, letter dated 6 July 2018.

expressed as decibels (dB), in air and underwater, and comparisons should not be attempted without specialist advice.

6. CONSTRUCTION NOISE AND VIBRATION

Construction Methodology

6.1 With reference to Mr Grant's evidence, construction works are to be carried out over a period of 24 months commencing November 2018. The majority of works will be completed within a 15 month period. Due to the constrained construction programme, provision is sought for works 24 hours per day, 7 days per week. However, activities with an impulsive or tonal character, such as impact pile driving and concrete cutting, will not be undertaken at night in accordance with proposed condition 110 m).

6.2 Representative construction activities include:

- a) Piling activities for wharf construction works, breakwater construction, pontoon and fender installation, and temporary construction platform construction.
- b) Construction of wharf superstructures using cranes to lift precast elements, pumping and placing of concrete.
- c) Dredging using a long reach excavator on a barge.
- d) Wynyard Point buildings platforms - flat concrete raft foundations, cranes and concrete pumps required.
- e) Services relocation - trench excavation and reinstatement.

6.3 Piling activities are predicted to generate the most significant potential noise and vibration effects. This is due to a combination of level and activity duration. Therefore, piling is the focus of the noise and vibration effects assessment.

6.4 The piling assumptions relevant to my assessment report are described as follows:

- a) Hobson Wharf extension and breakwaters using 600mm diameter precast concrete piles, bored into the seabed and backfilled in place. A contingency method included installing vibrated pile casings and impact piling if required.

- b) Halsey Wharf western breakwater using 600mm diameter precast concrete piles, installed as per subparagraph a) above.
- c) Wynyard Point eastern breakwater using 600mm diameter precast concrete piles, installed as per subparagraph a) above.
- d) Wynyard Point wharf infill section using 900mm diameter steel piles, driven using impact or vibratory methods. For the purposes of the underwater noise assessment, the piling rate assumed is 3 piles per day, comprising a total of 900 pile strikes with an enclosed pile head and dolly for impact driven piles, or 180 minutes of driving time for vibro driven piles.
- e) Brigham St ground improvements using closely spaced large diameter piles (e.g. 2m diameter), bored using a Continuous Flight Auger or stone columns using vibro displacement and compaction.
- f) Temporary construction platforms would be vibrated into, and out of, the seabed as required to support the piling operations.

6.5 The revised WEA piling methodology described in the CNVMP⁸ generally requires a smaller number of larger diameter piles. However, many additional piles are required to support breakwaters 7 and 8 on the east and west sides of Hobson Wharf.

6.6 The potential for significant noise and vibration effects primarily relate to Hobson Wharf piling works due to the proximity of sensitive receivers and duration of the piling works. The WEA primary piling methodology for the Hobson Wharf extension and breakwaters is summarised as follows:

- a) Vibrate casing into mud (1 – 2 minutes actuation time)
- b) Impact pile casing into rock (20 – 50 impacts)
- c) Drill rock socket (bore the pile footing within the pile casing)
- d) Install rebar cage in pile and fill pile with concrete to top of pile

⁸ Wynyard Edge Alliance CNVMP (3 August 2018), Section 3.

- 6.7 The CNVMP includes the following typical daily schedule for Hobson Wharf piling works based on an installation rate of three piles per day:
- a) Prior to 7am: Daily briefing and site setup.
 - b) Morning: Piling activities, including 1 – 2 min of vibro piling, 1 – 5 minutes of impact piling and 0.5 – 2 hours of pile boring per pile.
 - c) Afternoon / evening: Balance of pile boring if required, craneage, concrete works and setup for next piles.
 - d) After 10.30pm: Ancillary activities (e.g. reposition tug, survey piles, weld piling gates).
- 6.8 In accordance with proposed condition 110 k), impact and vibratory piling required within 30m of occupied buildings will be scheduled between 8am and 10am to mitigate noise and vibration effects on residents and avoid Maritime Museum opening hours and typical busy periods for bars and restaurants.
- 6.9 In accordance with proposed condition 110 l), impact piling within 100m of any occupied building on Princes Wharf is restricted to between the hours of 7am and 7pm to address amenity concerns in the evening raised by Princes Wharf. This relates to the eastern most piles on breakwater 6 not already captured by condition 110 k) discussed above.
- 6.10 A 'dolly' or 'cushion cap' between the impact piling hammer and the driving helmet will be used to reduce underwater and airborne noise levels.
- 6.11 The Hobson Wharf extension requires approximately two weeks of piling per row of piles. There are seven rows of piles, therefore, a cumulative piling period of approximately 14 weeks. Similarly, breakwater structures 5, 6 and 7 each require approximately 10 days of piling. Structure 8 requires 7 weeks of piling, but the Maritime Museum buildings will mitigate noise levels received east of Hobson Wharf.
- 6.12 I consider that the WEA piling methodology represents the best practicable option because it minimises the duration of piling works, minimises use of impact and vibratory

piling methods, and uses appropriate timing to avoid sensitive periods as far as practicable.

Construction related Airborne Noise

- 6.13 Airborne construction noise has been assessed using the relevant Auckland Unitary Plan: Operative in Part (**AUP:OiP**) rules, the Auckland Regional Plan: Coastal (**RCP**) rules and New Zealand Standard NZS 6803:1999. The coastal provisions of the AUP:OiP became operative on 31 May 2018. While the RCP no longer has any weight, I consider a brief explanation of the previous rules are useful in terms of background and context for the noise rules now applying in the coastal marine area (**CMA**) to the proposed activities.
- 6.14 In the RCP, no construction noise limits applied at buildings on Queens Wharf, Princes Wharf, Hobson Wharf and Halsey Wharf to avoid reverse sensitivity effects on port operations. Construction noise limits only applied on land and aligned with those for other activities in the CBD.
- 6.15 The AUP:OiP construction noise limits in rule E25.6.28 applying at buildings in the Business City Centre Zone are primarily 75 dB L_{Aeq} on weekdays and 60 dB L_{Aeq} at night (CBD Vol E, CB182, page 4448). By comparison, the construction noise limits in rule E25.6.27 applying at buildings in all other zones are 70 / 45 dB L_{Aeq} (day / night) with a constrained daytime period.
- 6.16 Queens Wharf, Princes Wharf, Hobson Wharf and Halsey Wharf are zoned CMA. Despite this, and to retain the effect of the RCP provisions, the Central Wharves Precinct and Port Precincts specifically adopt the limits in E25.6.28 and apply them at buildings on land only (i.e. no construction noise limits apply to receivers in the CMA) (CBD Vol E, CB182, page 4448). The Viaduct Harbour Precinct and Wynyard Precinct do not include a similar provision. Therefore, rule E25.6.27 applies (CBD Vol E, CB182, page 4447). This has some unusual consequences, as demonstrated with the following two examples:
- a) Fender and pontoon piling in the CMA next to North Wharf:
- The relevant construction noise limits applying at the adjacent restaurants on North Wharf in Wynyard Noise Area 1 are 70 / 45 dB L_{Aeq} , despite I214.6.4

enabling day-to-day activities to generate 70 decibels at all times in the CMA in front of those restaurants (CBD Vol E, CB196, page 4963). Note also that new buildings are required to meet minimum sound insulation requirements to “*minimise reverse sensitively effects on industrial and maritime land uses*”.

b) Breakwater piling in the CMA next to Hobson Wharf:

The relevant construction noise limits applying at Princes Wharf buildings are 70 / 45 dB L_{Aeq} . In reverse, no construction noise limits apply to Princes Wharf piling received at Hobson Wharf buildings. Note also that new buildings on Princes Wharf are required to meet minimum sound insulation requirements of the Port Noise Overlay in AUP:OiP part D25, which assumes an incident design level of 70 dB L_{Aeq} at all times. The objective of the overlay is “*the port is protected from reverse sensitivity effects arising from activities sensitive to noise*”, which would include a cruise ship berthed on Princes Wharf.

6.17 To provide a consistent approach, I consider the Business City Centre Zone limits from E25.6.28 should be applied to AC36 construction activities in the Viaduct Harbour Precinct and Wynyard Precinct CMA.

6.18 A proposed condition of any consent (109) provides certainty of the following Project Standards, generally aligned with AUP:OIP Rule E25.6.28 for construction in the Business City Centre Zone, and as modified by Mr Styles:

Day	Time	L_{Aeq} (30min)	L_{AFmax}
Monday to Saturday	0700 – 2230	75	90
Sunday	0900 – 1900	65	85
All other times (night-time)		60	75

6.19 I predict construction activities would generally comply with the relevant project standards above. However, some isolated activities, such as pile driving and concrete cutting, are predicted to exceed the daytime performance standards for brief periods. I have prepared detailed models of piling activities at representative locations using

'SoundPLAN', an environmental noise modelling programme. From the modelling results, I predict pile driving activities will exceed the standard 75 dB L_{Aeq} noise limit at the following occupied buildings:

- a) Maritime Museum: I predict noise levels of up to 85 dB L_{Aeq} at the closest façade from the Hobson Wharf extension (approx. 1 week for each of the closest three rows of piles), breakwaters 6 and 7 (approx. 10 days each) and breakwater 8 (7 weeks). While the Maritime Museum has provided written approval, consultation with the Maritime Museum is considered critical to manage the noise and vibration effects. Section 7.3 of the draft CNVMP relates specifically to the Maritime Museum. It identifies operating sensitivities and opportunities to avoid, remedy or mitigate the potential effects. For example, and as discussed in paragraphs 6.7 – 6.8, impact and vibratory piling within 30m of the Maritime Museum will be scheduled between 8am and 10am to avoid Maritime Museum opening hours.
- b) Hobson Wharf bars and restaurants: I predict up to 85 dB L_{Aeq} for the south end of breakwater 7 (approx. 2 – 3 days). I understand that busy periods for bars and restaurants typically start from 11am. Therefore, the piling timing and durations discussed in paragraphs 6.7 – 6.8 will avoid or mitigate the effects on these businesses.
- c) North Wharf restaurants: I predict noise levels of up to 80 dB L_{Aeq} at the closest façade from the closest Wynyard Wharf pontoon piles (approx. 1 – 2 piles / days per site / restaurant). The WEA piling methodology described in the CNVMP⁹ predicts that these piles would be vibrated directly into mud to embedment over a period of 15 minutes. As discussed in paragraph 6.8, all piles within 30m of a building will be scheduled between 8am and 10am. This will avoid typical busy periods for bars and restaurants.
- d) Wider Project Area: I predict compliance at all other receivers. However, construction noise levels are inherent variability due to factors such as equipment selection, methodology and operator skill and care.

⁹ Wynyard Edge Alliance CNVMP (3 August 2018), Section 3.

- 6.20 Night-works are required due to the constrained construction programme. Activities which have a distinctive impulsive or tonal character, such as impact pile driving and concrete cutting, will not be undertaken at night because they can cause significant adverse effects when undertaken at night-time, even when complying with the project standards summarised in paragraph 6.13. Other night-works may be undertaken provided they are not near residential receivers and comply with the night-time project standards. These activities potentially include; bored piling, vibro piling, generator use, concrete pours and vehicle movements. More specifically for Hobson Wharf, and as discussed in paragraph 6.7, night works relate to quieter ancillary activities such as reposition of the piling barge, survey of piles and welding piling gates in preparation for piling works during the day.
- 6.21 I predict exceedances of the daytime project standards for several nearby receivers. However, I consider these are reasonable provided they are of limited duration and BPO measures are implemented through a CNVMP to avoid, remedy and mitigate the noise emissions as far as practicable. This includes the measures to control effects of impact and vibratory piling in paragraphs 6.7 – 6.12.

Construction related Vibration

- 6.22 AUP:OIP rule E25.6.30 (1) (a) (CBD Vol E, CB182, page 4454) requires construction vibration to be measured and assessed in accordance with German Standard DIN 4150-3:1999 “Structural vibration – Part 3: Effects of vibration on structures”. The criteria relate to the avoidance of cosmetic building damage, such as cracking in paint or plasterwork, and are much lower than those that would result in structural damage. The criteria vary depending on the receiving structures sensitivity to vibration and the signal type (e.g. transient or continuous vibration).
- 6.23 AUP:OIP rule E25.6.30 (1) (b) requires construction to also comply with vibration amenity standards in occupied buildings. The thresholds are lower than those that relate to cosmetic damage, but allow more permissive levels for a short period if there is advanced communication detailing the works and providing contact details.
- 6.24 Proposed conditions of any consent (109A – 109C) provide certainty of the Project Standards, aligned with the requirements of AUP:OIP rule E25.6.30 (1).

- 6.25 Impact and vibratory piling methods generate appreciable vibration levels that dissipate with distance. I have predicted vibration levels for these activities using regression analysis of available measurements, with the addition of a 100% safety factor to ensure a conservative potential effects envelope.
- 6.26 I predict that impact and vibratory piling undertaken immediately adjacent to the Maritime Museum has the potential to exceed the cosmetic building damage thresholds. I recommend a pre-construction building condition survey and vibration monitoring for the Maritime Museum buildings. I predict compliance at other buildings.
- 6.27 Using the same regression analysis, I predict that impact and vibratory piling has the potential to exceed the vibration amenity limits for brief periods in the following buildings if occupied during piling works:
- a) Maritime Museum and restaurants on Hobson Wharf
 - b) North Wharf restaurants
 - c) Occupied offices between Brigham and Hamer Streets
- 6.28 Aligned with paragraph 6.19a) above, Section 7.3 of the draft CNVMP relates specifically to the Maritime Museum.
- 6.29 Aligned with paragraph 6.19b) above, the effects may be avoided through timing, minimising the period of disturbance and advanced communication works dates and duration. With reference to paragraph 6.8, impact and vibratory piling required within 30m of occupied buildings will be scheduled between 8am and 10am to mitigate vibration effects on residents, and avoid Maritime Museum opening hours and typical busy periods for bars and restaurants. With reference to paragraph 6.7, this will typically include 1 – 2 minutes of vibro piling and 1 – 5 minutes of impact piling for three piles per day. The duration of piling works within 30m of buildings is described in paragraph 6.19.
- 6.30 Vibration from the proposed piling works has the potential to be perceptible at receivers in the wider project area, such as the apartments on Princes Wharf. The effects for these receivers are expected to be minimal provided that the activity is brief and the timing of the activity is communicated in advance.

- 6.31 I consider the predicted vibration amenity effects are reasonable, provided that they are of a limited duration and BPO measures are implemented through a CNVMP to avoid, remedy and mitigate the vibration emissions as far as practicable. This includes the measures to control effects of impact and vibratory piling in paragraphs 6.7 – 6.12.

Construction related Underwater Noise

- 6.32 Section 16 ‘Duty to Avoid Unreasonable Noise’¹⁰ of the RMA requires adoption of the best practicable option to ensure underwater noise emissions do not exceed a reasonable level.
- 6.33 Section F2.18 of the AUP:OIP includes objectives and policies relating to the management of the adverse effects of underwater noise on marine mammals (CBD Vol E, CB191, page 4762). Table F2.19.8 (A114) classifies “*underwater blasting, impact and vibratory piling, and marine seismic surveys*” as restricted discretionary activities (CBD Vol E, CB191, page 4780). Therefore, an assessment of underwater noise effects is required for this project due to the use of impact and vibratory piling methods.
- 6.34 My colleague predicted noise from underwater piling noise using ‘dBSea’ which enables spatial visualisation of the various zones of influence. The model assumes mitigation in the form of a wooden or polymer dolly between the hammer and pile for the impact driven steel piles and construction summarised in paragraph 6.4 above.
- 6.35 Mr Paul Kennedy has identified that the following species of marine mammal that typical enter the Waitematā Harbour:
- a) Bottlenose dolphins, common dolphins and orca are mid-frequency cetaceans (mf) for the purposes of underwater noise sensitivity
 - b) Leopard seals are phocid pinnipeds (pw) for the purposes of underwater noise sensitivity;

¹⁰ S16 (1) states: “Every occupier of land (including any premises and any coastal marine area), and every person carrying out an activity in, on, or under a water body or the coastal marine area, shall adopt the best practicable option to ensure that the emission of noise from that land or water does not exceed a reasonable level”.

- c) Fur seals are otariid pinnipeds (ow) for the purposes of underwater noise sensitivity (these were not included in my original assessment, but have been assessed here with no change to the conclusions or management measures).

6.36 I have relied on the National Oceanic and Atmospheric Administration: 'Technical Guidance for Assessing the Effects on Anthropogenic Sound on Marine Mammal Hearing' (**NOAA**). The NOAA guidelines identify the received levels above which individual marine mammals are predicted to experience changes in hearing sensitivity. These changes are either temporary (**Temporary Threshold Shift** or **TTS**), or permanent (**Permanent Threshold Shift** or **PTS**).¹¹ Auditory threshold shifts can be caused from peak exposure (high-level impulsive events such as pile strikes) or from cumulative exposure (lower noise levels over an extended period such as from vibro-piling or multiple pile strikes).

6.37 The management protocol are linked to the predicted TTS zones. The zones in Section 5.3 of the WEA CNVMP¹² are much smaller than my assessment report due to the limited use of impact and vibratory piling methods. Regardless, and to address proposed condition 110C, the protocol in Section 6.7 of the CNVMP¹³ requires:

- a) Underwater noise monitoring of the first occurrence of impact and vibratory piling methods to allow verification of the TTS zones
- b) Visual monitoring 30 minutes prior to commencing piling operations to ensure there are no marine mammals within the TTS zones
- c) Use of a wooden (preferable) or plastic dolly for impact driven piles, 'soft starts' (gradually increasing the piling intensity) and minimising duty cycle
- d) Visual monitoring during piling and implement low power or shut down procedures if a marine mammal is identified within the TTS zones

¹¹ TTS in humans can be likened to the 'muffled' effect on hearing after being exposed to high noise levels such as at a concert. The effect eventually goes away, but the longer the exposure, the longer the threshold shift lasts. Eventually, the TTS becomes permanent (PTS).

¹² Wynyard Edge Alliance CNVMP, dated 3 August 2018.

¹³ Wynyard Edge Alliance CNVMP, dated 3 August 2018.

6.38 NOAA also provides interim guidance for behavioural impacts, which are variable in nature and scale. Mr Kennedy discusses the potential behavioural effects in the context of the Waitematā Harbour in his evidence (refer paragraphs 8.10 – 8.11).

7. OPERATIONAL NOISE

Operational Noise Performance Standards

Operational Noise (excluding Noise Events)

7.1 The team bases and village events are proposed in the Viaduct Harbour and Wynyard Precincts with respect to the AUP:OiP. With the exception of buildings on Princes Wharf and Hobson Wharf, all proximate noise sensitive receivers are zoned Business City Centre Zone. The following standard AUP:OiP Rule E25.6.8 noise limits apply to day-to-day activities received in the Business City Centre Zone (CBD Vol E, CB182, page 4432):

- | | | |
|----|--------------------|---|
| a) | 7am – 11pm (day) | 65 dB L_{Aeq} |
| b) | 11pm – 7am (night) | 60 dB L_{Aeq}
65 dB L_{eq} (63 Hz)
60 dB L_{eq} (125 Hz)
75 dB L_{AFmax} |

7.2 The following exceptions are noted:

- a) No noise limits apply to receivers on Princes Wharf and Hobson Wharf because they are not on a 'site' (they are located in the CMA and the AUP:OiP definition for a 'site' is on land). This anomaly is similar to the problems with the CMA construction noise rules discussed in paragraph 6.16. To provide a consistent approach, I consider the Business City Centre Zone limits from E25.6.8 should generally be applied to Americas Cup activities in the Viaduct Harbour Precinct and Wynyard Precinct CMA.
- b) AUP:OiP Rule I214.6.4.2 enables slightly higher noise limits for activities in Wynyard Precinct Noise Area 1 received at buildings with habitable spaces in

Noise Area 1, and slightly lower limits for those in Noise Area 2 (further away) (CBD Vol E, CB196, page 4964).

7.3 Proposed condition 168A provides certainty of the noise rules that apply to operational noise (excluding Noise Events discussed further below). Conditions 168A e) and f) proposed noise limits for Base B activities (Hobson Wharf extension) assessed at Princes Wharf. The reasoning for these controls are discussed in the JWS. In summary, the noise limits are aligned with those for the Business City Centre, except:

- a) 168A e) applies to all activities except amplified sound addressed by 168A f). It is anticipated this would apply to the launching and maintenance of boats on Base B. It does not include the low frequency controls, which are generally applied to address amplified sound, as this addressed separately in 168A f).
- b) 168A f) applies to amplified sound specifically. The 55 dB L_{Aeq} night-time noise limit is 5 decibels lower the normal 60 dB L_{Aeq} .

Noise Events

7.4 In addition to the day-to-day noise limits, AUP:OiP Viaduct Harbour Precinct Rule I211.6.1 (CBD Vol E, CB195, pages 4928) and Wynyard Precinct Rule I214.6.4(4) allow relaxed noise limits for 15 noise events¹⁴ per Precinct in each calendar year (CBD Vol E, CB196, pages 4964). The relevant noise limits are summarised as follows:

Precinct	Medium noise events (other events, 6 hours)	High noise events (up to 3 events, 3 hours)
Viaduct Harbour Precinct	72 dB L_{Aeq}	82 dB L_{Aeq}
	80 dB L_{A01}	90 dB L_{A01}
	76 dB L_{eq} (63 Hz)	76 dB L_{eq} (63 Hz)
	76 dB L_{eq} (125 Hz)	76 dB L_{eq} (125 Hz)
Wynyard Precinct	75 dB L_{A10}	85 dB L_{A10}
	80 dB L_{A01}	90 dB L_{A01}

¹⁴ Event times restricted to: Sunday – Thursday 10am – 10.30pm, Friday – Saturday 10am – 11pm, and New Years Eve 10am – 1am.

- 7.5 The Wynyard Precinct noise limits use the outdated L_{A10} measurement descriptor. For consistency, I consider that these should be converted to the L_{Aeq} equivalent, which would then align with the Viaduct Harbour Precinct rule.
- 7.6 I consider that Viaduct Harbour low frequency controls (63 Hz and 125 Hz) are not necessary for outdoor events. However, Point Body Corporate (37) seek to retain the low frequency controls in Viaduct Harbour Precinct Rule I211.6.1. I accept the retention of the Medium Noise Events low frequency controls, but I consider the High Noise Events low frequency controls are prohibitively low and would effectively constrain them to Medium Noise Events. I consider the High Noise Event low frequency controls should be increased by 10 decibels, which is in proportion with the overall L_{Aeq} and L_{A01} descriptors.
- 7.7 To address these matters, proposed condition 183Q replaces the noise limits in Standards I214.6.4 (4) (a) and I211.6.1 (a) (ii) with the following:
- a) Medium Noise Events:
 - 72 dB L_{Aeq} and 80 dB L_{A01}
 - 76 dB L_{eq} at 63 Hz
 - 76 dB L_{eq} at 125 Hz
 - b) High Noise Events:
 - 82 dB L_{Aeq} and 90 dB L_{A01}
 - 86 dB L_{eq} at 63 Hz
 - 86 dB L_{eq} at 125 Hz
- 7.8 Standards I214.6.4 (4) (a) and I211.6.1 (a) (ii) also does not explicitly exclude crowd noise from the noise events limits. However, by way of example, the citywide temporary events noise rule in AUO:OiP rule E40.6.1 (5) states: “*Crowd noise must not be included in any noise measurement*”. I consider that crowd noise is not effectively controlled with a noise limit, is not readily predictable or repeatable. I consider crowd noise will instead be addressed using the Noise Event Management Plan provisions in Conditions 183N – 183P.
- 7.9 I note that the changes proposed through condition 183Q are the subject of the Matters Not Agreed detailed in Section 4 of the JWS.

America's Cup Activities

7.10 Details of the AC36 activities are yet to be developed. Based on similar events in the Viaduct, such as the Volvo Ocean Race and Rugby World Cup, the potential noise making activities are:

- a) A series of PA speakers would be placed around the event village. They would play race commentary, interviews and promotional material at relatively low levels to inform and engage members of the public. These would be calibrated in accordance with proposed condition 168B and controlled to ensure compliance with the day-to-day noise rules in condition 168A.
- b) Syndicate base activities, including corporate and sponsor related events at their bases would be controlled to ensure compliance with the day-to-day noise rules in condition 168A.
- c) AC36 live music events (e.g. opening ceremony) would occur at scheduled times in primary entertainment areas, be limited in duration and number. They would be set up and controlled to ensure compliance with the event noise rules in conditions 183Q – 183R.
- d) The intensity of public activity would increase during AC36 events. In addition, I expect brief intermittent periods of crowd cheering during races and events.

7.11 Subject to the proposed amendments to conditions 168A and 183Q, I predict that the AC36 events would comply with the relevant noise limits.

Legacy Activities

7.12 Legacy activities would be assessed on a case by case basis. However, I consider the spaces and infrastructure which are proposed to remain for legacy activities generally have sufficient separation from noise-sensitive receivers to enable a range of future activities. These future activities will need to comply with the relevant AUP provisions at that time.

8. COMMENTS ON THE COUNCIL REPORT

8.1 I have reviewed the aspects of Auckland Council's report which are relevant to noise and vibration. I have also read the peer review prepared by Mr Jon Styles and Dr Matthew Pine (Styles Group). In summary:

- a) Mr Styles generally agrees with the conclusions of my assessment and the framework of the draft CNVMP I prepared. He has provided considerable further discussion on the potential effects to support this position.
- b) Mr Styles considers that the potential noise and vibration effects on the Maritime Museum are significant. I agree. As discussed in paragraph 6.19, Maritime Museum have since provided written approval. Nonetheless, specific measures are proposed to avoid, remedy or mitigate the potential effects as far as practicable.
- c) Mr Styles recommended changes to conditions 1 (r), 109 – 110C, 168A – 168B and 183Q to provide clarity, certainty and enforceability. These conditions were further refined during expert conferencing and mediation. The changes do not affect my assessment conclusions.

9. COMMENTS ON SUBMISSIONS AND MATTERS RAISED BY SECTION 274 PARTIES

9.1 I have reviewed the submissions and respond to concerns relevant to my expertise in the submissions of Mr Stevens (1), Mr Wiggs (11), The Point Body Corporate (39), Combined Owners and Residents of the Apartments in Sheds on Princes Wharf (48), ASB (78), Kiwi Property Group Limited (71) and Lighter Quay Body Corporate (70).

9.2 Mr Stevens (1) has three general concerns:

- a) Effects of pile driving on marine life: I have described the potential auditory effects in paragraph 6.36 and proposed adaptive management protocol in paragraph 6.37. The proposed measures will avoid significant auditory effects on marine mammals. Mr Kennedy provides further context on the potential behavioural effects in his evidence.

- b) Potential damage to Princes Wharf: I predict piling vibration would comply with the relevant criteria that relate to the avoidance of cosmetic building damage. Therefore, I do not consider there to be potential for damage to Princes Wharf.
- c) Duration of construction noise and vibration: I note that the address provided relates to one of the Sheds on Princes Wharf. Detailed information on the duration of Hobson Wharf piling activities is discussed in paragraphs 6.5 – 6.11.

9.3 Mr Wiggs (11) has three specific concerns:

- a) The 90 dB L_{AFmax} daytime noise limit is too high and the period too broad: The limits and periods align with standard construction noise limits for the Business City Centre in AUP:OIP E25.6.28. I also note that address provided (11 Pakenham Street) is more than 300m from the closest piling works and will be screened by buildings fronting the Viaduct Basin. At this receiver distance, I predict levels below 75 dB L_{AFmax} , which is the night-time noise limit for normal activities (rather than more permissive construction noise limit).
- b) Very loud activities should be prohibited at night: In accordance with paragraph 6.1, condition 110B m) requires that impact piling and concrete cutting may only be undertaken during the daytime periods defined in condition 109. Other night-works may be undertaken provided they comply with the project standards. The approach to night works is specifically addressed in Section 6.3 of the CNVMP¹⁵.
- c) Requests a noise complaints mechanism for both construction and events: Condition 110D requires monitoring in response to a reasonable construction noise and / or vibration complaint. Section 6.0 of the CNVMP sets out the communication, consultation and complaints protocol. Public signage and communication should also include contact details. Likewise, Condition 1830 includes objectives for a Noise Events Management Plan, including complaints handling procedures.

¹⁵ Wynyard Edge Alliance CNVMP (3 August 2018).

- 9.4 The Point Body Corporate (39) discuss two relevant matters:
- a) Typographical errors in the AUP:OiP Noise Events rule reference (conditions set dated 13 April 2018): I confirm revised conditions 183O and 183P refer to the correct rules.
 - b) Crowd noise should be subject to the noise rules: This matter is summarised in paragraphs 7.6 – 7.9 and detailed further in the JWS.
- 9.5 Princes Wharf apartment owners and residents (54) raise many concerns regarding noise and vibration. Mr Mark Vinall (Unio), Mr Karl Cook (Unio) and I met with David and Leonie Ramsay (submitter representatives), their legal specialist Sarah Watson (Duncan Cotterill) and acoustic expert Arif Zaher (NDY) on 6 July 2018. We generally discussed the following relevant aspects of their written submission:
- a) Vibration effects: I summarised the updated WEA Hobson Wharf construction methodology described in paragraphs 6.6 – 6.11. With reference to paragraph 6.7, this will typically include 1 – 2 minutes of vibro piling and 1 – 5 minutes of impact piling for three piles per day between 8am and 10am. The vibration levels could be perceptible at times, but are predicted to comply with the vibration limits applying to cosmetic building damage and vibration amenity at all times. Adverse comment is unlikely with prior knowledge of the works.
 - b) Certainty for night works: As discussed in paragraph 6.1, I advised that activities with an impulsive or tonal character, such as impact pile driving and concrete cutting, will not be undertaken at night. As discussed in paragraph 6.7, I advised that proposed night works on Hobson Wharf relate to quieter ancillary activities such as reposition of the piling barge, survey of piles and welding piling gates in preparation for piling works during the day.
 - c) Noise Limits: As discussed in paragraphs 6.13 – 6.17, I explained why I consider the Business City Centre Zone construction noise limits from E25.6.28 should be applied to Americas Cup construction activities in the Viaduct Harbour Precinct and Wynyard Precinct CMA to provide consistency across the project area and CBD. Mr and Mrs Ramsay preferred that the lower noise limits in E25.6.27 should be retained because the existing noise environment on Princes

Wharf is quieter than other parts of the inner city. However, as discussed in paragraph 6.16, Princes Wharf is a dynamic noise environment. Accordingly, new buildings on Princes Wharf are required to meet minimum sound insulation requirements of the Port Noise Overlay in AUP:OiP part D25 assuming an incident level of 70 dB L_{Aeq} at all times. The objective of the overlay is “*the port is protected from reverse sensitivity effects arising from activities sensitive to noise*”, which would include a cruise ship berthed on Princes Wharf. Conversely, and as discussed in paragraph 7.2, no limits apply to day-to-day activities and Noise Events received at Princes Wharf due to a similar anomaly in the operational noise rules. Again, to provide a consistent approach, I consider the Business City Centre Zone noise limits from E25.6.8 should be applied to Americas Cup activities in the Viaduct Harbour Precinct and Wynyard Precinct CMA.

- 9.6 ASB (78) and Kiwi Property Trust (71) are concerned about construction noise and vibration, and events noise effects on the ASB building in Wynyard Quarter. I predict construction noise levels will comply with the proposed construction limits at their building. They request to be kept informed of any potential disruption, and consulted where practicable to mitigate and manage these effects. Section 6.0 of the CNVMP sets out the communication and consultation protocol. I consider that the predicted noise and vibration effects at the ASB building would be suitably addressed through the communication protocol, however, any residual matters could equally be addressed through consultation if required.
- 9.7 Lighter Quay Body Corporate (70) questions the need for 24 hour works and suggests incentives could be utilised to prioritise noisy works during daylight hours. This matter is addressed by my response in paragraph 9.3b) to a similar submission point by Mr Wiggs (11).
- 9.8 Other submissions (Viaduct Harbour Holdings Limited (#33), Jack Tar (#42), The Conservatory (#43), Fu Wah New Zealand Limited (#49) and Rushworth Café (#67)) mention general concerns about disruption from construction noise. I consider that CNVMP provides a suitable adaptive management framework to minimise disruption in accordance with best practice.

10. CONCLUSION

10.1 I have assessed noise and vibration associated with the construction of AC36 infrastructure, hosting of the AC36 events, and potential legacy activities.

10.2 In relation to construction noise and vibration:

- a) I predict airborne construction noise will generally comply with the relevant project standards. However, I predict that piling and concrete cutting will exceed the limits for brief periods at occupied buildings.
- b) I predict construction vibration will generally comply with the relevant project standards. However, piles driven directly adjacent to the Maritime Museum have the potential to locally exceed the cosmetic building damage vibration limits. Vibration may be perceptible in the wider project area for brief periods.
- c) I consider the underwater noise effects should be managed by implementing low power or shut down procedures for the piling works when a marine mammal or diver is identified within the TTS zones.
- d) I consider the construction noise and vibration effects will be reasonable provided they are of limited duration and BPO measures are implemented through the draft CNVMP to avoid, remedy and mitigate the noise emissions as far as practicable. This includes the specific measures relating to piling and concrete cutting in the conditions 110 – 110C.

10.3 In relation to AC36 Events and potential legacy activities:

- a) AC36 Events include a series of public address (PA) speakers, syndicate base activities and live music noise events (e.g. opening ceremony).
- b) I consider that all AC36 activities can comply with the proposed operational noise conditions and the associated noise effects are reasonable.

- c) Legacy activities would be assessed on a case by case basis, as required. However, I consider that the applicable noise limits enable a wide range of future activities that would generally not constrain potential legacy activities.

Craig Fitzgerald
7 August 2018

APPENDIX A – EXISTING NOISE ENVIRONMENT MEASUREMENTS

A.1 The following table summarises a series of airborne noise levels at eight positions shown in paragraph 5.2 between 3pm and 5pm on Thursday 30 November 2017, 12pm and 2pm on Wednesday 13 December 2017 and 2pm and 3pm on Wednesday 7 March 2018. Evening measurements were undertaken between 9:30pm and 11pm on Saturday 9 December 2017.

Period	Measurement position	Noise levels (dB)			Noise sources and comments
		L _{Amax}	L _{Aeq}	L _{A90}	
Day	1 Silo Park	75	55	50	Trucks, marine construction/maintenance, music from boat area, pedestrians, birds
	2 Market Square	72	60	58	Pedestrians, restaurant patrons, boats
	3 Princes Wharf – South end	73	62	59	Road traffic, pedestrians, restaurant patrons
	4 Princes Wharf – Midway	65	54	51	Boats, pedestrians, restaurant set up, cars in carpark, birds
	5 Viaduct Events Centre	76	67	64	Crane unloading boat, refrigerator truck, construction noise from east of dock, vehicles
	6 North Wharf restaurants	75	62	58	Restaurant patrons, music, sea plane, helicopter and vehicle movements
	8 38 Hammer Street	77	60	51	Industrial activity, trucks, cars
	Evening	2 Market Square	86	71	69
4 Hobson Wharf – South end		72	55	52	Restaurants, pedestrians
7 Waitematā Plaza		69	57	55	Restaurants/bars, pedestrians, cars

A.2 The table below and overleaf summarises a series of further airborne noise levels at four positions shown in paragraph 5.2. The measurements were undertaken on Tuesday 11 July 2018 from 11.30pm until 4am the following morning.

Period	Measurement position	Noise levels (dB)			Noise sources and comments
		L _{Amax}	L _{Aeq}	L _{A90}	
Round 1	3 Princes Wharf – South end	75	66	63	Bar music, traffic, pedestrians
	4 Princes Wharf – Midway	72	52	51	Bar music, pedestrians, distant traffic, tanker on Wynyard Wharf just audible
	6 North Wharf restaurants	65	45	41	Distant bar music, generator, traffic
	7 Waitematā Plaza	68	45	39	Distant traffic, pedestrians, mech plant

Period	Measurement position	Noise levels (dB)			Noise sources and comments	
		L _{Amax}	L _{Aeq}	L _{A90}		
Round 2	3	Princes Wharf – South end	78	66	63	Bar music, traffic, pedestrians
	4	Princes Wharf – Midway	67	50	49	Bar music, pedestrians, tanker on Wynyard Wharf just audible
	6	North Wharf restaurants	73	54	44	Bar music, tanker on Wynyard Wharf, distant traffic.
	7	Waitematā Plaza	55	41	38	Distant traffic, distant boat engine, pedestrians

A.3 The following table summarises the average underwater noise levels at three locations shown in paragraph 5.6 for a period of two weeks (17 November – 1 December 2017). Note anomalies in the measured levels are discussed in paragraph 5.7.

Position	Period	Measured Levels (dB re. 1 µPa 63 Hz – 24 kHz)	
		RMS (15 min)	L _{peak} (1 sec)
MP1	Day (0700 – 2200) / Night	124 / 123	173 / 174
MP2	Day (0700 – 2200) / Night	119 / 118	166 / 168
MP3	Day (0700 – 2200) / Night	122 / 116	162 / 163

APPENDIX B – CONSTRUCTION NOISE AND VIBRATION MANAGEMENT PLAN

The Wynyard Edge Alliance CNVMP, dated 3 August 2018, is attached overleaf.



Wynyard Edge Alliance

America's Cup – Wynyard / Hobson Construction Noise and Vibration Management Plan (DRAFT)

This DRAFT management plan has been prepared for discussion purposes only.

When reading this plan please note the following:

- The plan is based on the amended proposed draft conditions dated 27 July 2018.
- The plan is based on the design and construction methodology as at July 2018 and these are subject to change as the design and construction planning is progressed concurrently with the resource consent process.
- The plan is a draft for discussion with relevant submitters, other stakeholders and Auckland Council specialists.
- The plan will continue to be refined to reflect the agreed changes to conditions, address key issues from the consent process and to reflect the developing design and construction planning.

Revision History

Revision N ^o	Description	Prepared By	Reviewed by	Approved on behalf of Wynyard Edge Alliance	Date
A	Draft plan for Auckland Council pre-submission comment Items highlighted green indicates details still to be confirmed by the Alliance	Craig Fitzgerald (Marshall Day Acoustics)	Brendon Barnett Bob Mawdsley Edwin Zwanenburg Kurt Grant Ted Polley	Ian Campbell	03-07-18
B	Draft plan for Auckland Council pre-submission comment Items highlighted green indicates details still to be confirmed by the Alliance	Craig Fitzgerald (Marshall Day Acoustics)	Bob Mawdsley Kurt Grant	Deborah Morley	18-07-18
C	Draft plan following submitter feedback	Craig Fitzgerald (Marshall Day Acoustics)	Kurt Grant	Ian Campbell	23-07-18
D	Draft plan for inclusion in evidence Items highlighted green indicates details still to be confirmed by the Alliance	Craig Fitzgerald (Marshall Day Acoustics)	Kurt Grant Bob Mawdsley Brendon Barnett	Ian Campbell	03-08-18

Disclaimer

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Appendices

Appendix A

Glossary of Terminology

Appendix B

Overview of Construction Works

Appendix C

Construction Noise Contours

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1 Relevant consent conditions

The consent conditions relevant to the Construction Noise and Vibration Management Plan (“CNVMP”) are summarised in Table 1.1 below. The conditions referenced are as per in the proposed draft resource consent conditions¹. **[Note: this CNVMP will be updated to reflect the final conditions when available]**

Table 1.1: Summary of consent conditions relevant to the CNVMP.

Condition Number	Condition requirement	Section referenced in the Plan
109	Construction noise shall be measured and assessed in accordance with the provisions of New Zealand Standard NZS 6803:1999 “Acoustics – Construction Noise” and comply with Project Standards (see Table 4.1) unless otherwise provided for in the CNVMP (refer condition 110).	4.1
109A	Vibration arising from construction activities which may affect people and buildings shall be measured in accordance with ISO 4866:2010 <i>Mechanical vibration and shock – Vibration of fixed structures – Guidelines for the measurement of vibrations and evaluation of their effects on structures</i> and shall comply with the Category A vibration standards (see Table 4.2).	4.2
109B	Vibration from construction activities shall comply with the Category A standards in Condition 109A unless otherwise provided for in the CNVMP (refer condition 110).	4.2
109C	Vibration may only exceed Category B standards at existing buildings located on Hobson Wharf and only subject to compliance with the management procedures set out in the CNVMP (refer condition 110).	4.2
110	a. At least 5 working days prior to Commencement of Construction, the consent holder shall submit a Construction Noise and Vibration Management Plan (CNVMP) to the Team Leader Compliance Monitoring – Central for certification.	This Plan
110A	<p>The objectives of the CNVMP are to:</p> <ul style="list-style-type: none"> a) Enable the identification of the Best Practicable Option (BPO) for the management of all construction noise and vibration effects; b) Define the procedures to be followed when the noise and vibration standards in the Construction Noise and Vibration conditions are not met following the adoption of the BPO; c) Set out the methods for scheduling works to minimise disruption; d) Ensure engagement with affected receivers and timely management of complaints; and e) Protect wellbeing of marine mammals. <p>The CNVMP shall be in general accordance with the Construction Noise and Vibration Management Plan as referenced in the Annexure to these consents, with any changes from that revision to be marked up with tracked changes and shall include:</p> <ul style="list-style-type: none"> a) A description of the works; 	<p>2.1</p> <p>2.2</p>

¹ Unio Environmental, 27 July 2018. America’s Cup Wynyard Hobson – Panuku Amended Proposed Conditions.

Condition Number	Condition requirement	Section referenced in the Plan
	b) Hours of operation, including a specific section on works permitted at night, incorporating clear definitions of the works permitted to be undertaken at night;	3.1, 6.3
	c) Contact details for staff responsible for implementation of the CNVMP;	2.5
	d) The construction noise and vibration performance standards for the project;	4
	e) Minimum separation distances from receivers for plant and machinery where compliance with the construction noise and vibration standards is achieved;	5, Appendix C
	f) Identification of affected sensitive receivers where noise and vibration performance standards apply;	5, Appendix B, Appendix C
	g) A specific section setting out the predicted noise and/or vibration levels, mitigation, monitoring and management measures (including communication with stakeholders) that will be adopted for works which cannot comply with the project standards specified in Conditions 109 and 109A. This section shall include the information above for each activity that cannot practicably comply. This section may be in the form of site specific plans which would require certification from the Council before the works can proceed;	6, 7, 8
	h) Management and mitigation options to manage the underwater noise effects on marine mammals from impact and vibratory piling methods, including defined marine mammal management zones, marine mammal observation procedures, measurements of underwater noise at the commencement of vibratory and impact piling to calibrate underwater noise model, and procedures to adopt when marine mammals are present inside the management zones;	6.7, 8.4
	i) Methods and frequency of monitoring and reporting. This shall include monitoring during the first occurrence of impact piling, bored piling, vibro piling, other activities that are predicted to exceed the project standards in Condition 109 and the Category A standards in Condition 109A, and repeated if different equipment is utilised to undertake these activities;	8.1, 8.2
	j) Communication, consultation and complaints response protocol including specific provisions for determining the times that receivers are sensitive to noise and vibration and the extent to which-high noise and vibration works can be scheduled around those times where practicable (including residential, office, hospitality and tourism activities);	7
	k) A section requiring that impact and vibratory piling within 30m of occupied buildings (including on Hobson Wharf and North Wharf) shall be scheduled between 8am and 10am unless otherwise agreed with the building occupants;	3.1, 3.2, 6.7, Appendix B
	l) A section requiring that all impact piling within 100m of any occupied building on Princes Wharf is restricted to between the hours of 7am and 7pm, unless the Council certifies that impact piling outside of these hours is consistent with the BPO; and	3.1, 3.2, 6.7

Condition Number	Condition requirement	Section referenced in the Plan
	m) A section requiring that impact piling and concrete cutting may only be undertaken during the daytime periods defined in Condition 109.	3, 6.3, 6.6, 6.7
110A	In all cases, piling work may not commence until the absence of marine mammals inside the effects management zones identified in the CNVMP is confirmed visually. All piling work shall cease in the event that a marine mammal is detected within the effects management zones identified in the CNVMP.	6.7
110B	In the event of a noise and/or vibration complaint, monitoring shall be undertaken where the activity and methodology has not already been shown to be compliant with the Project Standards in Conditions 109 – 109C at that location. Council may waive the requirement for further monitoring where it would not better inform the complaint.	7.4

DRAFT

2 Introduction

This Construction Noise and Vibration Management Plan (“CNVMP”) forms part of a comprehensive suite of environmental controls within the Construction Environmental Management Plan (“CEMP”) for the America’s Cup Infrastructure Project (“the Project”). The Project is being delivered by the Wynyard Edge Alliance (“the Alliance”).

2.1 Scope and objectives of the Construction Noise and Vibration Management Plan

This CNVMP identifies the performance standards for the Project and sets out best practicable options (BPO) for noise and vibration management.

The objectives of the CNVMP, as outlined in Condition 110A are to:

- a) Enable the identification of the BPO for the management of all construction noise and vibration effects;
- b) Define the procedures to be followed when the noise and vibration standards in the Construction Noise and Vibration conditions are not met following the adoption of the BPO;
- c) Set out the methods for scheduling works to minimise disruption;
- d) Ensure engagement with affected receivers and timely management of complaints; and
- e) Protect wellbeing of marine mammals.

This Plan addresses the matters in Conditions 109 – 110B (refer to the quick reference guide to conditions in Section 1 at the front of this Plan).

The final version of this CNVMP will be submitted to the Team Leader Compliance Monitoring – Central in accordance with Condition 110 for certification.

This CNVMP shall be implemented throughout the construction period. It shall be considered a ‘living document’ that is expanded and updated as the Project progresses and working conditions become clearer. It is intended to be the primary tool to manage the Project’s construction noise and vibration effects.

This CNVMP will be updated if necessary to reflect changes in design, construction methods or to manage effects. In accordance with the consent conditions, any amendments are to be agreed by the Team Leader Compliance Monitoring – Central in writing prior to implementation of any changes. A copy of the original CNVMP and subsequent versions will be kept for the Project records, and marked as obsolete. Each update of the Plan will be issued with a version number and date.

A glossary of terminology is included in Appendix A.

2.2 Project description

For a description of the Project, refer to the Project Description within the CEMP. The construction details relevant to this plan are set out in Section 3.

2.3 Associated Management Plans

The CEMP outlines the environmental management framework for the Project and details the relationship between the CEMP, environmental management plans, design certification requirements and the resource consent conditions. It also provides an overview of the management plans required by the conditions (their purpose and content etc.) and other environmental mitigation measures to be implemented during construction.

The CEMP outlines the Project construction methodology, which is relevant to the context of this CNVMP.

2.4 Responsibilities

The Alliance Project Director has the overall responsibility for the Alliance complying with the requirements outlined in this CNVMP.

The Alliance Construction Manager in conjunction with the Alliance Construction Environmental Manager will implement the CNVMP. Refer to the CEMP for more detail on roles and responsibilities within the Alliance as they relate to construction environmental management of the Project.

2.5 Project contacts

Table 2.1 provides the contract details for key Alliance staff as they relate to this CNVMP, along with the Project hotline, for general queries or complaints. Further, complaint response requirements specific to this CNVMP are detailed in Section 7.4.

Table 2.1: Project contact details

Project hotline	TBC	
Stakeholder Manger	Michael Goudie	021 810 194
Construction Manager	Kurt Grant	021 834 512
Construction Environmental Manager	Brendon Barnett	021 527 461
Acoustic Specialist	Craig Fitzgerald (MDA)	021 534 899

Further Project contact details are provided in the CEMP.

3 Proposed America's Cup Infrastructure Works

3.1 Construction timing

Construction works will occur over a duration of approximately 24 months, commencing in November 2018. The majority of works will be completed within a 15 month period. Due to the constrained construction programme, some works may be undertaken 24 hours per day, 7 days per week. However:

- Impact pile driving and concrete cutting will not be undertaken at night (refer Sections 6.3, 6.6 and 6.7).
- Impact and vibratory piling within 30m of occupied buildings will be scheduled between 8am and 10am unless otherwise agreed with the building occupants (refer Section 6.7 and Appendix B).
- Impact piling within 100m of any occupied building on Princes Wharf will be scheduled between 7am and 7pm, unless otherwise certified by Council (refer Section 6.7).

3.2 Construction methodology

Construction activities relevant to this plan include:

- Piling activities for wharf construction works, breakwater construction, pontoon and fender installation and temporary construction platform construction (further methodology detail is provided below).
- Construction of wharf superstructures using cranes to lift precast elements, pumping and placing of concrete etc.
- Dredging using a long reach excavator on a barge.
- Wynyard Point buildings platforms - flat concrete raft foundations; cranes and concrete pumps required.
- Services relocation - trench excavation and reinstatement.

Refer to the CEMP for a detailed description of the proposed construction method for the various Project activities. Site maps identifying the Project works area, sensitive receivers and pile layout are provided in Appendix B.

3.2.1 Piling Methodology

Piling activities are predicted to generate the most significant potential construction noise and vibration effects. For the purposes of this CNVMP, the assumed methodology described in Table 3.1 is based on an installation rate of three piles per day. The structures noted are shown in Appendix B. **[Note: The construction methodology for the structures is still to be confirmed and this section of the CNVMP will be updated as further details become available]**

Table 3.1: Summary of piling activities

Activity	Description
Hobson Wharf extension and breakwaters	<p>Structures:</p> <ul style="list-style-type: none"> • Wharf extension, including breakwater 4: 813mm steel piles (x98) • Breakwater 5: 1,200mm steel piles (x16) • Breakwater 6: 1,200mm steel piles (x12) • Breakwater 7: 1,200mm steel piles (x20) • Breakwater 8: 610mm steel piles (x140) <p>Primary piling methodology (except breakwater 8):</p> <ol style="list-style-type: none"> 1. Vibrate casing into mud (1 – 2 minutes actuation time)

Activity	Description
	2. Impact pile into rock (20 – 50 impacts) 3. Drill rock socket 4. Install rebar cage in pile 5. Fill pile with concrete to top of pile Piling methodology breakwater 8: Primary method above, but without stage 2
Halsey Wharf	Structures: <ul style="list-style-type: none"> • Breakwater 2: 1,200mm steel piles (x24) • Breakwater 3: 1,200mm steel piles (x24) Refer primary piling methodology for Hobson Wharf.
Wynyard Wharf infill and breakwaters	Structures: <ul style="list-style-type: none"> • Wharf infill: 1,500mm steel piles (x71) and 1,050mm steel piles (x19) • Breakwater 1: 1,200mm steel piles (24 piles) • Breakwater 1b: 1,200mm steel piles (x4) Refer primary piling methodology for Hobson Wharf (except wharf infill). Piling methodology for wharf infill: 1. Excavation through seawall rock bund by progressively inserting an oversized casing with a vibrohammer and using a clamshell grab to remove the basalt rock from within the casing 2. Once the casing reaches the underside of the bund, backfill the casing with weak concrete or pea gravel 3. Use a vibrohammer to extract the temporary casing 4. Vibrate the permanent pile into seabed (1min actuation time) 5. Impact drive the pile into the underlying bedrock (20 – 50 impacts) 6. Drill out material within pile 7. Install rebar cage in pile 8. Fill pile with concrete to top of pile
Pontoon and Fender piles various locations	310 UC and 600 – 700mm diameter steel piles (x229 approx.) Vibrate directly into mud to embedment (up to 15min actuation time)
Temporary construction platforms	If temporary work platforms and associated support piles are installed for construction access, the temporary piles will likely be vibrated in (setup) and out (on removal).

The potential for significant noise and vibration effects primarily relate to Hobson Wharf piling works. The typical timing and duration of these activities are described further below.

The Hobson Wharf extension will require approximately two weeks of piling per row of piles. Seven rows of piles require installation, resulting in a cumulative piling period of approximately 14 weeks. Similarly, breakwater structures 5, 6 and 7 will each require approximately 10 days of piling. Structure 8 will require approximately 7 weeks of piling, however the Maritime Museum buildings will serve to mitigate noise levels received to the east of Hobson Wharf.

The typical daily schedule for Hobson Wharf piling works is summarised as follows:

- **Prior to 7am:** Daily staff briefing and site setup;
- **Morning:** Piling activities, including 1 – 2 minutes of vibro piling, followed by 1 – 5 minutes of impact piling and 0.5 – 2 hours of pile boring per pile;
- **Afternoon / evening:** Balance of pile boring, crange, concrete works and setup for next piles;

- After 10.30pm: Ancillary activities (e.g. reposition tug, survey piles, weld piling gates).

Impact and vibratory piling required within 30m of occupied buildings on Hobson Wharf will be scheduled between 8am and 10am to mitigate noise and vibration effects (refer Section 3.1). This timing will avoid these activities during the Maritime Museum opening hours and typical busy periods for bars and restaurants (lunchtime and evening peaks). However, timing may be varied by agreement with the building occupants. Piles located within 30m of buildings are identified in Appendix B.

Impact piling within 100m of any occupied building on Princes Wharf will be scheduled between 7am and 7pm, unless otherwise certified by Council (refer Section 3.1). This timing will mitigate the effects on residents. Due to the more restrictive constraint on piling within 30m of any building above, this requirement will likely apply to the eastern most piles on Breakwater 6.

DRAFT

4 Performance Standards

[Note: the Project construction noise and vibration standards are yet to be confirmed and the subject of further discussion with Auckland Council]

4.1 Noise

Construction noise shall be measured and assessed in accordance with the provisions of New Zealand Standard NZS 6803:1999 “Acoustics - Construction Noise”. The noise limits apply at 1m from external façades of occupied buildings.

Construction noise shall comply with the Project Standards in **Condition 109** and outlined in Table 4.1, unless otherwise provided for in this CNVMP.

Table 4.1: Project Standards for noise as per **Condition 109**

Day	Time	L _{Aeq} (30min)	L _{AF} (max)
Monday to Saturday	0700 – 2230	75	90
Sunday	0900 – 1900	65	80
All other times (night-time)		60	75

4.2 Vibration

Construction vibration shall comply with the Project Standards in **Condition 109A – 109B** and outlined in Table 4.2, and shall comply with the Category A vibration standards unless otherwise provided for in this CNVMP. Vibration may only exceed Category B standards at existing buildings located on Hobson Wharf and within the CMA.

Table 4.2: Project Standards for vibration as per **Condition 109A**

Receiver	Time	Category A	Category B
Occupied dwellings, hotels and motels	2230 – 0700	0.3mm/s PPV	1mm/s PPV
	0700 – 2230	2mm/s PPV	5mm/s PPV
Other occupied buildings	All times	2mm/s PPV	5mm/s PPV
All buildings	All times	5mm/s PPV	Tables 1 and 3 of DIN4150-3:1999

Construction vibration which may affect people and buildings shall be assessed in accordance with ISO 4866:2010 “Mechanical vibration and shock – Vibration of fixed structures – Guidelines for the measurement of vibrations and evaluation of their effects on structures”.

4.2.1 Cosmetic Building Damage

Construction vibration to be measured in accordance with German Standard DIN 4150-3:1999 “Structural vibration – Part 3: Effects of vibration on structures”. The short-term (transient)² vibration limits in Figure

² Short-term (transient) vibration is “vibration which does not occur often enough to cause structural fatigue and which does not produce resonance in the structure being evaluated”

4-1 will apply at building foundations in any axis. The vibration limits in all other cases are summarised in Table 4.3.

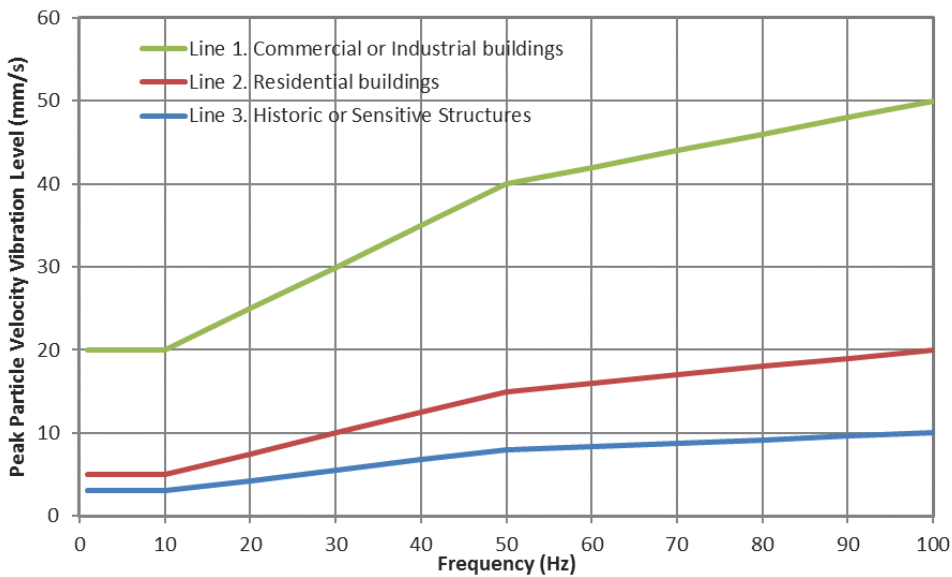


Figure 4-1: Short-term (transient)² vibration at building foundations (DIN 4150-3 1999: Figure 1)

Table 4.3: Vibration at horizontal plane of highest floor (DIN 4150-3 1999: Tables 1 and 3)

Structure Type	Peak Particle Velocity Vibration Level (mm/s)	
	Short-term (transient) ²	Long-term (continuous) ^{3, 4}
Line 1. Commercial or Industrial buildings	40	10
Line 2. Residential buildings	15	5
Line 3. Historic or Sensitive Structures	8	2.5

The criteria relate to the avoidance of cosmetic building damage, such as cracking in paint or plasterwork. Cosmetic building damage effects are deemed 'minor damage' in the Standard and can generally be easily repaired. The cosmetic building damage thresholds are much lower than those that would result in structural damage. The Standard states: *"Experience has shown that if these values are complied with, damage that reduces the serviceability of the building will not occur."*

4.3 Underwater Noise

There are no underwater noise limits in New Zealand legislation. Therefore, this CNVMP relies on guidance from the US Department of National Oceanic and Atmospheric Administration (NOAA)⁵.

The marine mammal 'species of interest' in the Waitematā harbour are Orca, common dolphin and bottlenose dolphin. These species are all classified as mid-frequency cetaceans (MF). There is also the

³ Long-term (continuous) vibration includes types not covered by the short-term vibration definition

⁴ The long-term (continuous) criteria can apply at all floor levels, but levels are normally highest at the top floor

⁵ 'Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing', NOAA (July 2016)

potential for fur seals to be in the project vicinity, which are classified as otariid pinnipeds (OW), and there is a resident leopard seal in Westhaven Marina. Leopard Seals are classed as phocid pinnipeds (PW).

The NOAA criteria for MF cetaceans, OW pinnipeds and PW pinnipeds are summarised in Table 4.4.

Table 4.4: Summary of NOAA TTS and PTS thresholds⁶

Species	Threshold Type	Impulsive sources (e.g. impact piling)	Non-impulsive sources (e.g. vibro piling)
Mid-Frequency Cetaceans	Temporary Threshold Shift (TTS)	224 dB L_{peak} 170 dB $SEL_{cum(mf)}$	178 dB $SEL_{cum(mf)}$
	Permanent Threshold Shift (PTS)	230 dB L_{peak} 185 dB $SEL_{cum(mf)}$	198 dB $SEL_{cum(mf)}$
Otariid Pinnipeds	TTS	226 dB L_{peak} 188 dB $SEL_{cum(ow)}$	199 dB $SEL_{cum(ow)}$
	PTS	232 dB L_{peak} 203 dB $SEL_{cum(ow)}$	219 dB $SEL_{cum(ow)}$
Phocid Pinnipeds	TTS	212 dB L_{peak} 170 dB $SEL_{cum(pw)}$	181 dB $SEL_{cum(pw)}$
	PTS	218 dB L_{peak} 185 dB $SEL_{cum(pw)}$	201 dB $SEL_{cum(pw)}$

Safety guidelines for human divers published in a NATO Undersea Research Centre (NURC) publication⁷ recommends divers should avoid areas where noise levels exceed 160 dB re 1 μ Pa rms (125Hz – 4kHz). This is considered an acceptable threshold for experienced divers, or those in shallow water at the coastline. We note that for inexperienced divers, behavioural responses such as changing heart rates or breathing frequency have been found to occur at levels above 154 dB re 1 μ Pa rms⁸, however we consider it unlikely that inexperienced divers would be in the vicinity while works are being undertaken.

⁶ SEL thresholds have a reference of 1 μ Pa²s and L_{peak} thresholds have a reference of 1 μ Pa

⁷ 'NATO Undersea Research Centre Human Diver and Marine Mammal Risk Mitigation Rules and Procedures', NURC-SP-2006-008, September 2006

⁸ US Navy (US Federal Register, 2002)

5 Predicted Levels

5.1 Noise

Table 5.1 provides indicative construction noise levels for the key Project construction activities, proposed construction machinery, their sound power levels and unmitigated setback distances to comply with noise levels of 75 dB L_{Aeq} and 60 dB L_{Aeq} . It will be used by the Alliance Project Director (or nominated person) prior to construction to inform what equipment will require mitigation and/or management and when. The table will be kept up to date by the Project's Acoustic Specialist (Table 2.1) when new information becomes apparent through noise monitoring (Section 8.1) or other means.

Table 5.1: Indicative noise levels at 1m from a building façade⁹ without effective noise barriers¹⁰

Equipment	Sound Power Level (dB L_{WA})	Noise Level (dB L_{Aeq}) at a distance of			Setback to achieve compliance (m)	
		10 m	20 m	50 m	75 dB L_{Aeq}	60 dB L_{Aeq}
Vibro piling	116	91	85	76	52	209
Concrete cutting	115	90	84	75	48	191
Impact piling (with casing and dolly)	114	89	83	74	44	174
Bored or CFA piling	111	86	80	71	33	132
Long reach excavator (39t)	106	81	75	66	20	83
Excavator (20t)	103	78	72	63	14	63
Concrete truck and pump discharging	103	78	72	63	14	63
Mobile crane (35t) operating	98	73	67	58	8	40

Piling and concrete cutting activities have the potential to exceed the standard 75 dB L_{Aeq} weekday daytime construction noise limit for brief periods. Noise contours for representative piling activities are included in Appendix C. In summary, brief intermittent exceedances during pile driving activities are predicted to locally exceed 75 dB L_{Aeq} at the following occupied commercial buildings (based on the piling methodology outlined in Section 3.2.1):

- Maritime Museum: Up to 85 dB L_{Aeq} during the Hobson Wharf extension, (approximately 1 week for each of the closest three rows of piles), breakwaters 6 and 7 (approximately 10 days each) and breakwater 8 (7 weeks)
- Hobson Wharf restaurants: Up to 85 dB L_{Aeq} for the south end of breakwater 7 (approximately 2 – 3 days)
- North Wharf restaurants: Up to 80 dB L_{Aeq} for the closest pontoon pile (approx. 1 – 2 days per site / restaurant)

Vibro and impact piling will be the loudest construction activities and have a character that is more intrusive than other noise sources at a similar level (e.g. bored piling). With reference to Section 3.2.1, the

⁹ In accordance with the requirements of NZS 6803: 1999, inclusive of 3 decibels façade reflection

¹⁰ Effective noise barriers typically provide 10 decibels shielding (Section 6.5)

duration of vibro and impact piling will be minimised, and scheduled to mitigate disturbance for residents, avoid the Maritime Museum opening hours, and avoid typical busy periods for bars and restaurants on Hobson Wharf and North Wharf.

5.2 Vibration

Table 5.2 provides indicative construction vibration levels for key construction activities that have the potential to result in vibration in building structures and their approximate safe distances to enable compliance with the vibration limits at building foundations. It will be used by the Alliance Project Director (or nominated person) prior to construction to inform what equipment will require mitigation and/or management and when. The table will be kept up to date by the Project Acoustic Specialist (Table 2.1) when new information becomes apparent through vibration monitoring (Section 8.2) or other means.

Table 5.2: Indicative distances to comply with vibration limits at building foundations

Equipment	Amenity Setback (m) ¹¹		Cosmetic Building Damage Setback (m) ¹¹		
	2mm/s PPV		Heritage & Sensitive Structures	Residential	Commercial
Impact piling ¹²	61		36	19	3
Vibrated pile casings	19		15	6	3

Impact and vibratory piling will be undertaken within a few metres of the Maritime Museum. Therefore, will be within the cosmetic building damage setback for a commercial building. With reference to Section 7.3, building condition survey(s) will be undertaken in accordance with Section 8.3.

In addition to the above, impact and vibratory piling is predicted to exceed the vibration amenity limit of 2mm/s PPV at restaurants at the south end of Hobson Wharf and fronting North Wharf. With reference to Section 3.1, impact and vibratory piling will be scheduled to avoid occupied or busy periods, prior communication will be required in accordance with Section 7.1.

5.3 Underwater Noise

The indicative zones of influence for the worst-case impact piling works are presented in Table 5.3. The zones are shown as distances from the pile being installed.

The zones are graphically shown on the figures in Appendix C. Three representative piling locations are shown:

- Figure 6: Hobson Wharf.
- Figure 7: Breakwater 2.
- Figure 8: Breakwater 1.

Vibro piling works will be very short in duration (approximately 1 – 2 minutes per pile). Therefore, the zones of influence for vibro piling will be negligible (i.e. <20m) and not addressed in detail. These zones include the mitigation measures of a wooden cushion between the impact hammer and pile cap. Refer to Appendix C for a description of these mitigation measures.

¹¹ Based on regression analysis of available vibration measurements, plus a 100% safety factor

¹² Assumes transient low frequency vibration criterion from Table 1 of DIN 4150-3 :1999 is applicable

Table 5.3: Zones of influence for steel piles

Species	Threshold	Impact piling zones			Vibro piling zones	
		1,200mm dia	813mm dia	667mm dia	600mm dia	310mm UC
All species	PTS – peak			Below criteria		
	TTS – peak			Below criteria		
Mid-frequency cetaceans	PTS – cumulative exposure	<20m	<20		Below criteria	
	TTS – cumulative exposure	50m	50m	25m	50m	<20m
Otariid pinnipeds	PTS – cumulative exposure	<20		Below criteria		
	TTS – cumulative exposure	50m	<20	<20m	<20m	Below criteria
Phocid pinnipeds	PTS – cumulative exposure	50m	<20	<20m	<20m	Below criteria
	TTS – cumulative exposure	220m	155m	125m	75m	<20m

For any temporary work platforms and associated support piles installed to provide construction access, smaller temporary piles will likely be vibrated into the ground and removed on completion of the works. The temporary piles will be quicker and quieter to install than permanent piles. As such, the associated management zones will be notably smaller.

6 Mitigation and Management

6.1 Training

All staff will participate in a Project induction prior to the start of construction as outlined in the CEMP. Attention given to the following matters related to implementation of this CNVMP:

- Construction noise and vibration limits (Section 4).
- Activities with the potential to generate high levels of noise and/or vibration (Section 5).
- Noise and vibration mitigation and management procedures (Section 6).
- The sensitivity of receivers and any operational requirements and constraints identified through communication and consultation (Section 7).

Awareness of current noise and vibration matters on, or near active worksites, will be addressed during regular site meetings and/or 'toolbox' training sessions.

Refer to the CEMP for further detail on Project environmental training.

6.2 Equipment Selection

When selecting construction equipment, the following will be implemented:

- Prioritise construction methodologies that minimise noise and vibration where practicable (e.g. bored piling instead of impact or vibro piling methods).
- Prioritise electric motors over diesel engines where practicable.
- Prioritise rubber tracked equipment over steel tracked equipment where practicable.
- Equipment shall be suitably sized for the proposed task.
- Equipment shall be maintained and fitted with exhaust silencers and engine covers.
- Avoid tonal reversing or warning alarms (suitable alternatives may include flashing lights, broadband audible alarms or reversing cameras inside vehicles).

6.3 Night Works

Where practicable, night works will be avoided. Where necessary, noisy works will be programmed early in the evening or night-time period to avoid sleep disturbance. It is noted that people tend to be less disturbed by low frequency, continuous engine noise, as opposed to intermittent noise or activities with special audible character (e.g. reversing beepers, whistling, banging tailgates or shouting).

Activities which have a distinctive impulsive or tonal character, such as impact pile driving, concrete breaking and concrete cutting can cause significant adverse effects when undertaken at night-time, even when complying with the construction noise limits. Therefore, these activities will not be undertaken at night, including impact piling and concrete cutting.

Other works may be undertaken at night provided they are not in close proximity to residential receivers and provided they comply with the night-time noise limits. These potentially include bored piling, vibro piling, generator use, concrete pours and vehicle movements. The Construction Environmental Manager shall involve the Acoustic Specialist (Table 2.1) in the scheduling of night works and monitoring to ensure compliance with the consent conditions.

Stakeholder engagement will be critical in relation to night works (refer to Section 7 of this Plan for further detail).

6.4 General measures

Complaints can arise whether or not noise and vibration levels comply with the Project limits. To avoid complaints, general mitigation and management measures will include, but are not be limited to, the following:

- Avoid unnecessary noise, such as shouting, the use of horns, loud site radios, rough handling of material and equipment, and banging or shaking excavator buckets.
- Avoid steel on steel contact, such as during the loading of scaffolding on trucks.
- Avoid high engine revs through appropriate equipment selection and turn engines off when idle.
- Maintain site access ways to avoid pot holes and corrugations.
- Mitigate track squeal from tracked equipment, such as excavators (may include tensioning and watering or lubricating the tracks regularly).
- Minimise construction duration near sensitive receivers.
- Stationary equipment (e.g. generators) shall be located away from noise sensitive receivers and site buildings and material stores used to screen them.
- Utilise noise barriers where appropriate (Section 6.5).
- Implement specialised mitigation measures for concrete cutting (Section 6.6) and piling (Section 6.7).
- Ensure advanced communication is complete (Section 7) prior to commencing activities that are predicted to exceed the noise and vibration performance standards (Section 5).
- Undertake monitoring as appropriate (Section 8).

6.5 Noise Barriers

Temporary noise barriers will be used where a construction noise limit is predicted to be exceeded (refer to Section 5.1) and the barriers will noticeably reduce the construction noise level. The barriers shall be installed prior to works commencing and maintained throughout the works. Effective noise barriers typically reduce the received noise level by 10 decibels.

The following guidelines shall be incorporated in the design and utilisation of temporary noise barriers:

- The panels shall be constructed from materials with a minimum surface mass of 6.5 kg/m². Suitable panels include 12 mm plywood or the following proprietary 'noise curtains':
 - Duraflex 'Noise Control Barrier - Performance Series' (www.duraflex.co.nz)
 - Soundex 'Acoustic Curtain - Performance Series' (www.ultimate-solutions.co.nz)
 - Flexshield 'Sonic Curtain with 4 kg/m² mass loaded vinyl backing' (www.flexshield.co.nz)
 - Alternatives shall be approved by a suitably qualified acoustic specialist (it is noted that some proprietary noise curtains have insufficient surface mass for general use)
- The panels shall be a minimum height of 2 m, and higher if practicable to block line-of-sight.
- The panels shall be abutted or overlapped to provide a continuous screen without gaps at the bottom or sides of the panels.
- The panels shall be positioned as close as practicable to the noisy construction activity to block line-of-sight between the activity and noise sensitive receivers.

Where positioned on the site boundary, additional local barriers shall be considered near the activity to ensure effective mitigation for sensitive receivers on upper floor levels.

6.6 Concrete Cutting

Concrete cutting will be managed to:

- Avoid evening and night-time periods (refer Section 3.1).
- Minimise the cutting period, and, the number of cutting periods where practicable (e.g. complete all cutting in one extended period rather than two shorter periods with the same overall duration).
- Use a unit fitted with a blade shroud and a 'quiet' blade type (tooth design) where practicable.

6.7 Piling

Piling shall be managed to:

- Avoid impact pile driving at night (refer Section 3.1).
- Schedule impact and vibratory piling within 30m of occupied buildings between 8am and 10am unless otherwise agreed with the building occupants (refer Section 3.1 and Appendix B).
- Schedule impact piling within 100m of any occupied building on Princes Wharf between 7am and 7pm, unless otherwise certified by Council (refer Section 3.1 and Appendix B).
- Prioritise piling methods that minimise noise and vibration where practicable (e.g. augured or press-in piles over impact driven or vibratory piling methods).
- Avoid alternating rotation of the bored piling auger to loosen spoil into the muck bin where practicable. The kelly bar connection typically creates a very loud banging that often results in noise complaints. This action is unnecessary for general auger use, but may be necessary if a coring barrel is required to drill through obstructions.
- Use a non-metallic 'dolly' or 'cushion cap' between the impact piling hammer and the driving helmet to reduce underwater and airborne noise levels (e.g. plastic or plywood – preferably plywood).
- Use an enclosed impact piling driving system that shrouds the point of impact.

In accordance with condition 110A, the following procedure shall be implemented to manage the effects of underwater noise on marine mammals and divers:

- Undertake visual monitoring 30 minutes prior to commencing piling operations to ensure there are no marine mammals or divers in the area.
- Use 'soft starts' (gradually increasing the intensity of piling) and minimise duty cycle where practicable.
- Undertake visual monitoring during piling operations to identify any marine mammals or divers that enter the area.
- Implement low power or shut down procedures when a marine mammal is identified within the TTS zones (based on the current methodology, Table 5.3 identifies a zone of up to 220m for phocid pinnipeds and 50m for mid-frequency cetaceans and otariid pinnipeds).

7 Engagement

7.1 Communication

Written communication (e.g. newsletter) will be provided to occupiers of buildings within 100 m of the site at least 1 week prior to the Project commencing. Communication shall acknowledge that some construction activities are predicted to generate high noise and/or vibration levels that may result in disturbance for short periods. It shall include details of the overall works, its timing, duration and Project contact details, including for complaints and enquiries.

Written communication during the works will include:

- Public site signage, which will include Project contact details.
- Regular Project updates, which shall include details of impending activities that may result in disturbance, including night works (Section 6.3), concrete cutting (Section 6.6) and piling (Section 6.7). It shall also include scheduled timing and duration of these activities and contact details complaints and enquiries.
- Occupants of buildings predicted to receive noise levels exceeding the noise limits in Section 4.1 shall be advised at least 48 hours prior to the works commencing. With reference to Section 5.1, this relates to occupied buildings up to 52m from daytime piling activities.
- Occupants of buildings predicted to receive vibration levels exceeding the Category A performance standards in Section 4.2 shall be advised at least 48 hours prior to the works commencing. With reference to Section 5.2, this relates to occupied buildings within 60m of impact piling and 20m of vibro piling.

7.2 Consultation

Table 7.1 and Figure 8-5 in Appendix B identify sensitive receivers where noise and/or vibration is predicted to exceed the performance standards. In addition, if vibro/impact piling is undertaken within 50m of the existing Wynyard Point tanks, appropriate vibration thresholds and mitigation measures will be identified and agreed with the potentially affected bulk liquids company, and included in this CNVMP. **[Note: the current methodology does not involve vibro/impact piling within 50m of the tanks. This section will be updated when the construction methodology is confirmed].**

Table 7.1: Sensitive receivers

Address	Building Type ¹³	Occupancy	Noise (Section 5.1)	Vibration (Section 5.2)	
				Amenity	Cosmetic Building Damage
Hobson Wharf	Commercial	Maritime Museum	X	X	X
North Wharf (47 Jellicoe St)	Commercial	North Wharf Restaurants	X	X	-

Consultation will be undertaken to address reasonable concerns about noise and vibration on a case-by-case basis. The Alliance Project Director shall address any concerns and complaints in accordance with

¹³ Classifications with respect to Tables 1 and 3 of DIN 4150-3:1999 "Structural Vibration - Effects of Vibration on Structures" (i.e. historic/sensitive, residential or commercial/industrial)

Section 7.3. When discussing vibration concerns, it is important to convey that vibration can be felt at levels well below those that pose a risk of cosmetic building damage. A copy of all correspondence will be made available to Council upon request.

The following process will be implemented by the Alliance Project Director (or nominated person) in relation to any construction activity that when measured, exceeds the relevant construction noise and vibration performance standards:

- For exceedances of the construction cosmetic building damage vibration standards, activities shall cease as soon as safe and practicable to do so.
- Review the construction methodology, mitigation and management strategies to ensure they represent the BPO.
- Undertake consultation with affected parties to understand their sensitivities, including times, activities and locations. Consultation shall focus on a collaborative approach to managing the adverse effects from construction noise and vibration. A project representative shall be contactable during works. A record of consultation shall be kept at the site office and be available to the affected parties and Council if requested.
- Implement measures to avoid significant adverse effects as agreed with the affected party and monitor the activity to verify the extent of any adverse effects
- For exceedances of the construction vibration cosmetic building damage thresholds in Section 4.2, a detailed building condition survey will be undertaken in accordance with Section 8.3. If damage has not occurred, then that activity can continue provided the measured vibration level is not exceeded further and the construction methodology is the BPO. If damage has occurred, alternative construction methods will be investigated and the consent holder shall commit to repairing the damage within a reasonable timeframe.
- Temporary relocation shall be considered for sensitive receivers where all practicable noise and vibration management and mitigation measures have been implemented and significant adverse noise effects are predicted. This will be in exceptional cases only, and advice from the Acoustic Specialist (Table 2.1) will be sought prior.

7.3 Maritime Museum

The Maritime Museum has provided written approval for the Americas Cup construction activities, acknowledging the potential noise and vibration effects. Regardless, the following section details identifies noise and vibration sensitive activities, potential effects, and measures to avoid, or mitigate adverse effects as far as practicable.

The Maritime Museum comprises of a series of connected buildings located on Hobson Wharf. The northern most building that will be adjacent to most of the construction activities, appears to be a modern steel frame building. It contains the 'Blue Water Black Magic' exhibition across multiple levels around a central atrium, which features many boats, yachting memorabilia and interactive experiences. The older buildings at the southern end of Hobson Wharf house the more historic features and traditional displays.

The publicly listed opening hours for the museum are 10am – 5pm every day (except Christmas Day). Pile driving represents a small proportion of the overall time required to install a pile. Much of the associated time relates to formwork setup and pile alignment prior to driving. The driving component of the pile installation is the activity with the potential to generate high noise and vibration levels and is the focus of the noise and vibration predictions in Section 5. To avoid significant amenity effects, impact and vibratory pile driving within 30m of the museum buildings will be scheduled between 8am and 10am, Monday to Saturday.

7.3.1 Noise

Noise levels of 75 – 85 dB L_{Aeq} are predicted on the closest façade of the Maritime Museum within 30m of bored piling works. Based on the façade construction, it is predicted that internal noise levels will be up to 55 – 65 dB L_{Aeq} for short periods inside the immediately adjacent gallery space.

The predicted noise levels are comparable to those from the recently completed Hobson Wharf remediation works. At the time, a CNVMP was prepared to address noise and vibration effects from the Hobson Wharf remediation works. The key difference is that the America's Cup piling works are of a shorter duration (Section 2.1).

For bored piling within 30m of the museum buildings between 10am and 5pm:

- The exhibitions feature a large collection of display objects with accompanying written information. These features will generally not be significantly affected by noise from piling works. However, patrons may potentially spend less time in the space immediately adjacent to the piling works.
- When a tour group is taken through the museum, piling noise may affect communication when a guide is addressing the group near the piling works. In this case, it would be advisable for the guide to address the group in the adjacent gallery prior to entering, and/or after leaving, the exhibition.
- Three audio-visual experiences are provided near the northern façade and are reliant on a relatively low noise environment. These are the 'Teamwork Challenge' sailing experience on the ground floor and the 'No Latitude for Error' and 'Blakey' documentary booths on first floor level. It is expected that noise from piling would influence intelligibility of the audio component of these displays. Increasing the volume levels produced by these displays may mitigate the intelligibility issues to a point, but these displays may be affected for short periods while the closest piling works are undertaken.

7.3.2 Vibration

Impact and vibratory piling methods are proposed in close proximity to the Maritime Museum buildings. These activities have the potential to exceed the commercial cosmetic building damage thresholds (Section 5.2). Therefore, building condition survey(s) shall be undertaken in accordance with Section 8.3.

With reference to Section 3.1, impact and vibratory piling methods will be timed to avoid significant vibration amenity effects on customers. Vibration from other activities will be minimal, but may be perceptible at times. Staff and patrons shall be informed about the vibration levels they may experience and assured vibration damage can only occur at magnitudes well above the threshold of perception, and is unlikely to affect the quality of projected images associated with the audio-visual experiences identified above.

7.3.3 Consultation

Consultation with the Maritime Museum will be undertaken to mitigate and manage the noise and vibration effects. For example, this may include timing of the closest piles to avoid school holidays or target morning and evening periods when the gallery is often less busy.

Noise and vibration levels in other more distant areas of the museum are predicted to be significantly lower, and minimal disturbance is anticipated.

7.4 Complaints Response

All construction noise and/or vibration complaints will be recorded in a complaints file that is available to Council on request. For each complaint, an investigation will be undertaken involving the following steps as soon as practicable:

- Acknowledge receipt of the concern or complaint within 24 hours and record:
 - Time and date the complaint was received and who received it

- Time and date of the activity subject to the complaint (estimated where not known)
 - The name, address and contact details of the complainant (unless they elect not to provide)
 - The complainants' description of the activity and its resulting effects
 - Any relief sought by the complainant (e.g. scheduling of the activity)
- Identify the relevant activity and the nature of the works at the time of the complaint
 - If a reasonable complaint relates to building damage, inform the on-duty site manager as soon as practicable and cease associated works pending an investigation
 - Review the activity noise and/or vibration levels (Section 5) to determine if the activity is predicted to comply with the relevant performance standards (Section 4) at the complainants' building. Monitoring shall be undertaken (Section 8) where the activity and methodology has not already been shown to be compliant with the Project Standards in Conditions 109 – 109C at that location. Council may waive the requirement for further monitoring where it would not better inform the complaint.
 - Review the mitigation and management measures in to ensure the activity represents the BPO (Section 6). Review the relief sought by the complainant. Adopt further mitigation and management measures as appropriate
 - Review the potential residual effects (Section 5) of activities that are predicted to exceed the relevant performance standards (Section 4)
 - Report the findings and recommendations to the Alliance Project Director, implement changes and update this CNVMP as appropriate
 - Report the outcomes of the investigation to the complainant, identifying where the relief sought by the complainant has been adopted or the reason(s) otherwise.

In most cases, ceasing the activity will provide immediate relief. In some cases, this may not be practicable for safety or other reasons. The complainant shall be kept updated regularly during the time it takes to resolve the matter.

8 Monitoring

8.1 Noise

Construction noise levels shall be monitored as follows during construction:

- During the first occurrence of impact piling, bored piling, vibro piling and other activities that are predicted to exceed the noise limits (Section 5.1).
- In response to a noise complaint (Section 7.4).
- At 1m from the most affected building façade, or proxy position and adjusted for distance and façade reflections where appropriate.
- By a suitably qualified and experienced specialist (e.g. Member of the Acoustical Society of New Zealand) in accordance with the requirements of New Zealand Standard NZS 6803: 1999 “Acoustics - Construction Noise”.
- For a representative duration, reported with the measured level (e.g. 65 dB $L_{Aeq(30min)}$).
- The results will be used to update Section 5.1 if appropriate.

A noise monitoring flowchart is presented in Figure 8-1.

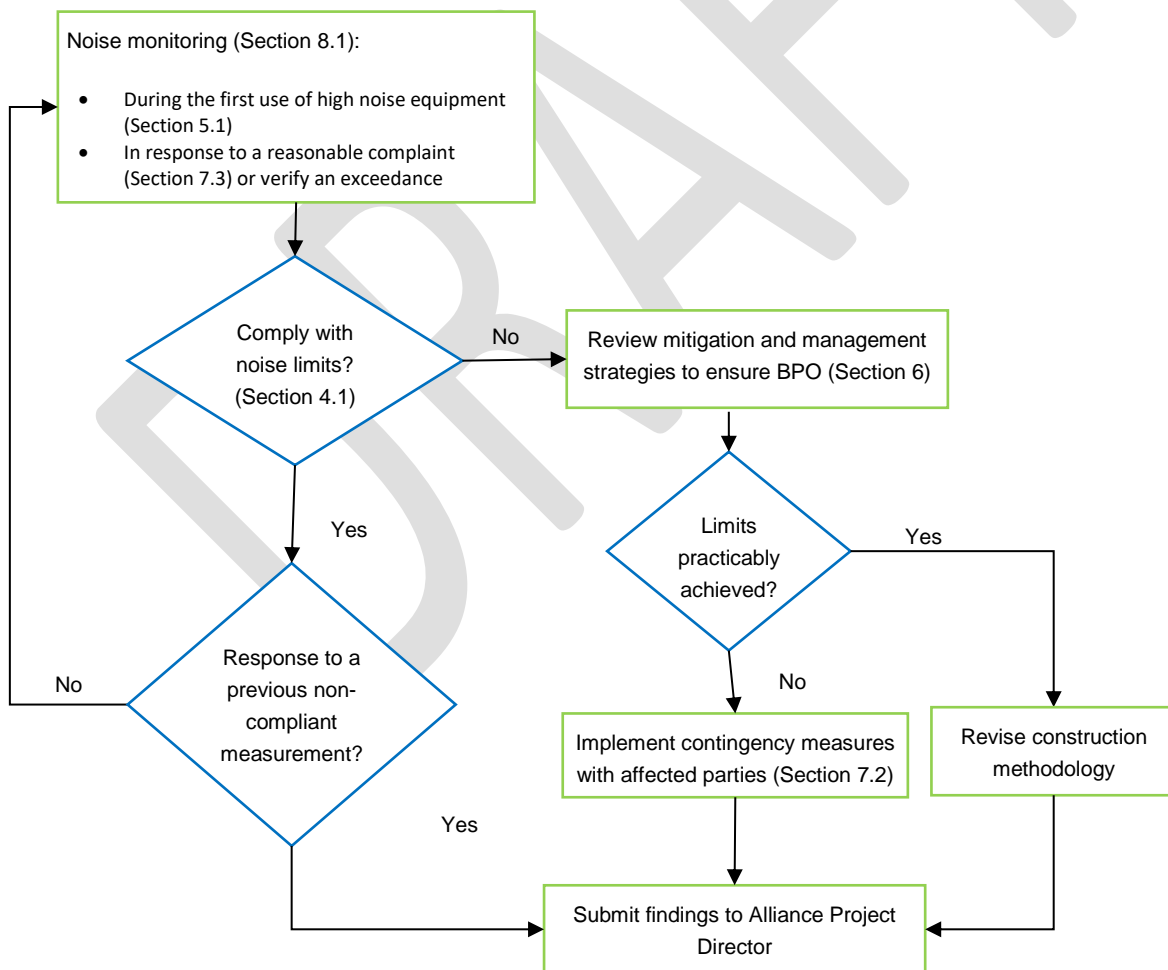


Figure 8-1: Noise Monitoring Flow Chart

8.2 Vibration

Construction vibration shall be monitored as follows during construction:

- At the Maritime Museum during the first occurrences of impact and vibratory piling (Section 5.2) and following the completion of pre-construction building condition surveys (Section 8.3).
- In response to a vibration complaint (Section 7.37.4).
- At the closest building foundations and/or the top floor level as appropriate where consent to access the building of interest has been requested and granted.
- By a suitably qualified and experienced specialist (e.g. Member of the Acoustical Society of New Zealand) in accordance the requirements of German Standard DIN 4150-3:1999 “Structural vibration – Part 3: Effects of vibration on structures”.
- For a representative construction duration, measured in 2 second intervals.
- The results will be used to update Section 5.2 if appropriate.

A vibration monitoring flowchart is presented in Figure 8-2.

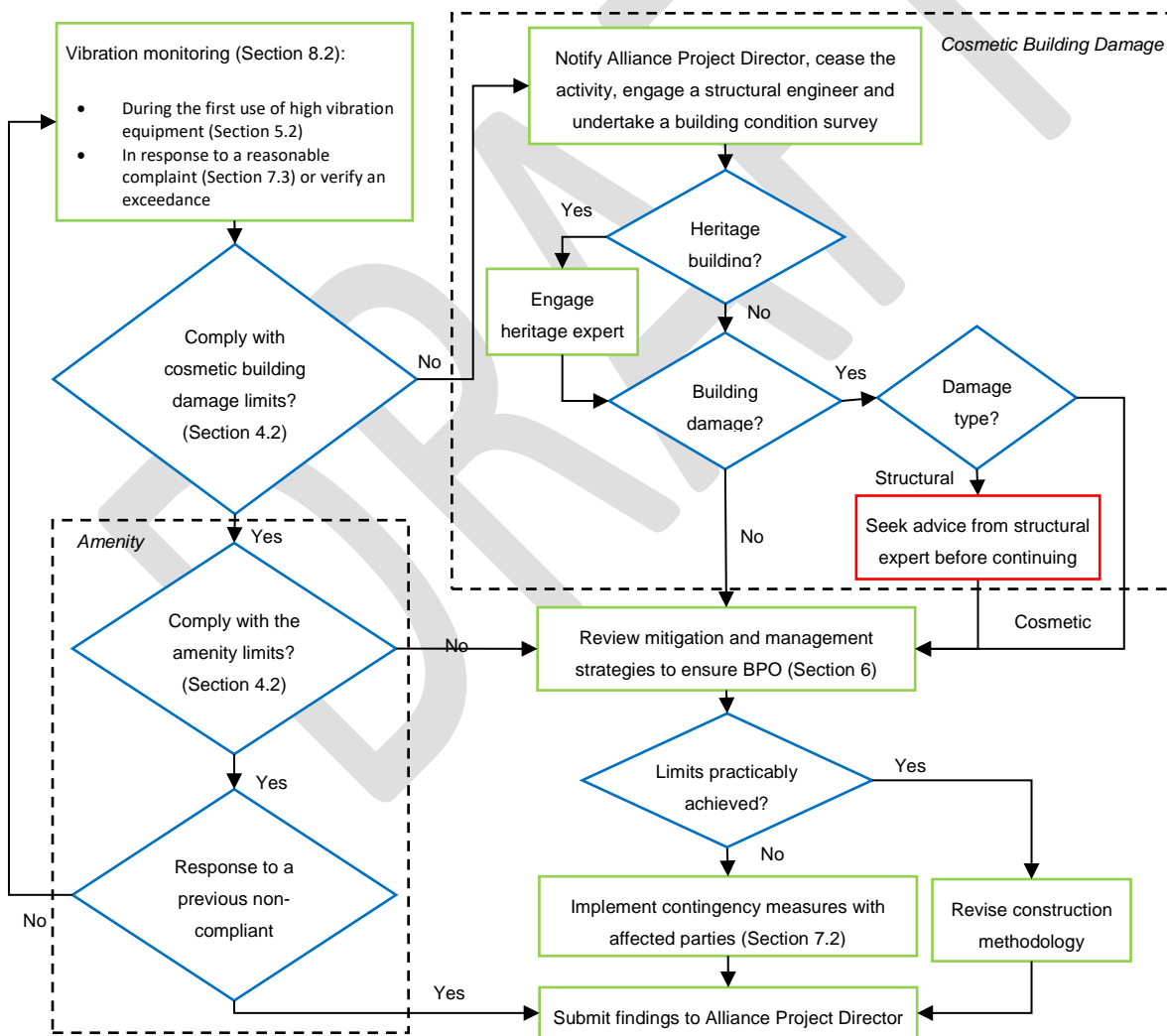


Figure 8-2: Vibration Monitoring Flow Chart

8.3 Building Condition Surveys

Cosmetic building damage (e.g. plaster or paint cracking) is an effect that is relevant to the building owner only (i.e. rather than tenants or leaseholders). People generally perceive vibration at levels significantly lower than those levels that would result in cosmetic building damage and an understanding of this often alleviates receivers' concerns.

A condition survey will be undertaken for the Maritime Museum (Sections 5.2 and 7.3).

The Alliance Project Director shall request in writing the approval of the property owner to undertake a building condition survey at the following times:

- Prior to construction commencing and where vibration is predicted to exceed the cosmetic building damage limits (Section 5.2).
- During construction, where vibration is measured to exceed the cosmetic building damage limits in (Section 5.2) and/or in response to a reasonable claim of damage from construction vibration (Section 7.3).
- Post construction, to avoid subsequent claims of damage from construction vibration (Section 7.3).

If a vibration exceedance has occurred but there is no resulting cosmetic damage, then that activity will continue provided the measured vibration level is not exceeded further and the construction methodology already adheres to the BPO. If damage has occurred, alternative construction methods shall be investigated and the Alliance will rectify the damage at its own cost, as soon as practicable, in consultation with the owner of the property.

Each building condition survey shall:

- Be undertaken by a suitably qualified person.
- Provide a description of the building.
- Determine the appropriate structure type classification¹⁴ with respect to DIN 4150-3:1999 "*Structural Vibration - Effects of Vibration on Structures*" (i.e. historic/sensitive, residential or commercial/industrial).
- Document and photograph the condition of the building, including any cosmetic and/or structural damage.

The results will be provided to the property owner and be available to Council on request

8.4 Underwater Noise

The Alliance will visually monitor the water inside the 'zones of influence' identified in Section 5.3 and implement the management measures in Section 6.7.

Underwater construction noise levels shall be monitored:

- During the first occurrence of impact piling.
- By a suitably qualified and experienced specialist.
- For a representative duration.

¹⁴ Classifications with respect to Tables 1 and 3 of DIN 4150-3:1999 "*Structural Vibration - Effects of Vibration on Structures*" (i.e. historic/sensitive, residential or commercial/industrial)

- The results will be used to update the Sections 5.3 and Section 6.7 as appropriate.

The underwater noise measurements will be undertaken using compact self-contained hydrophones (underwater sound recording units). The Acoustic Specialist (Table 2.1) will supply the hydrophone units and rigging. The Alliance will supply a boat to deploy and retrieve the units at agreed locations. Calm sea state is required for good acoustic measurement conditions. The generic setup for each hydrophone unit is shown in Figure 8-4.

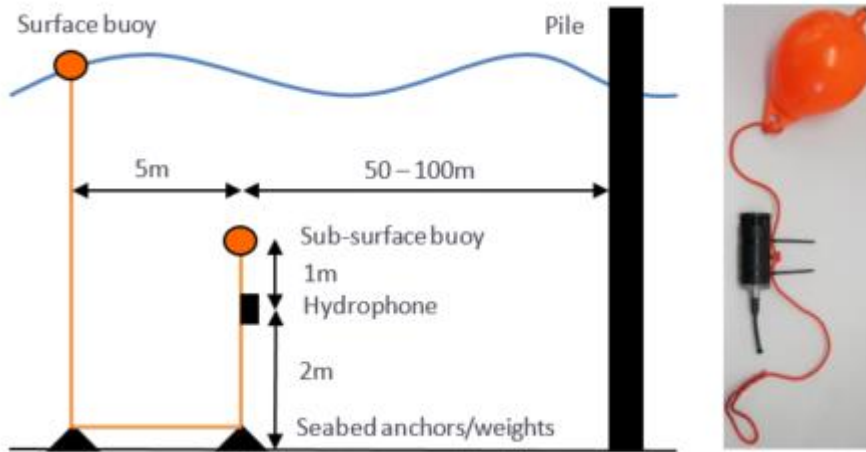


Figure 8-3: Hydrophones indicative setup (not to scale)

Appendix A

Glossary of Terminology

DRAFT

Noise	A sound that is unwanted by, or distracting to, the receiver.
dB	Decibel (dB) is the unit of sound level. Expressed as a logarithmic ratio of sound pressure (P) relative to a reference pressure (Pr), where $dB = 20 \times \log(P/Pr)$. The convention is a reference pressure of $Pr = 20 \mu\text{Pa}$ in air and $Pr = 1 \mu\text{Pa}$ underwater.
dBA	The unit of sound level which has its frequency characteristics modified by a filter (A-weighted) to more closely approximate the frequency bias of the human ear. A-weighting is used in airborne acoustics.
L_{Aeq}(t)	The equivalent continuous (time-averaged) A-weighted sound level commonly referred to as the average level. The suffix (t) represents the period, e.g. (8 h) would represent a period of 8 hours, (15 min) would represent a period of 15 minutes and (2200-0700) would represent a measurement time between 10 pm and 7 am.
L_{AFmax}	The A-weighted maximum noise level. The highest noise level which occurs during the measurement period.
NZS 6803:1999	New Zealand Standard NZS 6803: 1999 "Acoustics - Construction Noise"
Vibration	When an object vibrates, it moves rapidly up and down or from side to side. The magnitude of the sensation when feeling a vibrating object is related to the vibration velocity. Vibration can occur in any direction. When vibration velocities are described, it can be either the total vibration velocity, which includes all directions, or it can be separated into vertical (up and down vibration), horizontal transverse (side to side) and horizontal longitudinal direction (front to back) components.
PPV	Peak Particle Velocity (PPV) is the measure of the vibration amplitude, zero to maximum, measured in mm/s.
DIN 4150-3:1999	German Standard DIN 4150-3:1999 " <i>Structural Vibration - Effects of Vibration on Structures</i> "
Underwater noise	A sound that is unwanted by, or distracting to, the receiver underwater.
L_{peak}	The peak instantaneous pressure level (un-weighted).
RMS	Root Mean Square (RMS) is the equivalent continuous (time-averaged) sound level commonly referred to as the average level (period matches the event duration).
SEL	Sound exposure level (SEL) is the total sound energy of an event, normalised to an average sound level over one second. It is the time-integrated, sound-pressure-squared level. SEL is typically used to compare transient sound events having different time durations, pressure levels and temporal characteristics.
SEL_{cum}	The SEL _{cum} is the 'cumulative' sound energy of all events in a 24 hour period, normalised to an average sound level over one second.
TTS	Temporary Threshold Shift (TTS) is the temporary loss of hearing caused by sound exposure. The duration of TTS varies depending on the nature of the stimulus, but there is generally recovery of full hearing over time.
PTS	Permanent Threshold Shift (PTS) is the permanent loss of hearing caused by acoustic trauma. PTS results in irreversible damage to the sensory hair cells of the ear.

Appendix B

**Overview of Construction
Works**

DRAFT

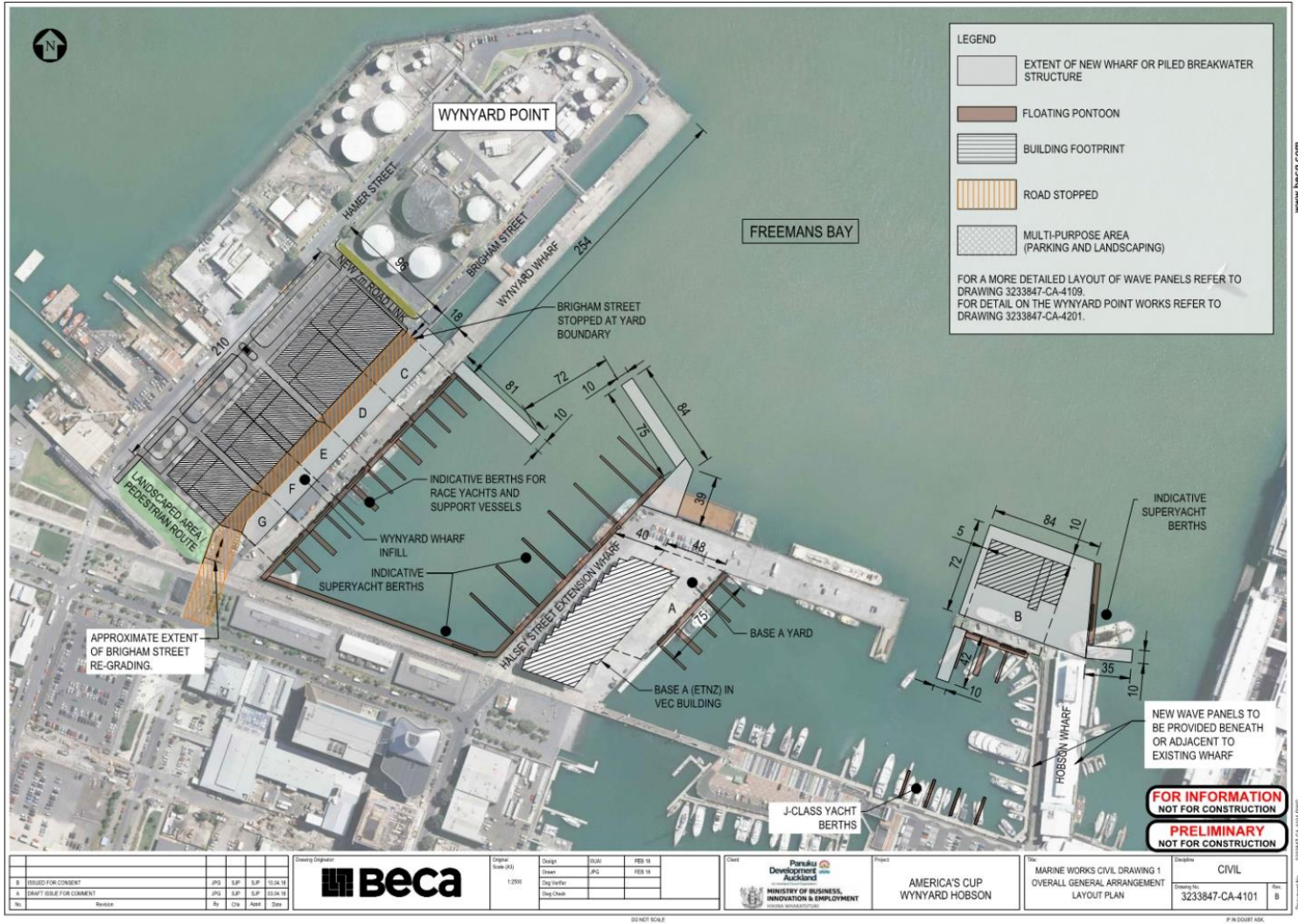


Figure 8-4: Proposed Infrastructure¹⁵

¹⁵ BECA report 'America's Cup Engineering Concept Drawings', drawing 3233847-CA-4101 rev B, dated 10 April 2018



Figure 8-5: Noise sensitive receivers and monitoring locations

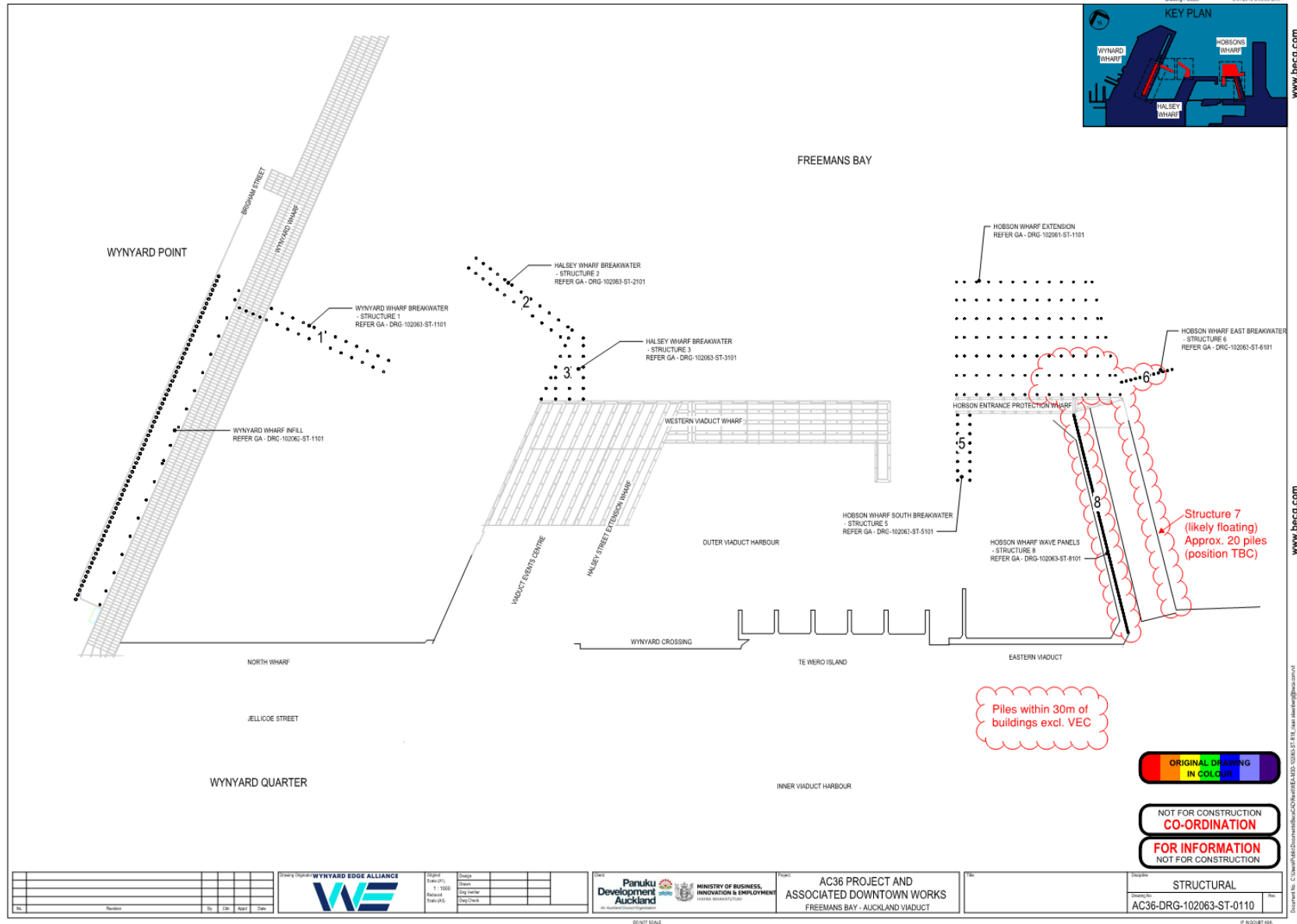


Figure 8-6: Noise sensitive receivers and monitoring locations

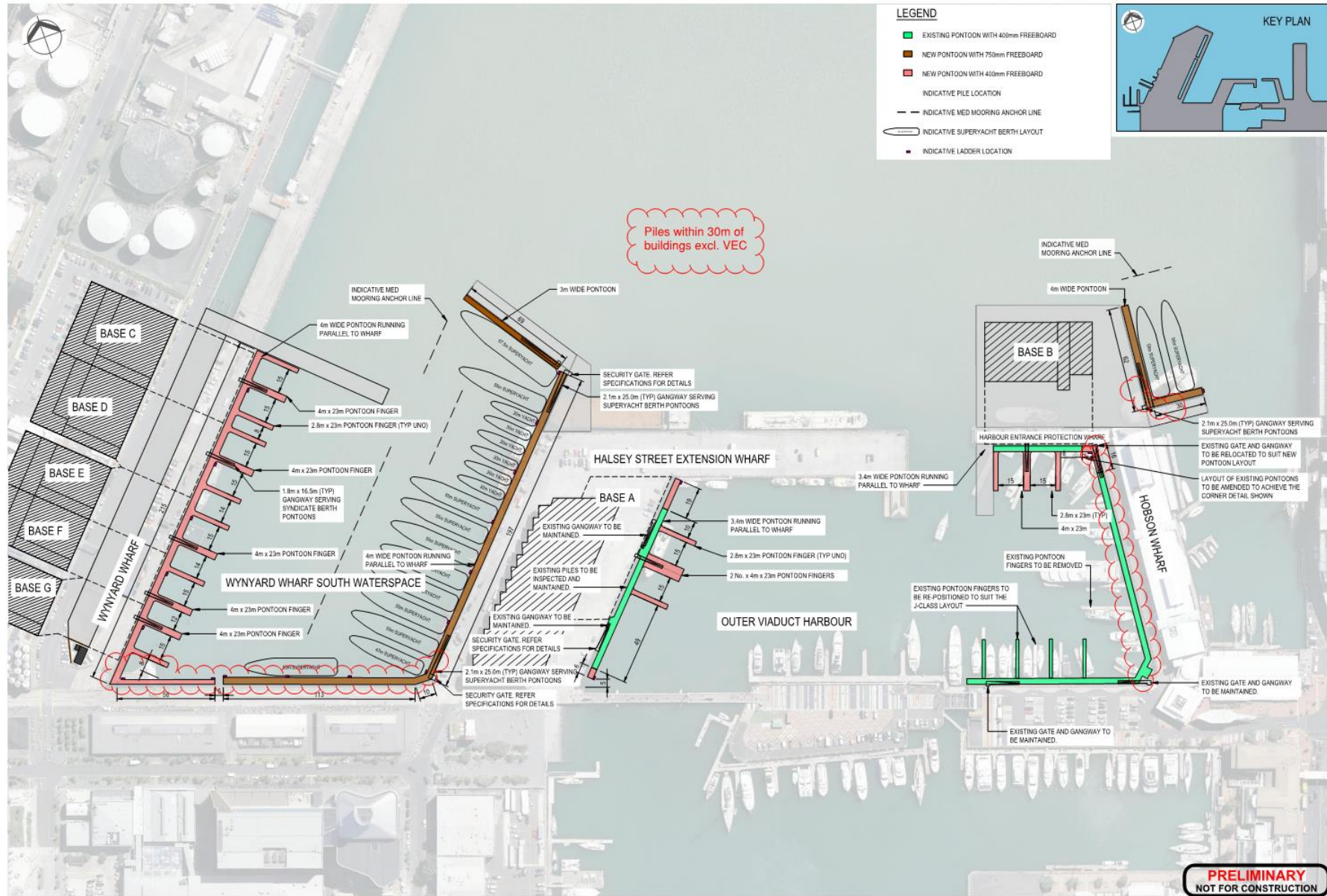


Figure 8-7: Noise sensitive receivers and monitoring locations

Appendix C

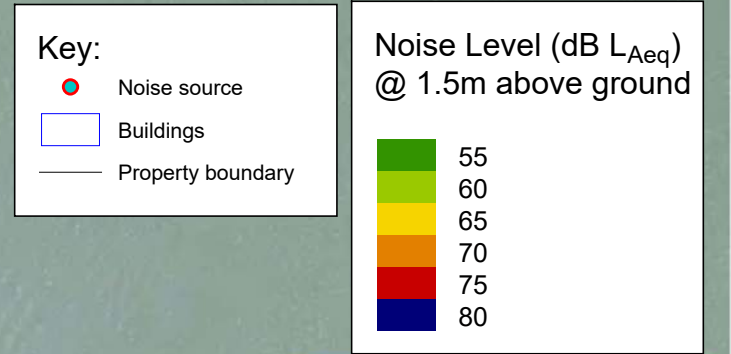
Construction Noise Contours

Airborne construction noise contours:

- Figure 1: Hobson Wharf Impact Piling
- Figure 2: Halsey Wharf Impact Piling
- Figure 3: Wynyard Wharf Infill Impact Piling
- Figure 4: Hobson Wharf Structure 7 Bored Piling
- Figure 5: North Wharf Pontoon Vibro Piling

Underwater construction noise management zones:

- Figure 6: Hobson Wharf Impact Piling
- Figure 7: Halsey Wharf Breakwater 2 Impact Piling
- Figure 8: Wynyard Wharf Structure 1 Impact Piling



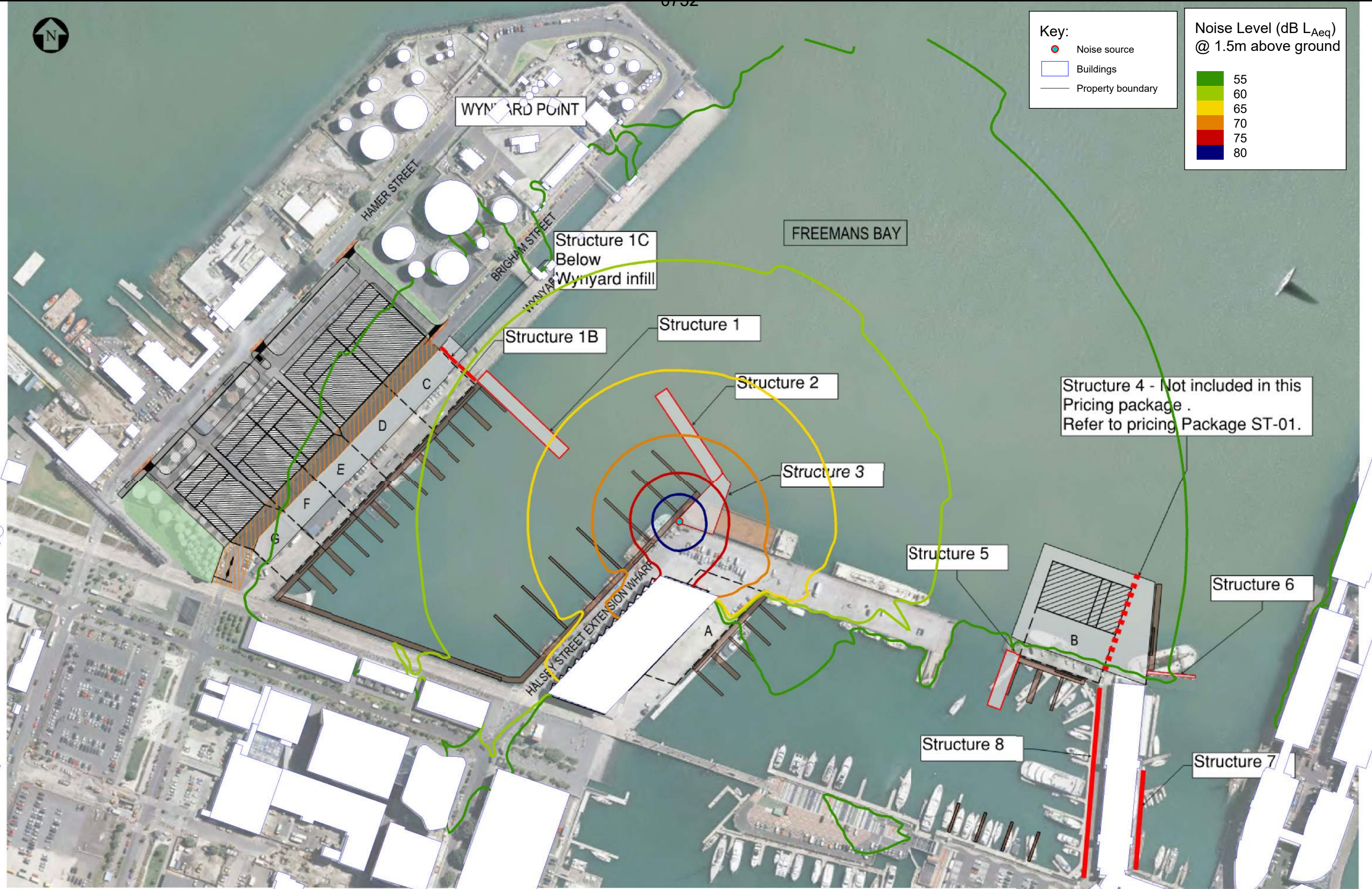


Key:

- Noise source
- Buildings
- Property boundary

Noise Level (dB L_{Aeq}) @ 1.5m above ground

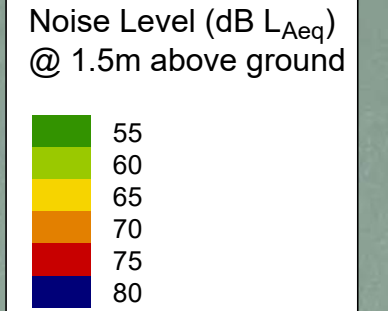
	55
	60
	65
	70
	75
	80





Key:

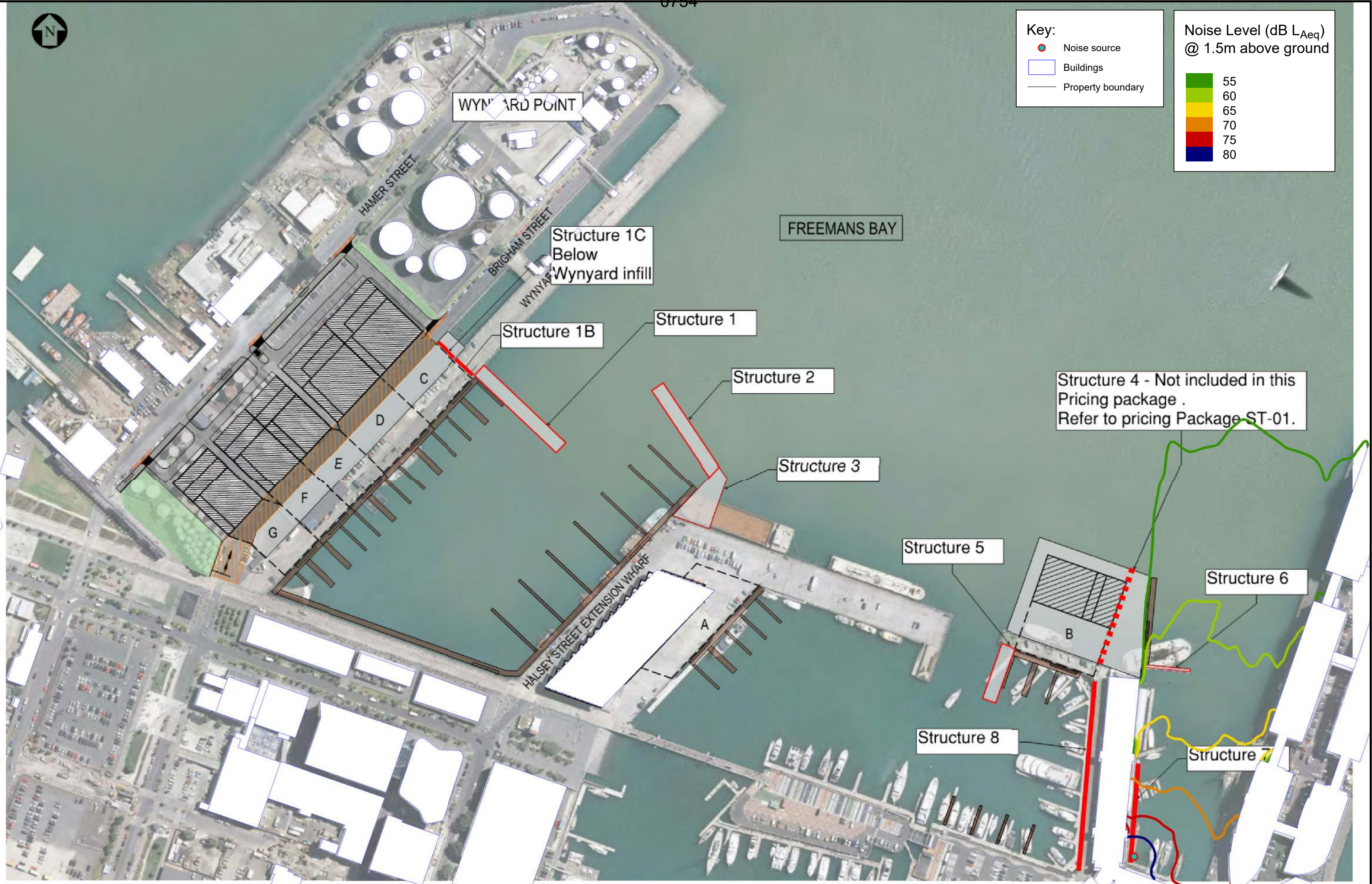
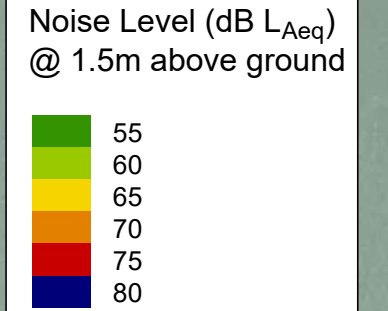
- Noise source
- Buildings
- Property boundary





Key:

- Noise source
- Buildings
- Property boundary





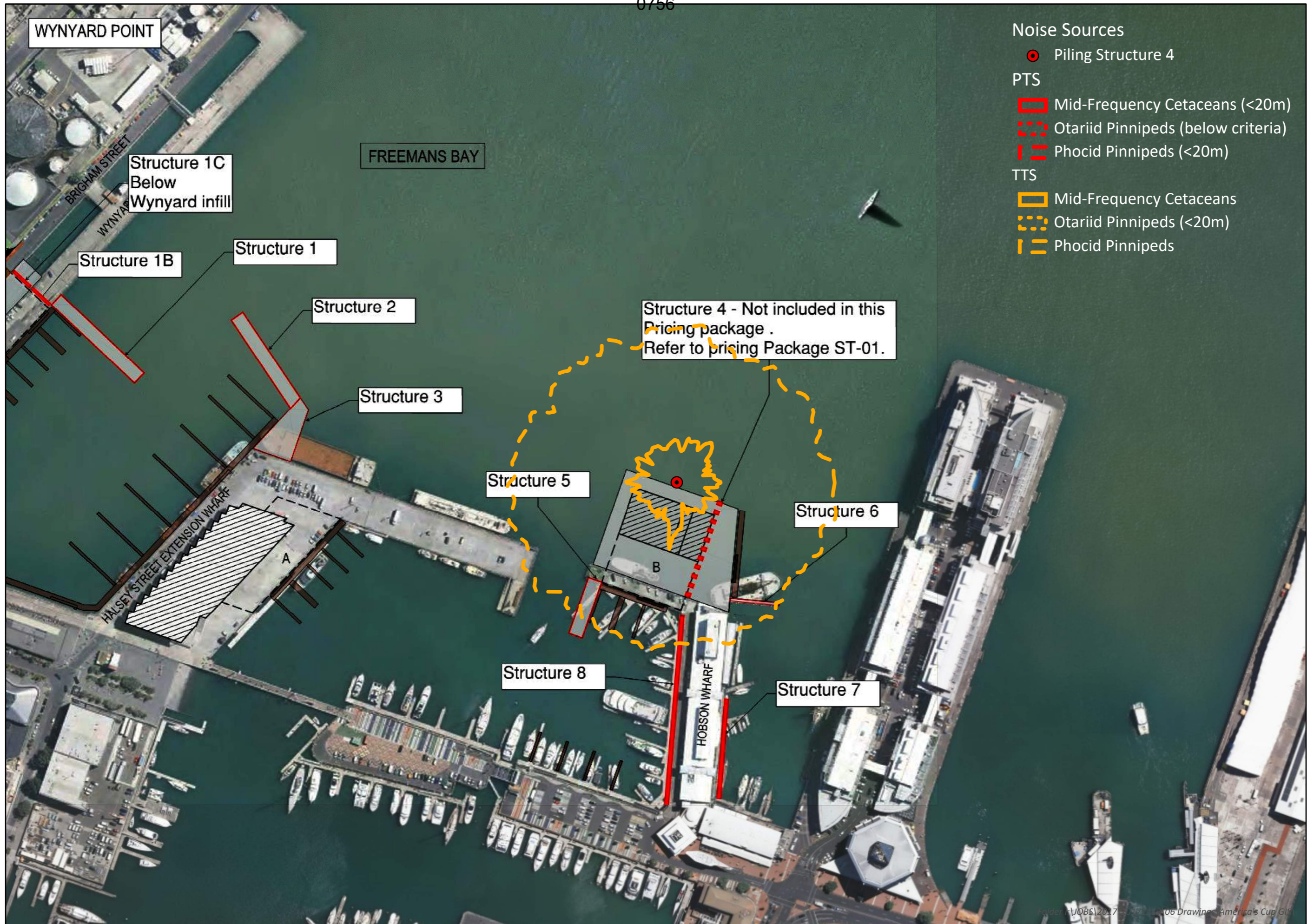
Key:

- Noise source
- Buildings
- Property boundary

Noise Level (dB LAeq) @ 1.5m above ground

	55
	60
	65
	70
	75
	80





Noise Sources

- Piling Structure 4

PTS

- ▭ Mid-Frequency Cetaceans (<20m)
- ▭ Otariid Pinnipeds (below criteria)
- ▭ Phocid Pinnipeds (<20m)

TTS

- ▭ Mid-Frequency Cetaceans
- ▭ Otariid Pinnipeds (<20m)
- ▭ Phocid Pinnipeds

Structure 4 - Not included in this Pricing package .
Refer to pricing Package ST-01.

Power:\V0BS\2017-09\06\Drawings\America's Cup GIS

Noise Sources

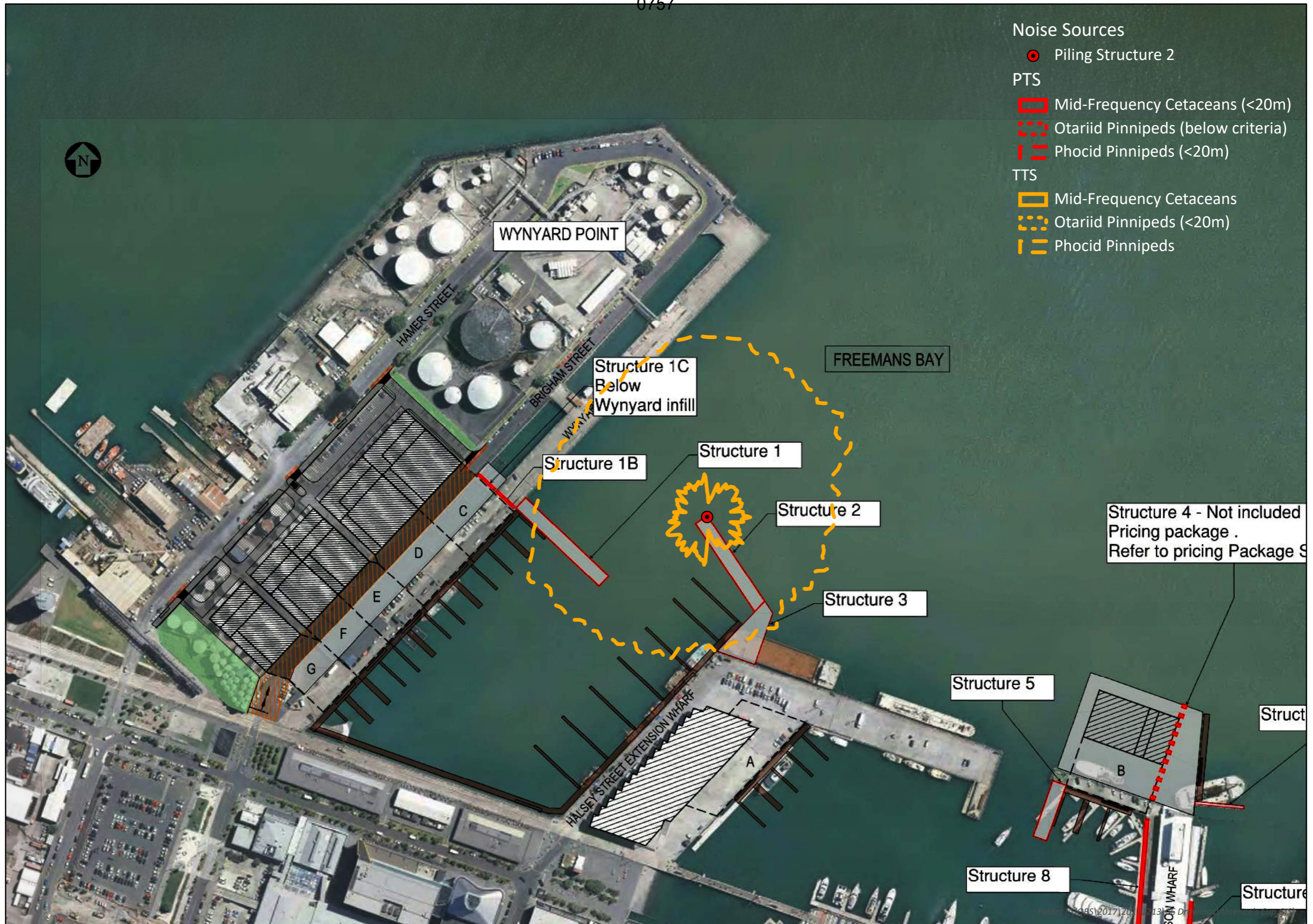
- Piling Structure 2

PTS

- ▭ Mid-Frequency Cetaceans (<20m)
- ▭ Otariid Pinnipeds (below criteria)
- ▭ Phocid Pinnipeds (<20m)

TTS

- ▭ Mid-Frequency Cetaceans
- ▭ Otariid Pinnipeds (<20m)
- ▭ Phocid Pinnipeds



Structure 4 - Not included
Pricing package .
Refer to pricing Package S



- Noise Sources
- Piling Structure 1
- PTS
- ▭ Mid-Frequency Cetaceans (<20m)
 - ▭ Otariid Pinnipeds (below criteria)
 - ▭ Phocid Pinnipeds (<20m)
- TTS
- ▭ Mid-Frequency Cetaceans
 - ▭ Otariid Pinnipeds (<20m)
 - ▭ Phocid Pinnipeds

FREEMANS BAY

WYNYARD POINT

Structure 1C
Below
Wynyard infill

Structure 1B

Structure 1

Structure 2

Structure 3

Structure 4
Pricing pack
Refer to pr

Structure 5

HALSEY STREET EXTENSION WHARF

Structure 8

AC36 - Underwater Management Zones
Figure 8: Structure 1 Impact Piling (1,200mm steel piles, 3 piles/day @ 50 strikes/pile)