Attachment 26

Bledisloe North Wharf & Fergusson North Wharf Extension

Navigational Safety Assessment

Prepared for Port of Auckland Limited

by

Navigatus Consulting

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Bledisloe North Wharf & Fergusson North Wharf Extension – Navigational Safety Assessment

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1 Executive Summary

1.1 Context

Port of Auckland Limited (POAL) is proposing to undertake construction of a new wharf at the northern end of the Bledisloe Terminal and an extension to Fergusson Wharf (the Project) to provide an additional berth at Bledisloe North and to increase efficiency of berthing operations at the Fergusson North Wharf.

This report provides a navigational and safety risk assessment of the Project.

The proposed development of the new wharf structure at the northern end of the existing Bledisloe Terminal will provide berthage for Roll-on Roll-off (RoRo) Pure Car Carriers (PCC) and for large cruise ships (>300m).

This proposed new Bledisloe North Wharf will provide a suitable berthing arrangement for the largest cruise ships that are forecast to visit Auckland. Currently such vessels are unable to berth in Auckland safely and reliably, requiring them to either anchor, hold position within the inner harbour anchorages using Dynamic Positioning (DP), berth at Fergusson North Wharf (which is not suited for such vessels), berth at Princes Wharf under very tight wind limits (ships up to 330m only), or not visit New Zealand at all.

The existing Fergusson North Wharf consists of a main wharf with mooring dolphins at each end. The operational range of the quay cranes (longitudinal wharf length that can be used for loading and unloading containers) is 295m. While the current configuration is operationally efficient for container vessels of capacity of up to 5,500 Twenty-foot Equivalent Units (TEU), vessels of 4,300 TEU are most representative of the capacity and size of the vessels currently most frequently berthed at the wharf.

However, there is a general increase in the size of container vessel in the global fleet. Shipping lines have signalled their intent to increase the number of 7,000-8,000 TEU vessels calling at Auckland in the next 2-3 years and vessels of up to 10,000 TEU within the next 10 years.

In its current configuration, Fergusson North Wharf could accommodate 10,000 TEU ships (up to 360m long)[1], however the dolphin arrangement to the eastern end prevents the quay cranes from accessing the full working length of these ships. This would cause significant issues through requiring repositioning the ship during loading/unloading or imposing unworkable restrictions on the vessel loading plan (due to ship-stability constraints).

The proposed Fergusson North Wharf extension will increase the efficiency of berthing operations at the wharf by enabling the quay cranes to access the full length of a 10,000 TEU, up to 360m length overall (LOA) ship. This will in turn remove the requirements for ships to reposition during loading/unloading and restrictions on vessel loading plans.

[1] Note: TEU, or a twenty-foot equivalent unit, is the standard measure of the container capacity of a container vessel. The physical size of vessels versus capacity is not precisely related. However, given accepted designs and natural constraints, any differences in the length, breadth and vertical bulk across a fleet of similar TEU will be limited. TEU is therefore a useful guide as to the likely absolute size of a given vessel – that being most relevant from a navigational perspective.

1.2 Benefits

By enabling a significant proportion of the cruise ships visiting Auckland to berth at the proposed new Bledisloe North Wharf, a number of benefits will be able to be realised, including:

- Improved safety and increased operating windows (dictated by wind limits) for cruise ship operations due to modern fit-for-purpose berthing arrangements to current specification and simplified and more efficient berthing manoeuvres.
- Reduced safety-risk to cruise ship passengers and other water users through removing the need for tenders to transport passengers to and from the largest cruise ships in the inner harbour anchorages.
- Avoiding the far from ideal occasional use of Fergusson North Wharf for the berthing of the largest cruise vessels.
- Reducing the demand for large cruise ships to need to utilise Princes Wharf and thus the reducing the level of operational disruption and risk to ferry operations in the Downtown Ferry Basin (DFB).
- Use of a purpose designed wharf suited for large cruise ships, a further reduction in the potential exposure of the public to mooring line failure risk can be realised.

1.3 Navigational Risk Assessment

Navigatus has undertaken an evaluation and assessment of the changed risk profile of the harbour operations associated with the proposed changes to the use of the wharves by large vessels, the associated works and subsequent operations. This assessment has been undertaken in the context of the local environmental conditions and the operational context of the Port's activities as well as the local ferry traffic, cruise ship movements, other large commercial maritime traffic and the interaction with any other maritime activities in the area – both commercial and recreational.

The assessment considered the following with regard to navigational risk:

- Compliance with international design standards – turning area to the north of the wharf developments.
- Compliance with international design standards – clearance for berthed ships.
- The effect of tidal currents at the proposed wharf developments.
- Impact of the proposed physical and operational changes on:
  - Recreational maritime traffic due to the presence of 10,000 TEU vessels alongside Fergusson North Wharf and any associated increase in wind shadowing.
  - Operational use of Fergusson North Wharf due to the ability to operate cranes along the full length of the wharf.
  - Other commercial shipping (due to changes at the proposed Fergusson North Wharf).

- Recreational maritime traffic due to the use of the proposed Bledisloe North Wharf and any associated wind shadowing.
- Other commercial shipping (due to the proposed Bledisloe North Wharf).
- Cruise ship operations in general due to the availability of the proposed Bledisloe North Wharf.
- Cruise passengers and the public (ashore).
- Ferry traffic due to the proposed Bledisloe North Wharf.
- Ferry operations in the DFB.

1.4 Consultation

The following stakeholders were consulted with as part of this assessment:

- Harbourmaster's office regarding their expectations for the Navigation Safety Assessment (NSA), including any concerns regarding the proposed works/operations.
- POAL's Operations Manager, pilots and tug masters regarding advice on operational, procedural, scheduling and ship handling matters.
- Local commercial ferry operators Fullers and SeaLink.
- Royal New Zealand Navy (RNZN) as key large vessel users of the nearby navigable water within the harbour.
- Representatives of local yacht clubs including;
  - Royal New Zealand Yacht Squadron (RNZYS).
  - Royal Akarana Yacht Club.
  - Short Handed Sailing Association of New Zealand.
  - Devonport Yacht Club.
  - Auckland Sailing Club.
  - Ponsonby Cruising Club.
  - Richmond Yacht Club.
  - Tamaki Yacht Club.

The general finding from the consultation of the professional mariner stakeholders consulted was that the proposed Project would act to make for simpler and more efficient operations (Ferry operations in the DFB) or have no material effect on their operations (SeaLink, Fullers, RNZN).

With regard to the recreational harbour users, the only specific maritime issue raised, was that of wind shadowing from large, berthed vessels.

1.5 Wind Shadowing

An assessment has been undertaken of the probable extents of wind shadows cast by both the vessels currently routinely berthing at Fergusson North Wharf (represented by vessels of 4,300 TEU) and the largest vessels expected to be berthed at each of the proposed wharfs. The assessment considers the probability that a wind shadow will be formed, the extent of the wind shadow, and the resulting effect on sailing activities.

The assessment concluded that while the berthing of the largest vessels expected at Fergusson North Wharf creates a larger wind shadow than that of the vessels currently routinely berthing at this wharf, the difference is not significant. The difference in effects of the slightly larger wind shadow are likely to only be noticed by sailing vessels who have approached closer than the majority would judge as optimal.

Regarding the new Bledisloe North Wharf, it is concluded that wind shadowing will occur when the wind is from a southerly quarter and a large vessel is alongside. This effect will be new and extend, in part, north of the sail racing exclusion zone boundary.

The highest-impact situation is when there is a cruise ship and container ship alongside the new Bledisloe North Wharf and the extended Fergusson North Wharf with a steady south-easterly to south-westerly wind blowing. However, it is concluded that there is still at least 510 metres of clear air in the fairway for a sailing vessel to continue to sail through the Waitematā Harbour. The analysis indicates that the impact on sailboats due to wind shadowing from the proposed wharf developments will be limited in terms of overall period of occurrence and effect on the ability to make passage.

1.6 Conclusions

Our assessment has concluded that, provided the proposed wharf expansions and mooring arrangements are designed to current standards and maritime requirements, the Project presents no new or unique risks to navigation and the safety of water users within the Waitematā Harbour.

The overall navigational risk profile of the harbour is found to be lowered as a result of the Project. This is due to a reduction in the potential risks of an adverse interaction between a cruise ship and ferry traffic in the DFB and the removal of the occasional need to anchor very large cruise ships in the harbour.

When taking both the extent of the wind shadowing and the probability of occurrence into account, an analysis of wind shadowing from the largest vessels berthed at the new or extended wharves indicates that the impact on sail boats will be limited.

Overall, the new Bledisloe North Wharf and Fergusson North extension works are beneficial in terms of navigational risks and safety within the Waitematā Harbour. Provided compliance with normal maritime operational best practice and communication of changes the resulting risk profile for navigational safety will be as low as reasonably practicable (ALARP).

2 Introduction

2.1 Scope

This Navigational Safety Assessment (NSA) report assesses the impact of the Project on navigation at and near to the Port;

- between the eastern edge of Fergusson Terminal to the outer end of Princes Wharf,
- the Downtown Ferry Basin (DFB),
- the associated Waitematā Harbour area including the main navigation channel.

This assessment was undertaken via a comparative risk assessment that describes the navigation and safety hazards and risks associated with;

- the present situation, wharf and berthing arrangements, and port and harbour operations (i.e. prior to works commencing),
- the proposed Project work activities and impact of the change, and
- the post-Project works situation, wharf and berthing arrangements, and port and harbour operations.

2.2 Overview of Risk Methodology

This NSA has been guided by:

- AS/NZS 31000:2009 Risk Management – Principles and guidelines. Adopted international standard[2].
- Port and Harbour Marine Safety Code[3].
- Key Principles for Marine Safety Risk Management[4].
- PIANC Report N° 121 – 2014 Harbour Approach Channels Design Guidelines[5].

In accordance with the ISO 31000 risk management process, this NSA:

- Sets out the context and scope of the Project.
- Identifies risk aided by consultation with stakeholders.
- Describes the current port and harbour environment, channel and operations.
- Describes the proposed physical and operational changes to the Port.
- Analyses the changes to the harbour risk profile during and subsequent to the proposed works.
- Proposes any additional controls to address risks that are assessed as not being as low as reasonably practicable (ALARP).

[2] Similar to: International Organization for Standardization, “ISO 31000:2018 Risk Management.”
[3] Maritime New Zealand, “New Zealand Port and Harbour Marine Safety Code.”
[4] Maritime New Zealand, “Key Principles for Marine Safety Risk Management.”
[5] The World Association for Waterborne Transport Infrastructure, “PIANC Report N° 121 – 2014 Harbour Approach Channels Design Guidelines.”

2.3 Proposed Works

2.3.1 Purpose of Works

Port of Auckland Limited (POAL) is proposing to construct a new wharf at the northern end of Bledisloe Terminal and an extension to the existing Fergusson North Wharf. Resource consent is being sought using the Fast-track Approvals Act process.

2.3.2 Proposed Development- Bledisloe North Wharf

Rationale

The proposed development of a new wharf on the northern end of the existing Bledisloe Terminal, Bledisloe North Wharf, will provide berthage for Roll-on Roll-off (RoRo), pure car carriers (PCC) and for large cruise ships (>300m), reducing the typical size of cruise vessels utilising Princes Wharf and reducing operational disruption and risk to operators using the DFB as a result of the use of the space available within the DFB and less use of thrusters in high wind conditions.

The proposed new wharf will also provide a suitable berthing arrangement for the largest cruise ships (300m – 350m in length), currently unable to berth in Auckland safely and reliably, requiring them to either anchor, hold position within the harbour anchorages using Dynamic Positioning (DP), berth at the constrained Fergusson North Wharf, or berth (up to 330m) under very tight wind limits at Princes Wharf or not visit New Zealand altogether.

Construction of the new Bledisloe North Wharf will enable RoRo vessels that are currently utilising Captain Cook Wharf being relocated to the Bledisloe Terminal. We have been advised that this will in turn allow the sale of Captain Cook and Marsden wharves by POAL to Council for alternative uses (not dealt with in this application).

By enabling cruise ships greater than 300m length overall (LOA) to use the proposed Bledisloe North Wharf, a number of additional benefits are able to be realised. These benefits include:

- Improved safety margins and increased operating windows (wind limits) for cruise ship operations due to modern fit-for-purpose berthing arrangement at the new wharf.
- Reduced risk to cruise ship passengers and other water users through removing the need for large cruise ships from having to anchor mid-channel and so avoiding the need for the ship's tender-boats to transport passengers to and from shore.
- Avoiding the need to use Fergusson North Wharf to berth large cruise ships. Note that as this wharf is designed for container handling, large cruise ships must be ballasted to list[6] away from the wharf to avoid impact with the wharf quay cranes.

Existing Manoeuvring Procedures

Currently, cruise ships visiting Auckland are routinely accommodated in one of four locations - Princes Wharf, Queens Wharf, anchored within the Waitematā Harbour or at Fergusson North. Princes Wharf and Queens Wharf are dedicated cruise berths. Both take cruise ships

[6] "list" refers to a ship leaning to one side (off vertical).

up to 300m long in a wider range of wind conditions, and Princes Wharf takes some ships up to 330m long under tight wind restrictions. On rare occasions Fergusson North Wharf has also been used for large cruise ships up to 348m long but due to their unusual appendages this is complex. This is far from satisfactory from a passenger experience point of view, for port efficiency perspective or in terms of berthing safety.

Each berth assignment and vessel requires a detailed individual manoeuvring plan which is discussed and agreed between the POAL pilot and the vessel's master. Although there are exceptions and each manoeuvre is planned to suit the environmental conditions at the time (wind and tide), the main factors which influence the manoeuvring plans are vessel size and handling characteristics, and availability of tugs.

Generally speaking, the basic approach for each location is broadly:

- Princes Wharf (east face) – Approach from the east, reduce speed and turn to port. Berth starboard side to Princes Wharf (bow south). This berth can be utilised by cruise ships up to 330m in length, although there are constraints in terms of wind strength and direction for the larger vessels being able to remain berthed safely at this location.
- Queens Wharf (east face) – Approach from the east, reduce speed and turn to port. Berth starboard side to Queens Wharf (bow south). This berth is utilised by cruise ships up to 300m in length.
- Harbour (Anchor/DP) – Approach inner harbour anchorages from the east, stopping in assigned anchorage. Either anchor the ship in the designated location or maintain a stationary position utilising DP technology (or a combination of anchors and DP as appropriate to the conditions). Passengers are then transported to and from the Auckland CBD by the ship's tenders. This option is currently the only available option for cruise ships over 330m in length.
- Fergusson North Wharf – Approach from the east, reduce speed and turn to starboard. Berth starboard side to Fergusson North Wharf. If the vessel is a large cruise ship, it must be ballasted to list 5 degrees to port to avoid the overhanging lifeboats and balconies from contacting the wharf quay cranes. This takes careful ship handling and is clearly a less-than-ideal situation for the passengers.

Proposed Bledisloe North Wharf Design

The proposed new wharf will be purpose designed to support stern-quarter ramp RoRo vessels. The intent is to accommodate medium to large RoRo PCCs. It will also be able to accommodate cruise ships up to the size of the largest currently forecasted to visit New Zealand, being 348m LOA.

The proposed wharf will accommodate the type of RoRo vessels that currently utilise Captain Cook Wharf, as well as all cruise vessels (including those over 300m in length). The wharf itself consists of a 330m long x 27.5m wide concrete wharf deck, suspended above the water by steel-cased reinforced concrete piles. Work to replenish and extend the existing rip rap bunding and scour protection will also be undertaken. The proposed design allows for stormwater collection and treatment prior to discharge and incorporates pits and associated infrastructure to support the establishment of shore power in the future.

The below image (Figure 2-1) shows the proposed wharf design with indicative size of medium and large quarter-ramp RoRo vehicle carriers, as well as an Ovation Class (348m)[7] cruise ship with the bow slightly overhanging to the east.

Figure 2-1: Proposed new Bledisloe North Wharf (also showing berthing positions).

2.3.3 *Proposed Development – Fergusson North Extension*

Rationale

The existing Fergusson North Wharf currently consists of a main wharf with mooring dolphins at each end. The operational range of the quay cranes (used for loading and unloading containers) is 295m. The current configuration is operationally efficient for container vessels up to 5,500 Twenty-foot Equivalent Units (TEU), however there is a global increase in the size of container vessels in service. Shipping lines have signalled their intent to increase the number of vessels up to 7,000-8,000 TEU calling at Auckland in the next 2-3 years and up to 10,000 TEU within 10 years.

In its current configuration, Fergusson North Wharf can accommodate 10,000 TEU ships (360m long) using the existing mooring dolphins, however the quay cranes cannot access the full length of the ship. This causes significant issues as ships are required to be repositioned during loading/unloading (losing 2-3 hours) or subject to loading restrictions on the vessel loading plan (due to vessel stability and trim criteria having to be met) which are often unworkable.

[7] DNV Vessel Register

The Fergusson North Wharf extension will increase the efficiency of the wharf, by enabling the quay cranes to access the full length of the 10,000 TEU, 360m LOA ships that, as mentioned above are able to be berthed but currently cannot be efficiently serviced. This will remove the requirement for ships to reposition or the need for restrictions to be placed on vessel loading plans.

Proposed Fergusson North Wharf Extension Design

The proposed works at Fergusson North Wharf will see the existing wharf extended by installing steel-cased reinforced concrete piles into the seabed, and construction of a reinforced concrete wharf deck out to the face of the existing eastern mooring dolphin.

The physical completion of the consented reclamation is occurring in the area immediately to the south of the existing eastern mooring dolphin. A rock revetment will also be installed as part of the previously consented reclamation to aid in scour prevention to protect the reclaimed area.

The extent of the extension proposed by this Project is shown in blue below (Figure 2-2). The consented reclamation (shown in yellow) will soon be completed.

Figure 2-2: Proposed Fergusson North Extension.

2.4 Description of Works

The exact construction methodology will be determined by the contractor(s); however, it is anticipated that all construction works will be able to be conducted from existing land, wharf structures and reclamations within POAL areas.

As described above in Sections 2.3.2 and 2.3.3, the new Bledisloe North Wharf and Fergusson North Wharf extension will be constructed of steel-cased reinforced concrete piles. These steel pile casings will be driven into the seabed using shore-based cranes and

either vibro-hammer or kinetic piling techniques. Once design depth is achieved, the casings will be filled with reinforced concrete and allowed to cure before the wharf deck is constructed (also steel reinforced concrete).

Rock revetments/bunding will also be carried out utilising excavators from the shore.

It is to be expected that some additional on-water activities, such as diving operations and water-based inspections of wharf structures/construction will be carried out at times during the construction period and that rock rip rap will be delivered by barge. However, standard maritime risk controls and existing operational procedures will ensure that these activities do not materially change the risk profile or introduce any new or unique risks.

A Construction Management Plan (CMP) will need to be prepared for the proposed works and will be provided by the construction contractor in consultation with POAL. The CMP will need to cover all safety related aspects of the construction, including general description of equipment and construction methodology. Given, as stated above, that almost all the works will be carried out from shore-side, it is likely most effective if navigational safety aspects of the works should be included in the CMP (see also Section 2.5).

2.5 Works Vessels

Disturbance of the coastal marine area will be inevitable to facilitate the construction of the toe trench at the Bledisloe North Wharf. The only disturbance of the seabed will be by way of the construction of the toe trench (excavation and filling), no dredging to alter the seabed levels is proposed for the Project.

If excavation of the seabed cannot be done from shore, a vessel will have to be used. However, any vessels conducting this excavation of the seabed, on-water inspections or construction support activities will be subject to the requirements of Maritime New Zealand's (MNZ) Maritime Operator Safety System (MOSS). The specifics relating to the safety of operations of these vessels will be detailed in the CMP provided by the construction contractor in conjunction with POAL. Many of the standard maritime risk controls detailed at Section 5.2 will also apply.

2.6 Regulatory Context

All vessels are subject to maritime legislation, regulations and rules. At the national level, MNZ sets Maritime Rules, of which the following apply:

- Maritime Rules Part 22 – Collision Prevention[8]
- Maritime Rules Part 90 – Pilotage[9]
- Maritime Rules Part 91 – Navigation Safety Rules[10]

At the regional level, Auckland Council makes and implements the Navigation Bylaw 2021[11] pursuant to sections 33M and 33R of the Maritime Transport Act 1994 and in line with the

[8] Maritime New Zealand, "Maritime Rules Part 22: Collision Prevention."
[9] Maritime New Zealand, "Maritime Rules Part 90: Pilotage."
[10] Maritime New Zealand, "Maritime Rules Part 91 - Navigational Safety Rules."
[11] Auckland Council, (2021): Ture ā-Rohe Urungi Āhuru, Navigation Bylaw 2021.

Maritime Rules. The Bylaw promotes safe recreational and commercial use of Auckland's waters and introduces several definitions and requirements, including:

- Use of restricted areas, access lanes, prohibited and restricted anchorages, reserved areas and special reserved areas
- Responsibilities of a person in charge of a large vessel[12]
- Responsibilities of a person near large vessels
- Duty of Master of a Vessel under 500 Gross Tonnage
- Moving Prohibited Zone
- Compulsory pilotage areas[13]

In addition, Part 33 of the Maritime Transport Act 1994[14] also gives the Harbourmaster a range of powers to manage maritime safety in the region.

[12] Any vessel of 500 gross tonnage or greater, and any vessel of 40 metres length overall or greater.
[13] Clause 53 of Bylaw
[14] New Zealand Government, Maritime Transport Act 1994.

3 Waitematā Harbour

3.1 Harbour General Description

Waitematā Harbour and its waterways play a major role in Auckland's transportation network. The geographic study area of Waitematā Harbour for this assessment comprises the maritime area between North Head and the Auckland Harbour Bridge.

The main berthing and cargo handling area is primarily operated by POAL, which is situated along the southern side of the harbour. It currently stretches from the Fergusson Container Terminal to Princes Wharf. POAL handles general cargo, bulk materials, containers, as well as cruise ships. Devonport Naval Base and the Babcock managed dockyard (which also provides a dry dock facility) are located on the northern side of the harbour, opposite the POAL container terminal. Passenger ferry services within and to destinations beyond the harbour are operated out of the DFB.

Other facilities and activity include the Chelsey Sugar facilities to the west of the Auckland Harbour Bridge serviced by bulk carrier vessels under the pilotage of POAL, super yacht and general maritime support activities in the St Mary’s Bay area and Westhaven Marina and Bayswater Marina based recreational boating. Yacht racing occurs in the area of the harbour bridge as well as through the harbour proper and east into the Hauraki Gulf.

Given the above activity, the harbour acts as a fairway for the associated traffic. Figure 3-1 shows the absolute distances between the various land features in the harbour. In practice, due to a demarcated defence area and some shallows off Stanley Point the navigable water is a little narrower than displayed in Figure 3.1. However, while the harbour can at times be busy the width is not constraining for watercraft and vessels and is not difficult to routinely navigate through.

Due to the mix of traffic types, the Harbourmaster has set out speed-restricted areas within the fairway. This largely to avoid significant speed differences between the high-speed craft such as ferries and the slower recreational craft causing navigational safety issues (refer Figure 3-4).

Figure 3-1: Satellite view of Waitematā Harbour with harbour widths marked.

3.2 POAL General Description

POAL facilitates the import and export of a range of products including those from the agricultural and industrial sectors from the surrounding regions, as well as the import of a diverse range of commodities, raw materials, and finished goods to support the industries and consumer markets of Auckland (New Zealand's largest city and industrial centre) and the surrounding regions. POAL serves as an official port of entry for the country. POAL serves as a significant commercial and customs port, connecting New Zealand's exports and imports to global markets through its strategic location on Waitematā Harbour. POAL is New Zealand's largest import port.[15]

3.3 POAL Operations

Current POAL operations include:

- The dedicated container handling facility at Fergusson Container Terminal. These operations include 900m of berth, use of eight ship-to-shore cranes, and a large straddle carrier fleet.
- Multi-cargo facilities across Marsden, Captain Cook, Bledisloe, Freyberg, and Jellicoe wharves. These facilities handle steel, timber, dry and liquid bulk, containers, and vehicles (delivered by quarter-ramp RoRo vessels).

[15] 2023 Annual Report.pdf (poal.co.nz).

- Marine services:
  - The Harbour Control team schedules commercial movements around the harbour and provides information to ships and other craft entering the harbour limits.
  - The hydrographic survey team ensures that the port meets requirements in the harbour by collecting accurate data. There is a dedicated hydrographic boat.
  - Pilotage, mandatory for vessels over 500 gross tonnage, is provided with two pilot boats operated by POAL. In addition, POAL provides routing data and maps for effective pre-planning, monitoring and safety management for a vessel's pilotage within the harbour.
  - POAL have four tugs which can be operated at any time, seven days a week.
  - The bunker barge *AWANUIA* is used in the port to provide a refuelling service to cruise, general cargo, and container ships when visiting Auckland.

3.4 Environmental Conditions

3.4.1 Area Winds

As with most New Zealand harbours, the Waitematā Harbour experiences seasonal weather patterns (Figure 3-2). These patterns are generally predictable, particularly during the summer months where the winds are strongly influenced by global meteorological conditions such as El Niño and La Niña. Winds at or exceeding gale (Beaufort Force (BF) 8 or ≥34kn) occur infrequently (approximately 2% of the time).[16]

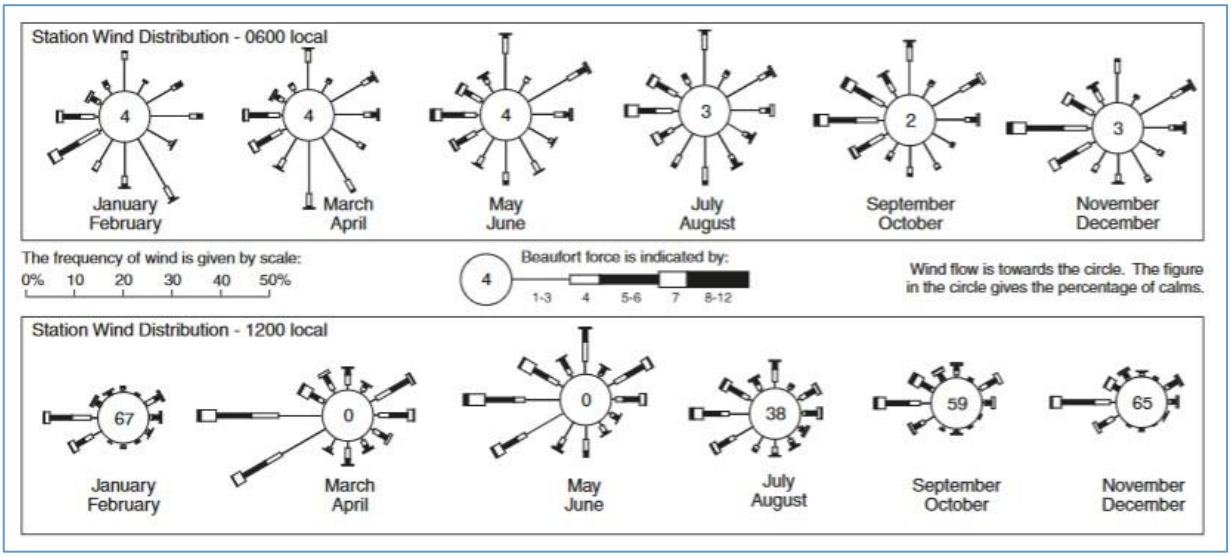


Figure 3-2: Auckland wind distribution[17].

Summer winds are variable, coming from any direction with approximately equal probability. Wind speeds are generally calm to moderate, mostly ranging between BF 1-4 (<16kn).

[16] NP 51 New Zealand Pilot (Auckland Airport station).
[17] NP51 New Zealand Pilot.

As autumn progresses, south-west winds become more prevalent. Predominant wind speeds are moderate to fresh (BF 4-6 or 11-27kn).

Winter provides the most predictable wind direction, predominantly from the south-west or west. Winter wind speeds are similar to those in autumn, with the highest likelihood of speeds in the BF 4-6 range. Winter is one of the least likely seasons to experience gale force winds.

In spring, the winds remain predominantly from the western quadrant with nearly equal chances of north-west, west, or south-west winds. Alongside winter, spring is the least likely season to experience gale force winds.

3.4.2 Local Harbour Winds

Local harbour winds are, as would be expected, influenced strongly by the local features including natural landforms as well as the local built environment – particularly the nearby city buildings. This results in wind patterns that differ from the general publicly available meteorological sources.

Winds from a westerly or easterly direction are, aside from being somewhat funnelled a little by the surrounding terrain, generally little disturbed by local features. However, winds from the South-west to South-east quarters as well as from the North-west to North-east quarters are very much influenced by the local features and can, as a result, be quite disturbed.

Information on the local winds for this study have been gathered from wind stations on Bean Rock (located in open water to the east of the Port) and from the Port's anemometers positioned on a building on Bledisloe North and a tall light pole on the eastern shoreline of the Port.

Given the importance of the local winds to the analysis of the effect on, and of, berthed ships on this analysis, local wind patterns are discussed in greater detail in Section 7. Included in that is a discussion on the effect of berthed large ships creating a 'wind shadow' under southerly wind conditions.

3.4.3 Tidal Streams

The timings and rates of tidal streams vary across the harbour, the state (low/flood/high/ebb) and range of the tide (springs / neaps), and the presence of structures (such as, in this case, the Fergusson Container Terminal) which can impact localised currents at berths.[18]

In the mid-channel area, the ebb (outgoing) tidal stream begins 45 minutes after high tide, while the flood (incoming) stream begins 4 hours and 45 minutes before high tide. However, along the shores of the harbour, both tidal streams commence 30 to 40 minutes earlier than in the mid-channel. Their current rates can vary considerably with the tidal cycle, with the peaks exceeding 1.7 knots (kn) during spring tides.

However, in the vicinity of the existing POAL wharves, the tidal streams may begin approximately 2 hours earlier during spring tides. Near port area, the incoming tidal stream is

[18] NP51 New Zealand Pilot.

significantly influenced at certain tidal stages by the presence of the Fergusson Container Terminal.[19]

A separate analysis of local tidal streams, including under differing wind conditions, has been carried out by the designers as part of the wharf design process[20]. This analysis calculated maximum currents of about 1.5 knots just off Fergusson North. Any changes to localised tidal currents will need to be compensated for in the manoeuvring plans for the berth.

3.4.4 Visibility

Visibility in Waitematā Harbour is generally good, with reports of reduced visibility, to an extent that may affect navigation, being relatively uncommon. Visibility is most likely to be reduced in conditions of heavy rain and squally showers, rather than fog, which is recorded approximately 13 days per year (3.5%).[21] That noted, harbour fog can occur and on rare occasions may persist for much of a diurnal cycle.

3.5 Aids to Navigation

The area is generally well served in terms of Aids to Navigation (AtoN) infrastructure. Leads, prominent marks and cardinals are well designed and in good condition. Fixed AtoN are located across the Auckland Pilotage Area and are in conformance with standard national[22] and international conventions.[23] That noted, the navigational chart of the harbour shows just one AtoN located on the main wharfage area of the Port – this being a fixed sectored light located on the end of Fergusson Wharf (see Figure 2-2). It is understood that the nautical charts do not precisely represent the current configuration of AtoNs.

3.6 Channel and Existing POAL Berths

For large vessels, the Waitematā Harbour is approached from the inner Hauraki Gulf via the dredged and buoyed Rangitoto channel, with the passage passing between Rangitoto Island and the beaches of Auckland's North Shore. The passage then sweeps to the west around the prominent North Head towards the Auckland Harbour Bridge. The geographical boundary for this NSA extends from the western extent of Mechanics Bay to just west of Princes Wharf and the associated shipping channels adjacent thereto (essentially the area marked as "Commercial Harbour" on the navigational chart. See Figure 3-3).

The commercial POAL berths can be seen on the below image. They consist of:

- Fergusson Container Terminal
- Freyberg Wharf
- Jellicoe Wharf
- Bledisloe Terminal

[19] NP51 New Zealand Pilot.
[20] Coastal Assessment Report Draft for Peer Review dated 17th Sept 2024, BECA.
[21] NP 51 New Zealand Pilot.
[22] Maritime New Zealand, Aids to Navigation Guideline.
[23] IALA, "IALA Guideline 1094 - Daymarks for Aids to Navigation."

- Marsden Wharf
- Captain Cook Wharf
- Queens Wharf
- Princes Wharf

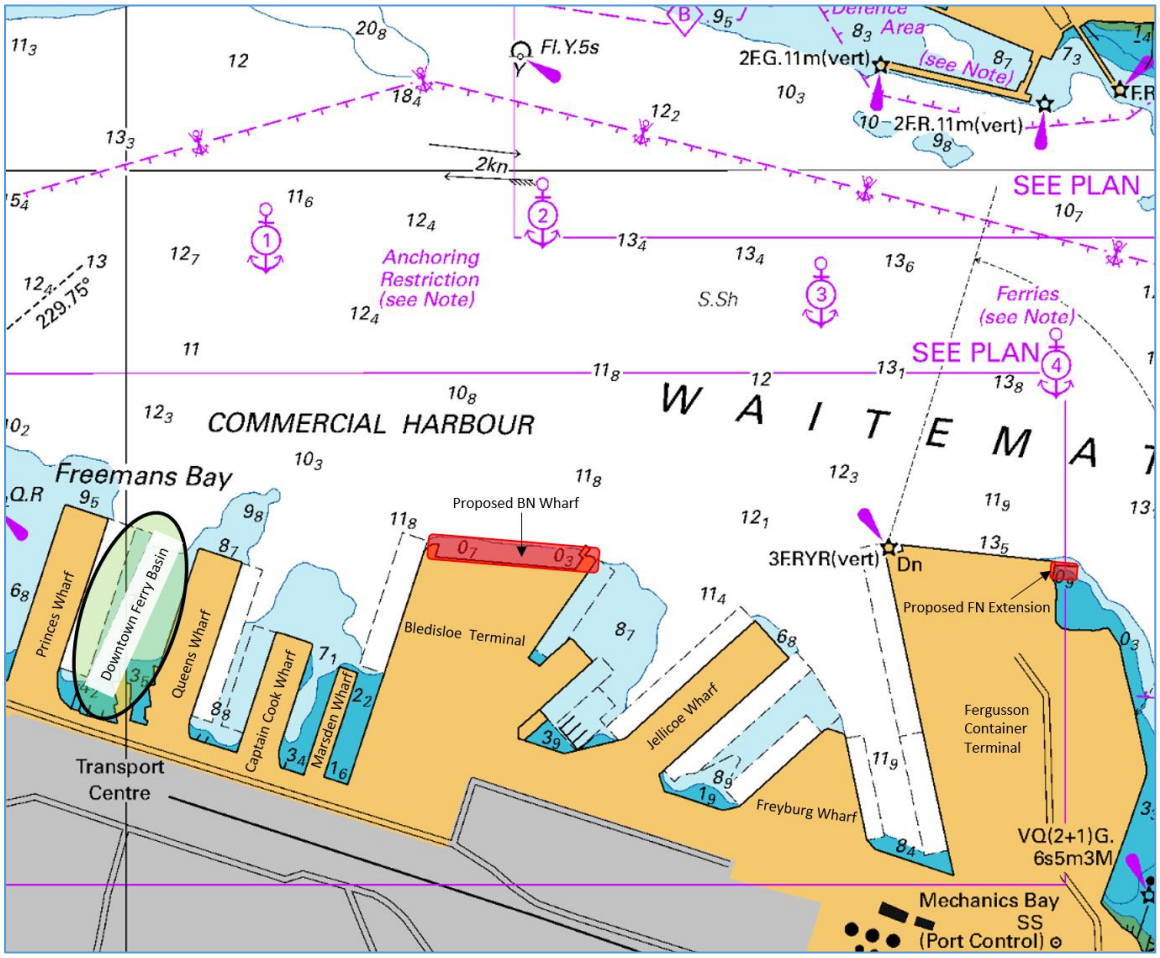


Figure 3-3: Geographic scope of navigational risk assessment.

3.7 Restricted Areas

A port security and Customs area has been established. This prevents any vessels without due permission from entering the waters within the POAL commercial port area, or the DFB (refer Figure 3-4).

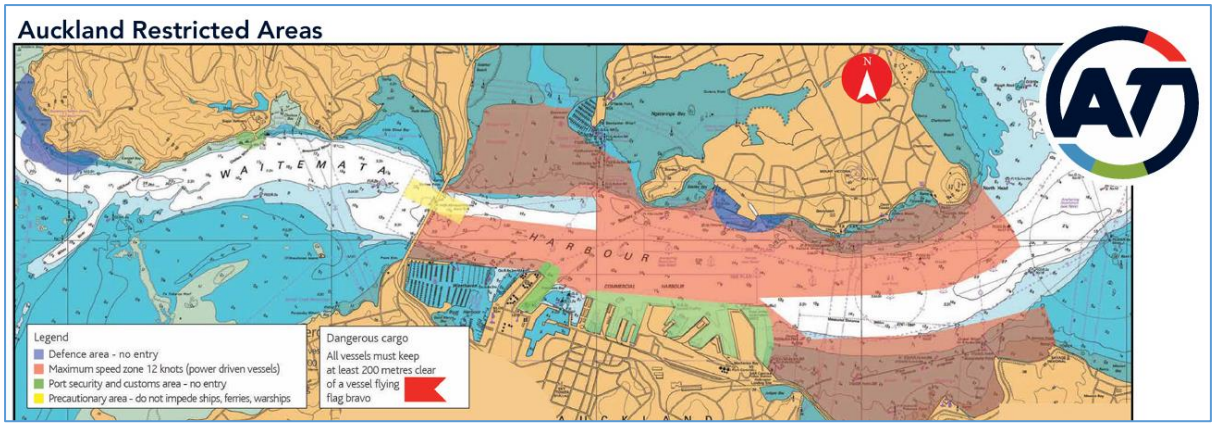


Figure 3-4: AT restricted area speed zones diagram.

Figure 3-4, published by Auckland Transport[24], shows the restrictions and up-lift speed zones within the harbour. It is noted that while readable, this image is not particularly clear as to the exact position of area and zone boundaries. The Harbourmaster has also promulgated a formal restricted area that restricts only vessels with permission entering within the POAL boundaries[25] (Figure 3-5).

Figure 3-5: Navigation Bylaw - POAL Restricted Area diagram.

There is an additional “race exclusion zone” published on some electronic navigation charts used by many recreational vessels (see Figure 3-6). It is understood that this was established by discussions between the Harbourmaster and the local yacht clubs to keep sailing vessels from being tempted to enter the commercial areas of the waterfront and the port’s restricted waters during racing. It should be noted that while this appears well known within the sail racing community and will be shown on the more commonly used recreational chart plotters, it has not been formalised on the official navigation charts and so does not appear on all charts.

[24] auckland-harbour-restricted-areas-october-2018.pdf (at.govt.nz)
[25] Auckland Council, (2021): Ture ā-Rohe Urungi Āhuru, Navigation Bylaw 2021

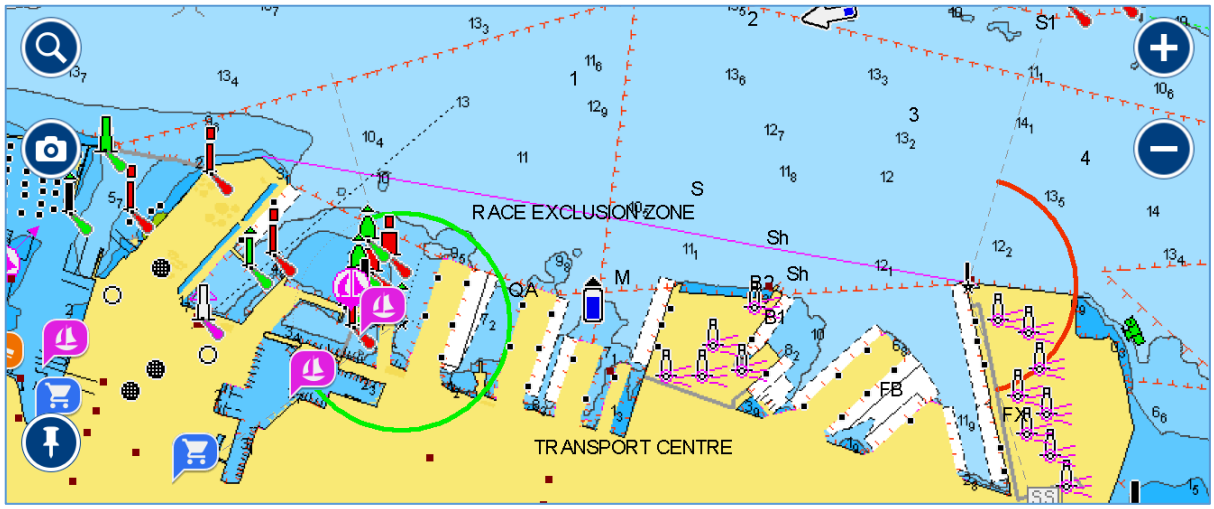


Figure 3-6: Race Exclusion Zone (not formally adopted).

On the northern side of the harbour, there is also a “Defence Area” extending 50m to seaward from the Devonport Naval Base Calliope South Wharf (see Figure 3-7). This area restricts access to only vessels that are authorised to enter the area.

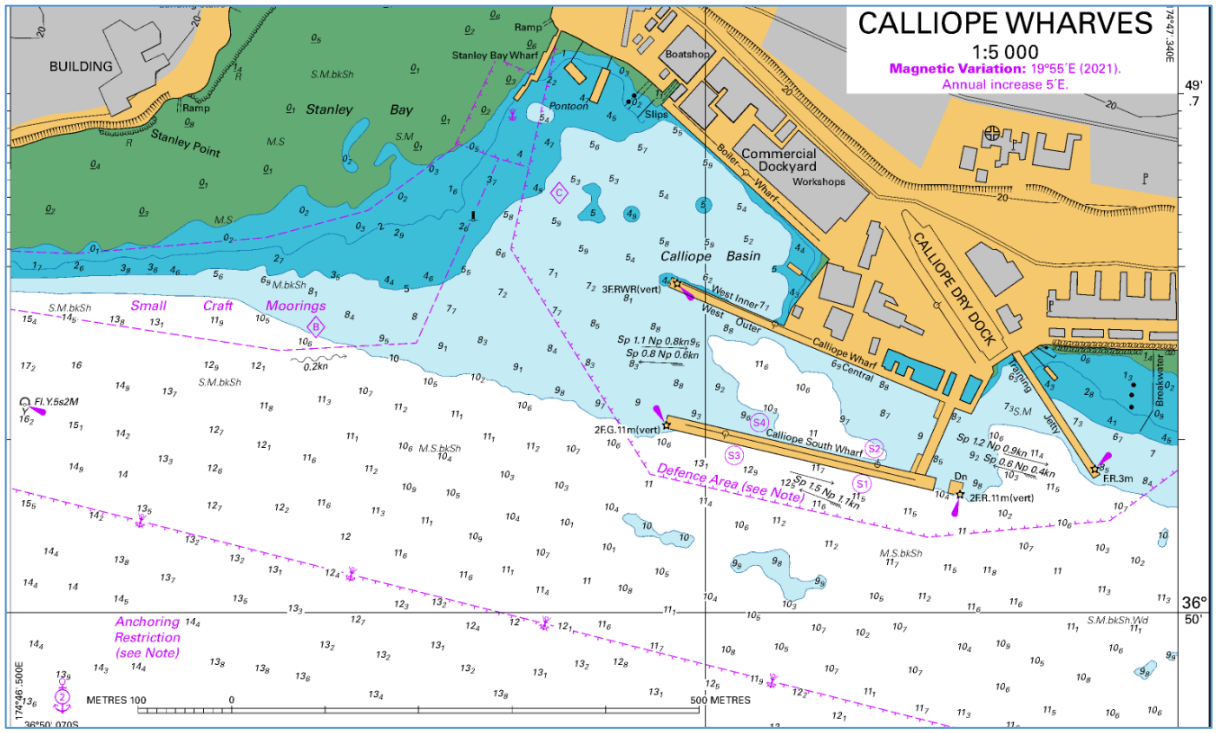


Figure 3-7: Devonport Naval Base – Defence Exclusion Zone.

3.8 Marine Activities

Waitematā Harbour is used extensively for a range of commercial and recreational activities. Vessels navigating the water space in the vicinity of the POAL commercial port, including Bledisloe and Fergusson wharves, range from large commercial vessels to ferries carrying people and vehicles, naval vessels, as well as a wide variety of private and commercial yachts and motor craft. Personal craft such as jet skis, kayaks and, to a lesser extent, stand up paddleboards (SUPs) have also been observed in the port's restricted area on occasion.

Westhaven Marina to the west of Wynyard Point berths nearly 2,000 smaller craft. Other nearby boat harbour and facilities in the vicinity of Westhaven, including the SeaLink RoRo ferry facility, are accessed by somewhat larger vessels via the same waterway. These, as well as the Bayswater marina on the Northern shore, add significantly to the overall activity in this part of the harbour.

Many yacht races, resulting in clusters of sailing vessels transiting together, are regularly held in the Waitematā Harbour. The harbour also sees heavy volumes of marine traffic for special domestic and international events such as the Auckland Anniversary Regatta held annually around the end of January, America's Cup style close-to-shore races and round the world race stop-overs.

3.8.1 Commercial Shipping

Auckland's commercial port is the second largest in the country (by volume and total ship visits), receiving over fifteen percent of the total number of international ship visits to New Zealand in 2023.[26] POAL ranked second in total ship visits (1063), container throughput (819,000 TEU) and bulk volume (6.4 million tonnes).

Table 3-1: POAL commercial vessel traffic[27].

Year	Bulk	Container	Other	Annual ship calls	Average ship calls per day
2013	335	363	269	967	2.6
2014	340	370	308	1018	2.8
2015	330	368	398	1096	3.0
2016	309	375	285	969	2.7
2017	340	368	390	1098	3.0
2018	329	365	391	1085	3.0
2019	319	368	390	1077	3.0
2020	318	356	362	1036	2.8
2021	301	342	355	998	2.7
2022	300	352	388	1040	2.8
2023	307	355	402	1064	2.9

[26] Deloitte, 2024 – New Zealand Ports and Freight Yearbook 2024.
[27] https://www.transport.govt.nz/statistics-and-insights/freight-and-logistics/sheet/figs-trade.

Table 3-1 indicates that annual ship calls to Auckland's commercial port have remained relatively steady over the ten-year period to 2023, with there being on average approximately 3 vessel calls per day (6 movements per day).

3.8.2 Cruise Ships

Cruise ship visits were generally increasing in number but were then heavily impacted by the global COVID-19 pandemic. As a result of international travel restrictions and wider general precautions, there was a two-year period where no cruise ships visited Auckland (see Table 3-2). However, after that hiatus, the number of cruise ship visits has rebounded to higher than pre-covid numbers with the 2023-2024 cruise season having a greater number of visits to Auckland than previous seasons. The number of cruise ships, as well as total passenger numbers forecasted to visit Auckland in the near future, is expected to continue to rise.

Table 3-2: Cruise ship visits to Auckland (2019 - 2024).

Year	Count of cruise ship visits[28]
2019-2020	113
2020-2021	0
2021-2022	0
2022-2023	89
2023-2024	134

3.8.3 Ferry Services

The Waitematā Harbour is traversed by a number of ferry services including Fullers360, SeaLink, and Belaire Ferries. The majority of ferry traffic comprises of point-to-point movements between the DFB and distal areas to the east such as Waiheke Island, Half Moon Bay and Pine Harbour as well as some to the west. While exact movement figures can and will change a little, illustrative DFB ferry movements are presented in Table 3-3.

Table 3-3: Illustrative daily ferry movements to/from Downtown Ferry Basin.

Service[29]	Weekday (Mon-Thu)	Friday	Saturday	Sunday	Notes
Bayswater	22	23	6	5	
Northcote Point/ Birkenhead	21	21	6	5	
Devonport	44	45	36	31	
Gulf Harbour	6	6	0	0	
Half Moon Bay	13	15	0	0	
Pine Harbour	22	24	6	4	Expected to increase in support of housing developments.
Rakino	1*	2	Occasionally 1*	1	Wednesday only.

[28] https://newzealandcruiseassociation.com/2023-2024-cruise-ship-schedule/
[29] https://at.govt.nz/timetables#ferry

Service[29]	Weekday (Mon-Thu)	Friday	Saturday	Sunday	Notes
Hobsonville/ Beach Haven	18	18	8	7	
Waiheke (Passenger)	30	42	25	23	
Great Barrier Island	1*	1	0	1	Weekday changes, but not every day.
Waiheke (Vehicular)[30]	6*	7	7	7	Mon 7, Wed 5.
Total Movements	**184**	**204**	**95**	**84**	

The Devonport and Waiheke routes are the busiest with nearly half of all ferry movements being one of those services. The weekends have notably fewer movements than the weekdays with some locations not having any weekend services.

3.8.4 Recreational Activity

The Waitematā Harbour is extensively used for recreational sporting purposes including yacht racing, kayaking, swimming and paddle boarding. Figure 3-8 and Figure 3-9 show publicly available GPS data from the fitness tracking application *Strava*[31]. These do not display all recreational maritime activity. However, by capturing a reasonably consistent cross section of active people on the water, it usefully indicates areas of congestion and gives a good sense of the relative traffic density, particularly of recreational sporting activity. Interestingly, inspection of the routes does importantly illustrate a proportion of craft that appear to hug the coastlines and indeed the wharves. This can reasonably be assumed to be representative of human propelled craft – namely, kayaks and SUPs.

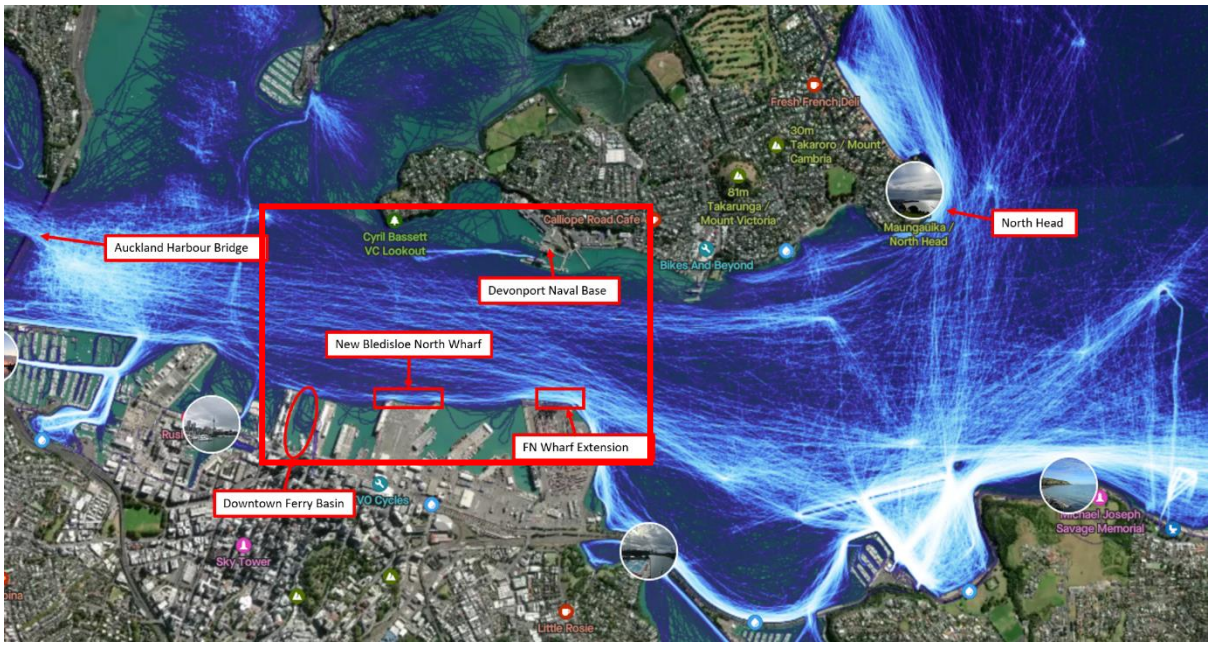


Figure 3-8: Relative traffic density of Waitematā Harbour.

[30] https://www.sealink.co.nz/timetables-fares/waiheke/half-moon-bay-waiheke?gad_source=1&gclid=Cj0KCQjwsuSzBhCLARIsAIcdLm7zXnA7H1Yny_NQx4yY50P92grF6u2r7JYojX0907FeBp9qAszGq3waAvmaEALw_wcB#timetables
[31] Strava, (2024): https://www.strava.com/maps/global-heatmap

Figure 3-9: Illustrative small craft traffic density of Waitematā Harbour (zoomed for scope of report).

3.8.5 Bledisloe North Camera Survey

Navigatus conducted a survey of vessel traffic in the vicinity of Bledisloe Terminal over the period of March 2024 - May 2024. The survey was conducted by installing cameras at the Northern end of Bledisloe Wharf (see Figure 3-10).

The footage was reviewed, with observations recorded for vessels that were assessed to have passed within a nominal range of less than 200m from the end of the existing wharf during daylight hours (See Figure 3-11). Further analysis was then conducted to determine the vessel type, activity and direction of travel. These results were then recorded, screen captures stored, and data analysed to identify if marine activity within the areas adjacent to the proposed new wharf posed a risk during the construction or subsequent operations from the proposed Bledisloe North Wharf.

Analysis of the camera survey footage noted 285 observations of vessels assessed to have transited within a distance of approximately 200m of the northern end of the proposed new Bledisloe North Wharf. Of the 285 observations (a single observation may include multiple vessels, such as a flotilla of yachts or group of kayaks travelling together), the vast majority were assessed to pass the proposed wharf at a distance greater than 100m.

Figure 3-10: Location and field of view of Bledisloe North survey cameras

Figure 3-11: Camera survey image - Ferry assessed to be approximately 200m from wharf.

A number of yacht races were observed during the period of the camera survey. It was seen that the vast majority of sailing vessels remained outside of the race exclusion zone (approximately 140m clear of Bledisloe North, refer Section 3.7) although there were some exceptions (see Figure 3-12).

Figure 3-12: Camera survey image - Yacht race (one vessel appears to be inside the nominated exclusion zone).

The camera survey also identified several instances where small recreational craft were observed close to the proposed construction area (see Figure 3-13, Figure 3-14, and Figure 3-15). These vessels were primarily kayaks or small power-driven vessels and jet skis. Over the course of the 3-month camera survey, approximately 30 vessels were assessed to have passed within approximately 50m of the proposed wharf.

Figure 3-13: Survey camera image – Jet-ski passing close to Bledisloe North.

Figure 3-14: Camera Survey Image - Sailing vessel (under power) passing close to Bledisloe North.

Figure 3-15: Camera Survey Image - Kayak passing close to Bledisloe North.

4 Risk Assessment Methodology

4.1 Outline

Navigatus has undertaken an evaluation and assessment of the changed risk profile of the harbour operations associated with the proposed changes to the use of the wharves by large vessels, the associated works and subsequent operations. This is within the context of the local environmental conditions, the operational context of the Port's activities (summarised in Section 3.2) as well as the local ferry traffic, cruise ship movements, other large commercial maritime traffic and the interaction with any other maritime activities in the area – both commercial and recreational.

4.2 Activity

The following has been undertaken as part of the assessment:

- Navigatus staff visited POAL and received a briefing regarding the proposed operational changes at POAL and rationale for the proposed Project.
- Navigatus and POAL consulted with the following stakeholders:
  - Harbourmaster's office regarding their expectations for the NSA, including any concerns regarding the proposed works/operations.
  - POAL's Operations Manager, pilots and tug masters regarding advice on operational, procedural, scheduling and ship handling matters.
  - Local commercial ferry operators Fullers and SeaLink.
  - Royal New Zealand Navy (RNZN) as key large vessel users of the nearby navigable water within the harbour.
  - Representatives of local yacht clubs including[32];
    - Royal New Zealand Yacht Squadron (RNZYS)
    - Royal Akarana Yacht Club
    - Short Handed Sailing Association of New Zealand
    - Devonport Yacht Club
    - Auckland Sailing Club
    - Ponsonby Cruising Club
    - Richmond Yacht Club
    - Tamaki Yacht Club.
- Consideration of the applicable navigational rules and regulations issued by MNZ and the Auckland Harbourmaster and the locational context in which the activity occurs.

[32] Each of these clubs was invited via the RNZYS.

- Review of the incident record for the area and the existing design and use case.
- Project meetings with wider project team.
- Technical discussions with engineers and other team experts.
- Analysis of publicly available positional data for commercial and recreational use of the Harbour.
- Survey of the general traffic patterns for commercial ferries and recreational vessels transiting in the harbour in relation to the study area. This was undertaken by capturing and analysing imagery from a remote camera over several months (refer Section 3.8.5).

4.3 Consultation

Consultation by Navigatus was undertaken by in-person discussions (where possible) with one or both of Geraint Bermingham and Adam Flaws – both experienced mariners. The consultation was supplemented by phone or email if clarification was sought during the meeting on any aspect of the Project.

In addition, Navigatus consulted with the POAL GM Infrastructure to understand his view about how the proposed construction activities would likely proceed at an operational level.

The following users (Table 4-1) were identified as users of the waters in Waitematā Harbour who could be impacted by the proposed project and hence requiring consultation and consideration.

Table 4-1: Summary of consultation

User	Summary of comments made during engagement
Harbourmaster's Office	Navigatus discussed proposed works/operations and our intentions for the NSA approach/methodology in person with the Harbourmaster and some of his team. This provided an opportunity for the Harbourmaster to raise potential concerns. No maritime related concerns were raised and any reduction in demand for use of Princes Wharf was seen as beneficial.
POAL Operations Manager, pilots	Navigatus discussed the proposals with the Chief Pilot and operations manager regarding the intended plans for scheduling during works and intentions for managing maritime risks during construction. While the berthing plans need to be developed, no concerns have been identified.
Commuter and local RoRo Ferries	Navigatus discussed the proposal in person with Fullers and separately with SeaLink. The Fergusson approaches overlap with the fast ferry lane from the east into Auckland Harbour. The Waitematā Channel is traversed by the Gulf Harbour ferry and Rakino ferry services, but, while ferries are not constrained to the channel, their master's wish to remain in the fast ferry lane. Scheduling conflicts occur between ferries operating in the DFB and cruise vessels currently berthing at Princes Wharf – this should be alleviated to some extent due to a reduction in the size of cruise ships having to berth at Princes Wharf with the implementation of the Project.
RNZN	Navigatus and POAL met with representatives of the RNZN in Devonport. Existing RNZN ships are not generally constrained by the current harbour layout. We do not expect any significant impact from proposed works or subsequent operations.

Recreational Users	Navigatus attended an evening briefing and consultation session at the RNZYS arranged by POAL. Recreational users made remarks about the effect of wind shadowing from large vessels while alongside. Navigatus confirmed that physical footprint of the Port will not extend further into the harbour than present. Recreational users mentioned the local 'race exclusion zone' and hence limited interaction during racing. This was subsequently researched and the details of how it was arranged and published was ascertained (Section 3.7).

The general finding from the consultation of the professional mariner stakeholders was that the proposed Project would act to make for simpler and more efficient operations (Ferry operations in the DFB) or have no material effect on their operations (SeaLink, RNZN).

With regard to the recreational harbour users, the only specific Project related maritime issue raised during the evening consultation meeting held at the RNZYS, was that of wind shadowing from large, berthed vessels. As a result, Navigatus undertook specific research and analysis into wind shadowing effects (see Section 7).

5 Standard Risk Treatments

5.1 Standards of Risk Management

The governing legislation for maritime safety in New Zealand is the Maritime Transport Act 1994. Section 17 of the Maritime Transport Act 1994 imposes a requirement on participants in the maritime system to ensure that activities are carried out safely. As this requirement falls most directly on the maritime operators, they need to be satisfied that operations are carried out in accordance with the relevant safety standards and that the risks are being adequately managed.

New Zealand is a member of the International Maritime Organisation (IMO) and actively implements a wide range of IMO recommendations and protocols.[33] The IMO has adopted the principle of ALARP which is generally applied internationally in maritime and other industries.

The Health and Safety at Work Act 2015 adopts a similar principle for the management of hazards: *So Far As Is Reasonably Practicable* (SFAIRP). A common feature of both the ALARP and SFAIRP approaches is the concept of reducing risk to as low as is reasonably practicable but not to the extent that results in a cost or effort that exceeds the benefits gained in risk reduction.

In this NSA, consideration is given to whether the proposed activities can be carried out, whether the changed wharfage would be safe and whether any proposed suite of risk treatments can be considered effective and reasonable and reduce risk to an ALARP level.

5.2 Standard Maritime Safety Controls

The vast majority of the navigation and safety risks associated with vessel operations are effectively mitigated through standard maritime safety controls. These being standard controls that are in place and are used to manage risk in the maritime environment on a daily basis under ‘business as usual’ operations. These controls can reasonably be expected to be in place throughout the proposed works and subsequent operations. It is expected that they will require no more than standard compliance monitoring and enforcement measures.

5.2.1 SOLAS Safety Management Systems

The safety management system for the International Convention for the Safety of Life at Sea (SOLAS) vessels (as defined in Maritime Rule Part 21) is provided under the International Safety Management Code (Code). This Code covers SOLAS vessels that are either New Zealand-owned or foreign flagged vessels that are visiting New Zealand that meet the requirements of Regulation 2 of the Code.

There are some exceptions where certain commercial vessels are required to meet the safety standards of SOLAS vessels. These vessels are required to be in Class and have an International Safety Management system in place (ISM Code).

[33] Refer Appendix 5 *Measures and Tolerability of Risk* of the Annex to IMO circular MSC-MEPC.2/Circ.12/Rev.2, *Revised Guidelines For Formal Safety Assessment (FSA) For Use In The IMO Rule-Making Process.* International Maritime Organization, “Revised Guidelines for Formal Safety Assessment (FSA) for Use in the IMO Rule-Making Process.”

SOLAS vessels (including those non-SOLAS vessels that meet the exceptions) are subject to Maritime Rule Part 21[34], section 1 and Maritime Rule Part 40B.[35]

5.2.2 Non-SOLAS Safety Management Systems

The safety management system for all non-SOLAS ships is broken into the following separate categories:

Commercial vessels are required to operate under a New Zealand Marine Transport Operators Certificate. The conditions of granting the certificate include that all the operator's vessels have a current Certificate of Survey and that the operator has an Operator Plan. This plan includes safe operating and information management procedures as well as a vessel survey plan, maintenance plan and safety equipment-list for each vessel. In addition, anyone operating the organisation's vessels must comply with the relevant maritime regulations including licence requirements.

Other non-SOLAS categories include:

- **Safe Operational Plans (SOPs)** for smaller specialist vessels and their operations.
- **Safety Case** for operations that don't fit under Maritime Rules.
- **Specified Limits Permit** for commercial operations within restricted areas.

These categories are further described on the MNZ website[36].

5.2.3 Seamanship

Vessels operating in a construction, diving, or other commercial capacity will be managed by professional crews with sufficient training and experience to be able to hold the relevant vessel operating licence. The quality of seamanship on non-commercial / recreational vessels in New Zealand varies considerably – particularly for powered craft. This in part as no training or licencing is required to own and operate a recreational boat. Use of larger sail craft requires a level of skill that invariably means that most skippers of such craft do understand the rules of the sea and can handle their boats reasonably well.

There are, at times, high levels of activity and concentrations of recreational boating traffic on the Waitematā Harbour. As noted above, levels of skill and understanding of the maritime rules vary greatly and the skipper's situational awareness and ability to take appropriate action to avoid collision cannot always be relied on. Regular compliance, monitoring and enforcement action by the Harbourmaster, particularly during peak recreational activity, is undertaken to help address the associated risk. Any dangerous breaches of local rules and regulations pertaining to seamanship and navigation safety should be recorded and reported to the appropriate authority (Harbourmaster's office or MNZ) – and most commercial mariners do this when required.

5.2.4 Navigation Bylaw 2021

The *Auckland Navigation Bylaw 2021* applies to the operation of vessels in the Waitematā Harbour and all other regional waters (see Section 2.6).

[34] Maritime New Zealand, "Maritime Rules Part 21: Safe Ship Management Systems."
[35] Maritime New Zealand, "Maritime Rules Part 40B: Design, Construction and Equipment – SOLAS Ships."
[36] Maritime New Zealand.

5.2.5 Auckland Harbour Control

POAL maintains a 24-hour harbour control that is responsible for implementing a range of services to assist the safe and efficient movement of shipping within Waitematā Harbour, namely:

- Monitoring of harbour traffic
- Communicating with vessels
- Planning shipping movements
- Pilot and tug services
- Security and surveillance
- Berth allocation and planning[37]

5.2.6 Maritime Rules Part 22: Collision Prevention

Maritime Rules Part 22 sets out what is known in marine circles as the “rules of the road”, regarding how vessels should manoeuvre to avoid collisions. These rules apply to all mariners including recreational vessels.

5.2.7 Navigational Charting / Notices

Charts and Notices to Mariners (NTM) are the principle means of communicating navigational information of locations and areas including hazards, depths and cautions as well as information on any AtoN. While paper charts are still available, charts are now typically maintained and updated in electronic form (Electronic Nautical Charts – ENC). Changes to features and hazards that are material to safe navigation must be included all relevant charts. Toitū Te Whenua – Land Information New Zealand (LINZ) manages New Zealand charts, while Maritime NZ manages NTMs. For minor temporary information, the Harbourmaster may also publish ‘local NTMs’ via the Auckland Council website.

Changes should be notified to the Harbourmaster and LINZ in a timely manner using the established maritime procedures. In the case of wharf construction and the associated excavation works, the updated charts will be expected to show the outline of the wharves, the confirmed depths of the pockets and bottom profile, and any associated cautions and any new or changed AtoN once the works are completed.

It is noted that in Waitematā Harbour, only one supplier of ENCs has been advised of the ‘racing exclusion zone’ and so the boundary to this zone is somewhat unofficial in that only recreational boaties who use chart plotters with chart files supplied by *Navionics* can see that zone on their charts.

[37] POAL - Marine Services.

6 Navigational Safety Assessment

6.1 Assessment Against PIANC

It is common practice to review new port/harbour designs against industry Standards as one of the first steps in a safety assessment process. For assessing harbours, the top-level industry Standard is The World Association for Waterborne Transport Infrastructure (PIANC) *Harbour Approach Channels Design Guidelines*[38].

Where a design is not covered by associated Standards, an assessment can be made against another maritime best-practice design baseline or where a design has been in place for an extended time – local experience. Where a design is not compliant with a Standard or established best practice, a higher level of examination is required to identify and mitigate any associated risks. Modern technology allows these assessments to be informed by hydrodynamic analyses and advanced vessel handling simulations.

In assessing a well-developed port/harbour such as Auckland, where routine navigation has been proven by experience to be safe, there is less value in assessing the entire port/harbour against a standard[39]. Rather, greater value can be obtained from assessing only the proposed changes against the standard.

6.1.1 Turning Area

A turning area is where vessels may be assisted by tugs to their berths, which may require the vessel to be turned or swung. In a port concept-design-phase, the nominal diameter of a turning basin should be ≥ 2 LOA.[40]

The design vessel for which the proposed Bledisloe North Wharf was conceived has a LOA of 348m. Under the PIANC guidelines, this would require a turning area of 696m. The width of the harbour adjacent to Bledisloe Wharf is approximately 1100m. The vessel turning area at the proposed wharf therefore exceeds the minimum turning area requirements under the PIANC Standard.

The design vessel for which the proposed Fergusson North extension is intended has a LOA of 360m, giving a minimum turning area of 720m to be compliant with the Standard. When we consider the design vessel against the narrowest channel width of 840m, between Fergusson North Wharf and Calliope South Wharf (allowing 50m for the Defence Area – see Section 3.7), it is assessed that the resulting available turning area exceeds the minimum requirement under the PIANC Standards.

6.1.2 Clearance for Moored Ships

The effects from passing vessels on ships berthed at the proposed new wharf at Bledisloe North and extended wharf at Fergusson need to be considered as the proposed berths are located close to the main navigation route in the harbour (fairway). Large vessels may pass

[38] The World Association for Waterborne Transport Infrastructure, "PIANC Report N° 121 – 2014 Harbour Approach Channels Design Guidelines."
[39] The proposed changes to Fergusson Wharf will not result in any changes with regards to manoeuvring room for arriving/departing vessels.
[40] The World Association for Waterborne Transport Infrastructure, "PIANC Report N° 121 – 2014 Harbour Approach Channels Design Guidelines."

relatively close to a vessel alongside while transiting to or from their berths. There is therefore a possibility that a passing vessel could disturb berthed vessels, which could cause disruption to cargo operations and excessive mooring line loads.

Operational limits will need to be determined with regard to the speed and separation distance of the passing ships, so interaction effects do not cause unnecessary disturbance to the moored vessel and possible damage to the lines and fenders. PIANC gives guidelines that can be used at the concept stage for determining the effect of passing ship speeds and separations. They provide an indication of conditions that are unlikely to cause significant disturbance to a moored ship:

- *Passing ship speed of 4 knots or less for a separation distance (hull side to hull side) of at least 2B*[41]
- *Passing ship speed should be 6 knots or less for a separation distance (hull side to hull side) of at least 4B*[42]

As large commercial vessels currently routinely pass container vessels berthed at the existing Fergusson North Wharf, and the proposed extension works will have no material change on passing distances or clearance between the berthed vessels and passing vessels, there would appear to be no requirement to assess the works at Fergusson against this standard.

This experience from the existing Fergusson North Wharf can also inform the consideration of the new Bledisloe North Wharf. As the distance from the proposed Bledisloe North Wharf to the fairway is greater than between Fergusson North Wharf and the fairway, it can be taken that the application of current practice will serve to protect from disturbance issues for vessels berthed at the proposed Bledisloe North Wharf.

6.2 Assessment of Changes to Navigational Risk Profile

The following sets out the assessed impact of the proposed wharves on other maritime activity in the harbour.

6.2.1 Tidal Currents at Proposed Wharves

Fergusson North Wharf

The occasional berthing of the Ovation class cruise ships, which are similar to the largest container vessels, and the berthing of container vessels of some 6,000 TEU capacity at Fergusson North Wharf has occurred and so no material change to berthing forces from this will result following the works. However, due to the pile construction and the natural narrowing of the harbour at this point, such vessels are exposed to high current forces while berthed. This causes higher forces to be exerted on the bollards and lines than is typically the case at solid wharves. These forces will also act in the late stages of berthing under a flood tide.

[41] Where B = the water plane beam of the passing vessel.
[42] PIANC 3.1.8.5 Clearance to Moored Ships.

The mooring design for the extended Fergusson North Wharf needs to account for these forces as will the Port's manoeuvring and berthing plans.

Bledisloe North Wharf

As this wharf is orientated to the natural tidal currents, tidal forces on berthed ships will be aligned and so the drag forces are aligned with the hull which is straightforward to design for.

6.2.2 Commercial Shipping

Fergusson North Wharf

All large commercial shipping into Waitematā Harbour will pass the proposed extension at Fergusson North Wharf. However, there is no material change to the wharf's footprint (with regard to navigable water and the width of the harbour). The proposed activities at the wharf will therefore present no increase in the difficulty of navigating within the harbour for commercial shipping.

The standard maritime controls that are applicable to business-as-usual activities within the harbour environment sufficiently mitigate any minor risks arising from changes in day-to-day operations within the port and adjacent channel.

It is therefore assessed that the proposed extension and subsequent operations will have no material impact on the navigational risk profile for other commercial shipping within Waitematā Harbour.

The construction of the wharf extension will be undertaken from the shore and largely involve pile driving and form work. Any on-water activity will therefore be very limited.

It is therefore assessed that the construction of the proposed Fergusson North Wharf extension will have no material impact on the navigational risk profile for other commercial shipping within Waitematā Harbour.

Bledisloe North Wharf

Large commercial shipping passaging to the upper harbour, Queens Wharf or Princes Wharf will pass the proposed new Bledisloe North Wharf. The proposed wharf will only extend 7.6m beyond the toe of the existing seawall in an area in which the harbour is over 1km wide. Given this, and that the wharf is set back from the main channel, there is no material change to the Port's footprint with regard to navigable water for large vessels. This distance means that, with a ship alongside, no interaction forces would be expected with passing vessels.

Given that the new Bledisloe North Wharf will not extend further to the west than the current structures, for those vessels passing Bledisloe North Wharf to berth on the western side of the Bledisloe Terminal, or further up the harbour, standard procedures and navigation plans keep them well clear to the north of the proposed Bledisloe North Wharf.

Given the water space available to the north for manoeuvring and berthing and the simple unobstructed design of the wharf, it is evident that operations for large RoRo vessels and cruise vessels utilising the proposed Bledisloe North Wharf will not constitute a difficult or complex manoeuvre in the context of harbour operations. The berth enjoys ample sea-room to enable a straightforward berthing approach/departure. The orientation of the berth is

exposed to a generally parallel tidal flow enabling vessels to stem the tide. Operational limits for wind provide sufficient safety margin when considering the power, manoeuvrability and limitations of attendant tugs.

As the standard maritime controls are sufficient to address any minor change in the risk profile, no non-routine risks have been identified and so no additional risk controls are suggested.

The construction of the new Bledisloe North Wharf will be undertaken from the shore and largely involve re-facing the existing face, pile driving and form work. Any on-water activity can therefore be expected to be very limited.

Given the above, it is assessed that the construction and subsequent operations at the new Bledisloe North Wharf will have very limited impact on large commercial ships passing and manoeuvring or otherwise using the harbour.

6.2.3 Ferry Traffic (General Harbour Navigation)

Ferries operating in Waitematā Harbour generally follow prescribed routes and, with the exception of manoeuvring to avoid other vessels, they seldom deviate from the most expedient, safe route. Given the design of the speed restricted areas in the harbour, the preferred route for ferries enroute to or from destinations to the east of the DFB generally passes the northern end of the Bledisloe Terminal at a distance of approximately 100-200m. As the proposed construction of the new Bledisloe North Wharf will be undertaken from the shore, extending only 7.6m beyond the bounds of existing structures, it is unlikely that either the construction activity or subsequent operations will have any impact on ferries passing the wharf or vessels secured alongside. That said, a vessel alongside the proposed berth will extend further out and also partially hinder a master's visibility to some extent – particularly if transiting close to the berthed vessel.

However, given ferries transit by the shortest route to remain clear of the 5-knot speed restriction within 200m of wharves (Figure 3-4) which takes them into the channel and hence not close to Bledisloe Wharf, any restriction in visibility will be limited. It is reasonable to conclude that, provided ferries do not pass close to a berthed ship, the proposed new wharf at Bledisloe North will not have any impact on ferry operations and will not materially alter the risk profile. However, if ferry masters are not disciplined in terms of maintaining good clearance, there could be some risk. No such behaviour was noted in the video survey described in Section 3.8.5.

As noted in Section 3.7, the exact boundaries of the speed-uplift zones are not particularly clear. It is therefore suggested that the Port, Harbourmaster and ferry companies review the boundaries to indicate the preferred clearances to a large berth vessel and publish a revised and clear chart of these. This will reinforce the effectiveness of standard maritime controls and, in turn, will limit any risk associated with activity close to the new Bledisloe North Wharf.

6.2.4 Ferry Traffic (DFB)

As a result of the Project, there is an overall reduction of risk to ferries operating within the DFB due to a reduced number of potential conflicts with large cruise ship arrivals and departures. Cruise ships and ferry operations within the DFB present challenges and risk to both through a number of potential interactions (see Appendix A).

The proposed works will enable cruise ships with a LOA greater than 300m to berth at the new Bledisloe North Wharf. This will see a reduction in the typical size of cruise vessels berthing at Princes Wharf and associated adverse effects arising from their interaction with ferries operating within or in the approaches to the DFB.

Given the expected less frequent use of Princes Wharf by larger cruise vessels, the DFB risk profile will decrease. The existing maritime and scheduling controls will continue to be sufficient, so no additional risk controls are proposed. It is also noted that the time required to berth and secure the smaller cruise vessels can be expected to typically be less than for larger vessels and so the impact on ferry schedules may be greater than simply the expected less frequent use of Princes Wharf by larger cruise vessels.

6.2.5 Cruise Ships

As above (Section 6.2.4) and as a result of the Project, there is an overall reduction in risk to cruise ships due to the deconfliction of operations within the DFB enabled by the construction of the new Bledisloe North Wharf. The difficulty of berthing/unberthing a cruise ship at the proposed Bledisloe North Wharf is greatly reduced by a number of factors, including negating the need to manoeuvre in a basin or back the vessel. The new Bledisloe North Wharf will also be aligned generally parallel with the tidal flow, greatly enhancing manoeuvrability and reducing tidal set.[43]

In addition to the reduction in risk associated with more simplified ship handling and fewer potential conflicts with ferry operations, cruise ship operations will see reduced risk through improved berthing arrangements at the new Bledisloe North Wharf. The new wharf will be designed and constructed to modern standards, with higher load bearing and impact resistance capabilities.

The ability for the largest cruise ships currently forecasted to visit Auckland, the Ovation class (348m LOA, 49m beam), to berth at the new Bledisloe North Wharf alleviates the requirement for any cruise ship to remain in position within the inner harbour anchorages or use the Fergusson North berth. This reduces risk by (also see Appendix A and Section 6.3):

- Removing a large vessel (348mx49m) from the centre of a busy and (at times) congested waterway – thereby – reducing the risk of collisions and close quarters situations between all types of vessels.
- Removing the need to load passengers into tenders, transport them to a safe disembarkation point within the CBD (and vice versa) – thereby – reducing the risk of a passenger falling overboard. Also reducing the risk of a collision between a tender and another vessel and reducing general congestion.
- Reducing conflict with The Fergusson quay cranes and taking passengers through the container terminal.

6.2.6 Recreational Traffic

The proposed construction and subsequent operations at Bledisloe North Wharf and Fergusson North Wharf will have no material impact on the navigational risk profile for

[43] The movement of a ship induced by tidal forces

recreational traffic within Waitematā Harbour. The standard maritime controls that are applicable to business-as-usual activities within the harbour environment sufficiently mitigate any minor risks arising from changes in day-to-day operations within the port and adjacent channel.

Large numbers of recreational vessels of all types pass the commercial port throughout the day. These include a wide range of vessels from personal watercraft, kayaks, sailing vessels and small power-driven vessels through to much larger superyachts and larger power-driven vessels. The channel to the north of the commercial port is also a popular location for yacht racing, and at times large numbers of sailing vessels can be observed throughout the main channel.

Generally speaking, most recreational vessels keep clear of the commercial port area (this is underpinned by the restricted areas in Section 3.7). A small proportion of recreational vessels are unaware of or disregard the requirement to keep clear of restricted areas and venture close to the northern extremes of Bledisloe and Fergusson Terminals.

The area of navigable water to the north of the proposed new Bledisloe North Wharf and the Fergusson North extension is wide (refer Figure 3-1) and represents an ample area for the volume of all types of traffic at any given time. It is expected that the construction activities and subsequent operations in the two proposed sites will have very limited impact on the behaviour of recreational traffic, and that vessels will alter their navigation to pass construction or vessels alongside at a similar distance to that which they currently pass fixed structures or vessels.

The proposed works and operations will have no material impact on the width of the fairway, and thus will have no bottle-neck effect on recreational traffic. The proposed activities will, therefore, not effect recreational navigation within the harbour.

The standard maritime controls are sufficient to continue to mitigate the inherent risk profile of the harbour and address any minor changes to the risk profile, therefore no additional risk controls are proposed.

6.2.7 Construction Workers and Equipment

Despite the majority of construction works being carried out from shore, there may be some activity carried out from seaward. There is some risk to construction workers and their equipment from the maritime environment and that risk mitigation will, at times, depend on good communications between shore side and water side teams. Additionally, any construction activity on the water does present collision and wake risks with passing vessels.

This risk from passing vessels can be effectively mitigated through the addition of non-standard controls. It is recommended that the area immediately adjacent to the active construction site at Fergusson North is not used for berthing and loading/unloading of vessels. This can be achieved through effective scheduling of container vessels to utilise the remaining berths on the western side of Fergusson Container Terminal, and elsewhere within the commercial port. The western end of Fergusson North Wharf may still be used for ships that do not encroach on the active construction area.

Where there are no suitable alternatives available, operational container vessels may still utilise Fergusson North Wharf for berthing, loading and unloading. Prior to such

movements/operations, a specific operational level risk assessment should be carried out considering the following risk factors, including but not limited to:

- The environmental conditions at the time
- The manoeuvrability of the vessel(s)
- The level of experience of all personnel (pilot, crew, tug master and crew, line handlers etc.)
- Serviceability/reliability of equipment (both onboard the vessel and attendant tugs)

After considering the above, and any other relevant risk factors, the following risk treatments should be considered (as well as any other practicable and available mitigations) to ensure the activity is conducted with the residual risk ALARP:

- Consider abandoning the planned berthing – reschedule or delay until an alternative berth is available
- Ensure physical barriers around the construction site are in place to ensure safe separation is maintained between berthing/operations and construction activity
- Consider using additional tugs or pilots
- Consider conducting the manoeuvre as a “dead ship” if propeller wash is considered a key hazard[44]
- Consider vacating the construction site of all personnel and vulnerable equipment until berthing/operations are complete.

With adherence to the above recommended additional controls and the standard risk controls in Section 5.2, the risk to construction workers and equipment arising from the proposed construction works is assessed as ***very low.***

6.2.8 General Public (Ashore)

When cruise ships are berthed alongside Princes Wharf, there is a risk (albeit low) to the public ashore due to the potential for a mooring line to part under tension. This can occur at any time, but particularly given wind effects that are at times experienced at this berth. If a person were to be in the line of recoil at the time of a mooring line parting, the consequences could be fatal. This is currently mitigated through operational means (e.g. assessment of mooring arrangements for specific wind conditions, mooring lines deployed as per mooring assessment, use of mooring fuses on mooring lines, temporary fencing and monitoring).

Bledisloe Terminal is not accessible by the public and passengers alighting will be under the control of crew. Therefore, members of the public will not be expected to be exposed to line-breakage risk when vessels are berthed at the new Bledisloe North Wharf. By reducing the typical size of cruise ships visiting Princes Wharf, there is a reduction in the risk to the general public.

The risk to the general public is clearly reduced as a result of the proposed works.

[44] A vessel which is not proceeding under its own power.

6.3 Summary of Changed Risk Profile

The following table summarises the changes to the existing risk profile as described and discussed above. A fuller risk register setting out the risks in detail is presented at Appendix A.

Table 6-1: Summary of change to harbour risk profile.

Aspect	Overall change in risk profile	Additional mitigations
PIANC Compliance - Turning Area to the north of the wharves		
It is assessed that the available turning area to the north of Bledisloe North Wharf the exceeds the minimum requirement under the PIANC Standards.	No change.	None required.
It is assessed that the available turning area to the north of Fergusson North Wharf the exceeds the minimum requirement under the PIANC Standards.	No change.	None required.
PIANC Compliance - Clearance for berthed Ships		
The application of current practice will protect vessels berthed at the proposed Bledisloe North Wharf from disturbance from other vessels passing by.	No change.	None required.
Tidal Currents at proposed wharves		
Higher than typical tidal forces acting on larger vessels at FN Wharf resulting in greater mooring line forces than would be the case for a solid wharf,	Nil if designed for.	Design mooring arrangements for forces. Consider forces during development of berthing plan and apply currently accepted standards.
Other commercial shipping - Fergusson North Wharf		
It is assessed that the construction of the proposed Fergusson North Wharf extension will have no material impact on the navigational risk profile for other commercial shipping within Waitematā Harbour.	No change.	None required.
Other commercial shipping - Bledisloe North Wharf		
It is assessed that the construction and subsequent operations at the new Bledisloe North Wharf will have very limited, if any, impact on large commercial ships passing and manoeuvring or otherwise using the harbour.	Limited adverse change.	None required.
Ferry traffic (general harbour navigation)		

Aspect	Overall change in risk profile	Additional mitigations
The current speed-uplift area boundaries (Figure 3-4) were developed without consideration of a wharf on the face of the existing Bledisloe North Wharf. Clearances may therefore not be appropriate.	Potential increase.	Review / refine speed-uplift areas if the Harbourmaster considers this necessary.
Ferry traffic (DFB)		
There will be an overall reduction in ferry-cruise ship conflict risk in the DFB as cohort of ships berthing at Princes Wharf will typically be the smaller of the visiting cruise ships.	Reduction.	None required.
Cruise ships		
Berthing/unberthing of cruise ships at the proposed Bledisloe North Wharf will be simpler than berthing/unberthing at any other wharf in the harbour.	Reduction.	None required.
The new Bledisloe North Wharf will be designed and constructed to modern standards, with higher load bearing and impact resistance capabilities.	Reduction.	None required.
The ability for the largest cruise ships to berth at the new Bledisloe North Wharf will alleviate the requirement for any cruise ship to remain in position within the inner harbour anchorages.	Reduction.	None required.
Recreational traffic		
The proposed construction and subsequent operations at the new Bledisloe North Wharf and Fergusson North Wharf will have no material impact on the navigational risk profile for recreational traffic within the Waitematā Harbour.	No change.	None required.
Sail racing activity		
Given the informal race exclusion zone, the proposed construction and subsequent operations at the new Bledisloe North Wharf and Fergusson North Wharf will have no material impact on the navigational risk profile for sail racing within the Waitematā Harbour. However, this zone not being marked on all charts undermines the effectiveness of this existing control.	No change.	Formalise the exclusion zone.
General public (ashore)		

Aspect	Overall change in risk profile	Additional mitigations
By reducing the demand for large cruise ships to need to use Princes Wharf and hence load on mooring lines, there is a reduction in the risk to the general public.	Reduction.	None required.
Permanent charges in navigational features within the harbour	Potential increase	Use established maritime communication measures to advise mariners of the changes (charting, list-of-lights, confirm Navaid configurations)
Temporary changes in navigational features and hazards within the harbour during construction.	Increase (temporary)	Use established maritime communication measures to advise mariners of the hazards (NTM, local NTM, CMP)

7 Effect on Winds in the Harbour

7.1 Wind Shadowing

Large vessels such as cruise ships, quarter-ramp RoRo vessels, and container ships which berth at the port or will berth at Fergusson North and Bledisloe North wharves may, under certain conditions, cause localised turbulence and 'wind shadowing' (i.e. reduced wind speed and energy) to the lee side of the vessel. When the wind is from a southerly quarter (SE through S to SW) this shadowing does and will extend into the Waitematā Harbour to the north of the berthed vessels.

Wind shadowing is a phenomenon experienced by vessels in the lee of large, upwind objects whereby the large objects (e.g. large vessels, headlands and cliffs, built environments etc) disrupt the wind flow creating an area of wind vortices and lowered wind speeds.

In the local case, depending on wind conditions, this could impact the power and useability of the wind available to sailing vessels making passage in the harbour fairway. If close to the berthed vessel, the vortices may cause some risk to smaller sail boats.

As such, the scale and probability of the impacts has been assessed and is discussed in this report.

7.2 Wind Shadow Analysis Methodology

To assess the probability and scale of wind shadows cast by vessels berthed at Bledisloe North and Fergusson North wharves, the following activities were undertaken:

- Review of literature regarding wind shadows.
- Calculation of wind shadows in highest-impact conditions for the vessels that currently routinely berth at the existing Fergusson North Wharf (represented by a 4,300 TEU vessel) and the largest that can or may berth as a result of the proposed Fergusson North Wharf extension (up to 10,000 TEU).
- Calculation of wind shadows in highest-impact conditions for the largest design-case quarter-ramp RoRo and cruise ships that may berth at the proposed Bledisloe North Wharf. Figure B.1 and Figure B.2 in Appendix B show specifications for the representative container vessels.
- Analysis of wind data and production of wind roses to understand the likely wind conditions at the wharves and in the harbour.
- Probabilistic view of risk of wind shadows affecting sail boats.
- Discussion of the findings.

The analysis was completed with the following assumptions:

- Wind shadowing and turbulence effects from the nearby quay cranes, container stacks, city, and terrain are ignored. This shadowing is probably quite significant but varies greatly due to the movement of POAL's large quay cranes and container stacks.

- The wind conditions are worst-case southerly winds blowing beam-on to the berthed vessels.
- The air draught of each vessel is taken to the top of the container stacks for a container ship or the top deck of a RoRo or cruise ship. In effect, each vessel is assumed to be rectangular with container ships assumed to have containers across the entire LOA (noting that in reality a small portion of the bow of the vessel is kept free of containers).

Full details of the methodology of the shadowing methodology and calculated findings are in 9Appendix B.

7.3 Results – Extent of Shadowing

The following four images (Figure 7-1 to Figure 7-4) illustrate the extent of the calculated wind shadows.

The images are interrupted as follows:

- Shaded area (inner): extent of the shadowing where the effect of the upwind obstacle geometry is not negligible as calculated by the Walker, D.J. Wilson, and T.W. Forest model for SE to SW wind conditions.
- Shaded area (outer): extent of the shadowing where the wind speed is 75% of the unaffected wind speed as calculated by the John Kimball ‘Physics of Sailing’ methodology for SE through S to SW wind conditions.
- Straight boundary lines: Indicative of the extent of the effects given the wind is in the SE or SW.
- Red-dashed line: boundary across which racing yachts have been advised not to cross to the south.
- Pink-dashed line: RNZN Defence Area (restricted access).
- Blue-dashed line: shallows (non-navigable water space).

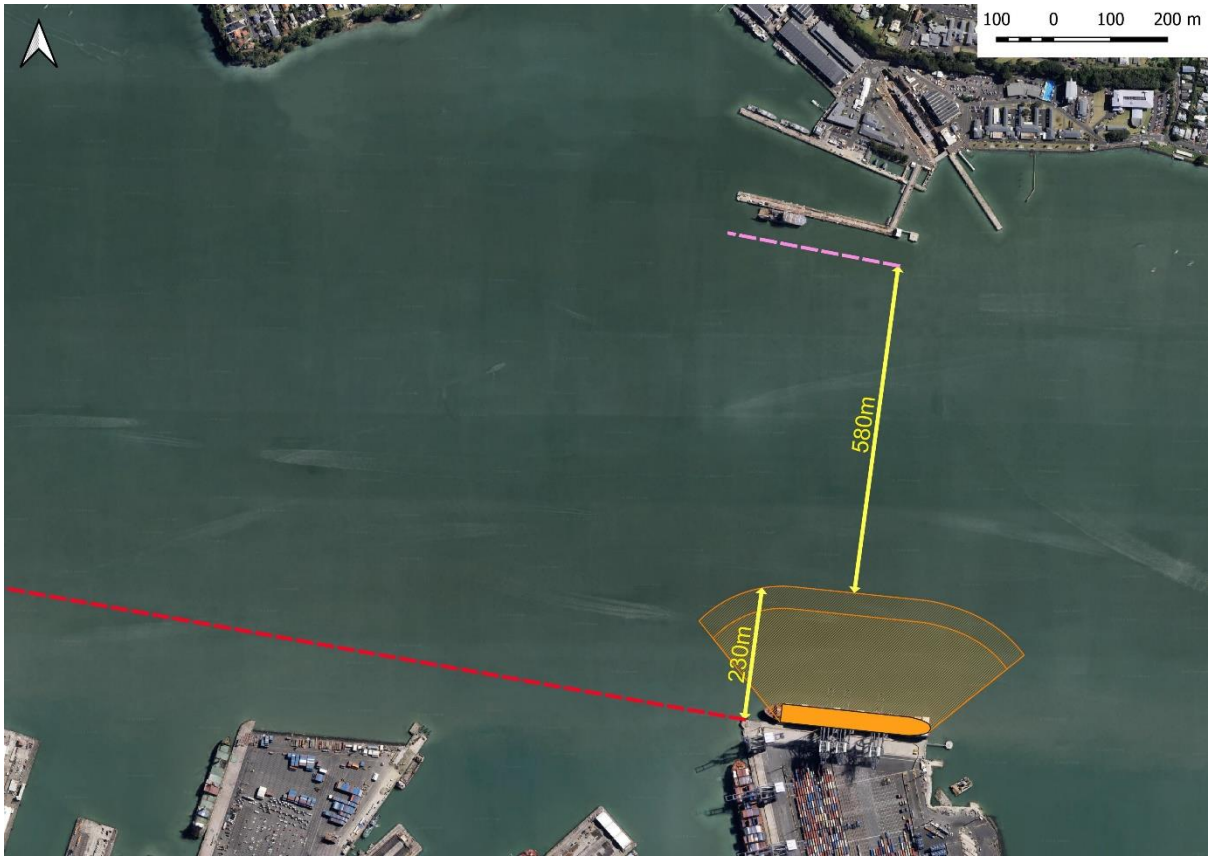


Figure 7-1: Wind shadow of a representative 4,300 TEU container vessel alongside Fergusson North Wharf.

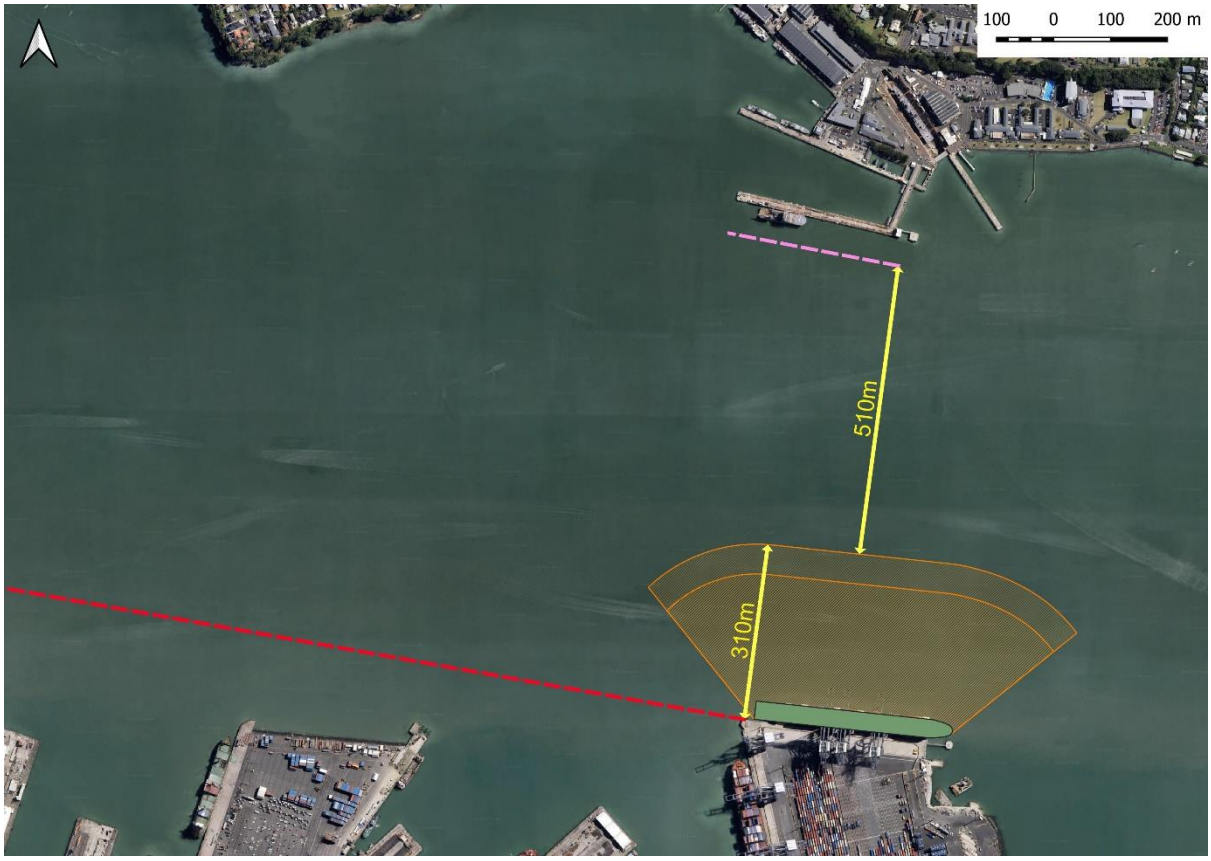


Figure 7-2: Wind shadow of a representative 10,000 TEU container vessel alongside Fergusson North Wharf.

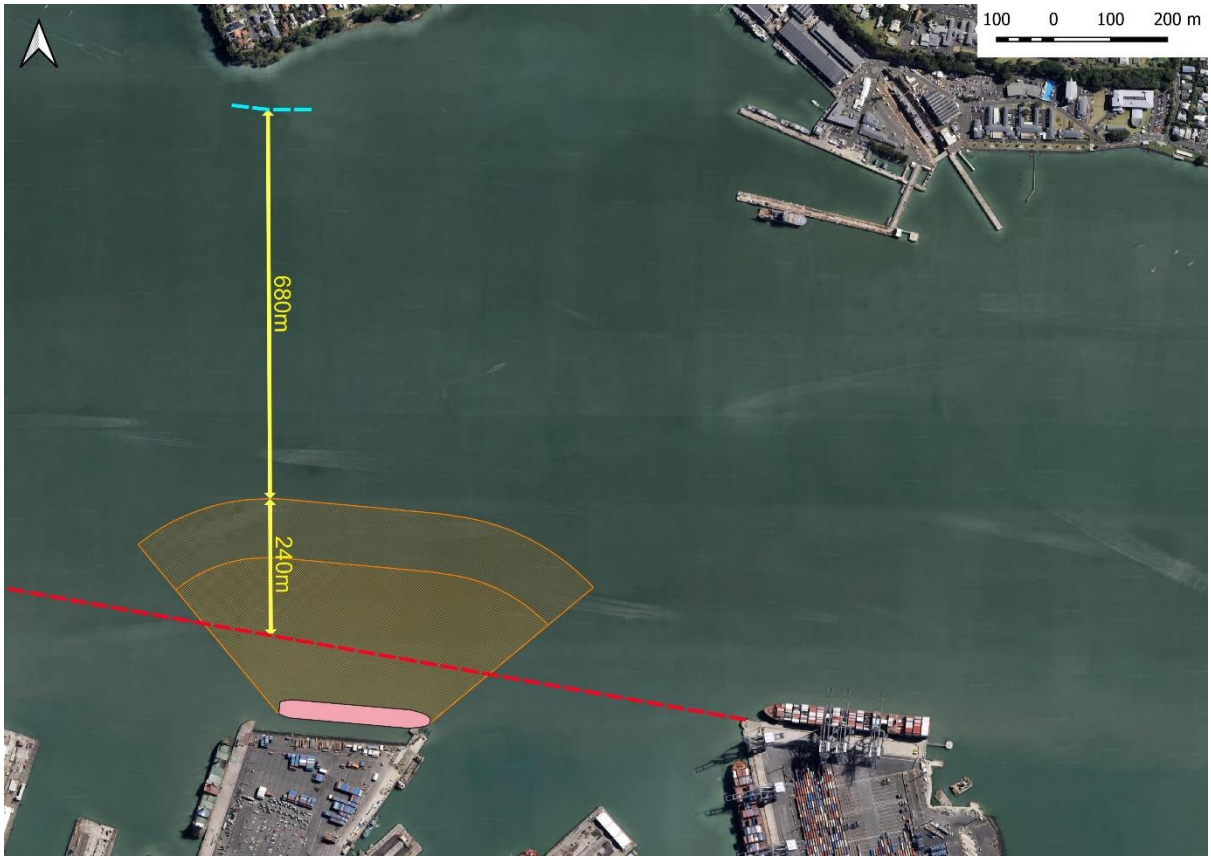


Figure 7-3: Wind shadow of a representative RoRo vessel alongside the new Bledisloe North Wharf.

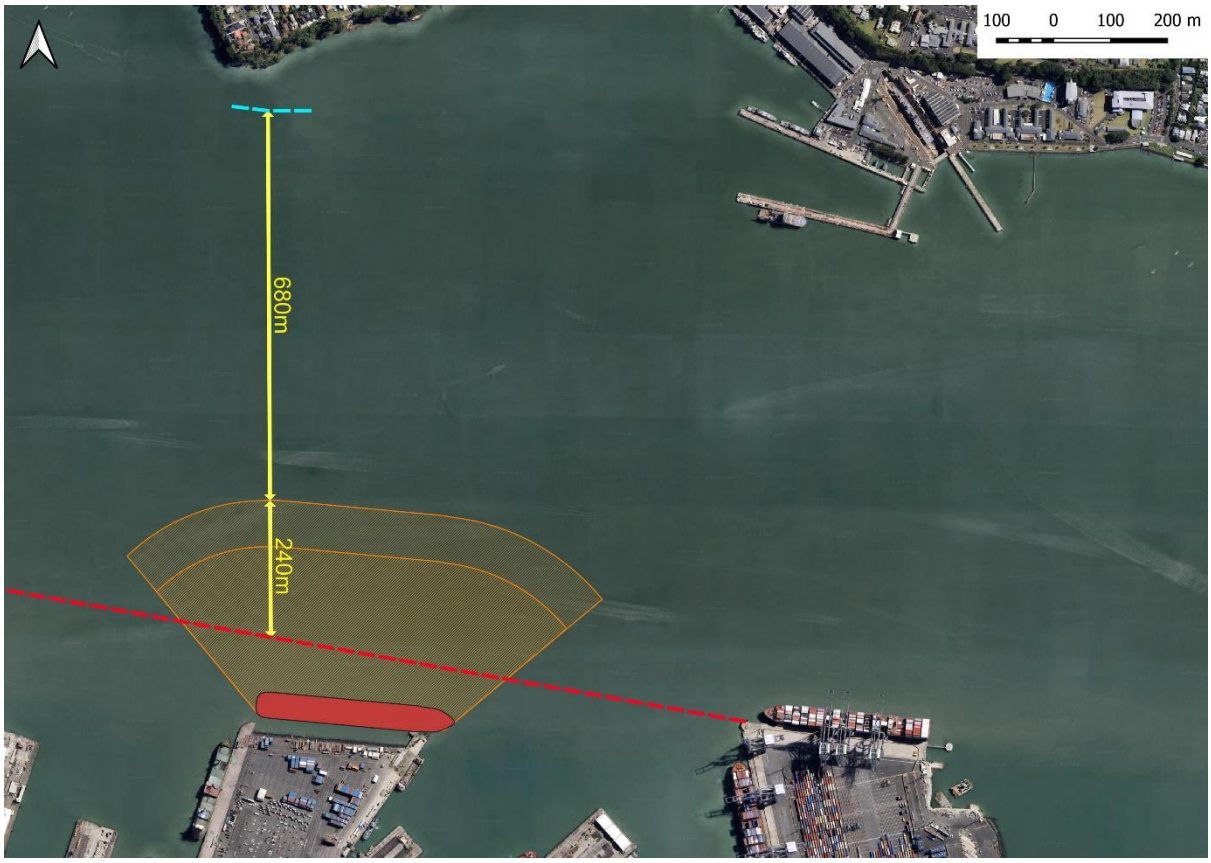


Figure 7-4: Wind shadow of a representative, large cruise ship alongside the proposed Bledisloe North Wharf.

7.4 Results – Probability of Shadowing Affecting Sailing Vessels

Wind data was supplied by POAL from anemometers stationed at Bledisloe North Wharf and Fergusson North Wharf. Berth occupancy at Fergusson North Wharf is assumed to be optimised. POAL advise that optimum berth occupancy is 60 to 70% of the time, and so the calculations assume that this is 70%.

South-easterlies to south-westerlies comprised 27% of the dataset. Royal New Zealand Yacht Squadron timetables suggest that races occur for 22.5 hours across the week – that is a race may be happening 13% of the time.

Hence, multiplying these proportions yields the probability that the berth is occupied, the wind conditions are such that wind shadowing across the harbour will occur is 19% of the time, and while a sail-race is occurring, 2.4% of the time.

A similar calculation can be performed for the new Bledisloe North Wharf – this produces similar results only modified by berth occupancy.

7.5 Points of Sailing

It is of note that if a southerly wind is blowing, vessels making passage under sail power to the west (up harbour) or to the east (towards the Hauraki Gulf) can be expected to have the wind on the beam – that is they will be 'reaching' (see Figure 7-5). Reaching is when the wind is on the beam of the vessel and the sails are set partly out from 'hauled-in'. This is the best / fastest point of sailing with the sails generating the greatest power. It is also usually the easiest to sail with the helmsperson having more directional latitude (freedom to alter course somewhat) than when sailing close to the wind. As the boat speeds up the 'apparent wind' (the wind that the sails experience due to the real wind and the wind created by the boat's motion), tends to come around more onto the bow of the vessel. As a result, for modern high-speed craft such as catamarans and foiling boats the best point of sailing tends to be more 'off the wind' than for slower more traditional sailboats.

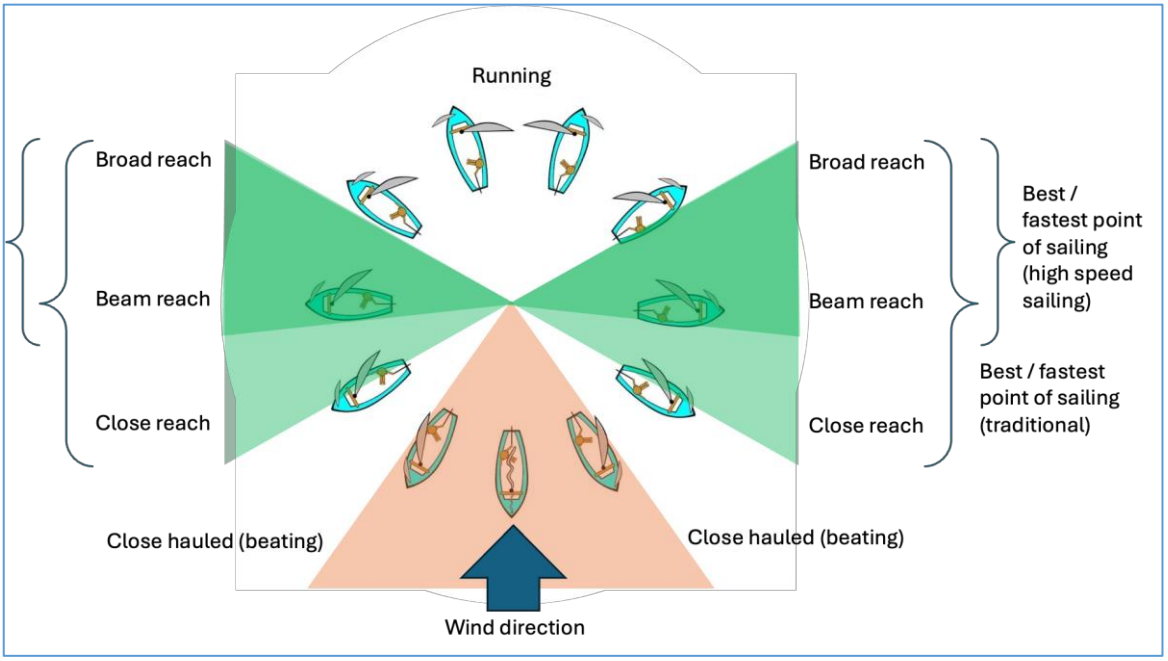


Figure 7-5: Points of sailing

It follows that in the situations when any wind shadowing may be occurring due to large, berthed vessels, passing sail-boats will be free to adjust their position in the fairway (move slightly further to the northern side) and exact track (straight or curved) with limited impact on overall transit time. Similarly, the helms person should be more able to respond to any turbulence and eddies than if on a beat (close hauled)

7.6 Conclusion – Wind Effects

The existing Fergusson Container Terminal can service vessels equivalent in size to a 10,000 TEU container vessels, albeit sub optimally. As such, the proposed new Fergusson North Wharf does not change the extent of potential wind shadowing effects. The formulae used (refer Appendix B) suggest that the wind shadow extents are most sensitive to the air draught of a vessel as opposed to LOA.

With regard to the new Bledisloe North Wharf, it can be concluded that wind shadowing will occur when the wind is from a southerly quarter and a large vessel is alongside. This effect will be new and extend, in part, north of the sail racing exclusion zone boundary.

When taking both the extent of the wind shadows and probability into account, we can conclude that in the rare, highest-impact situation that a large cruise ship and container ship are alongside at the new Bledisloe North Wharf and / or Fergusson North Wharf with a steady south-easterly to south-westerly wind blowing, there will still be at least 510 metres of clear-air in the fairway for a sailing vessel to continue to make passage along the Waitematā Harbour fairway. The analysis indicates that the impact on sail boats due to wind shadowing from the proposed wharf developments will be limited.

8 List of Proposed Risk Controls

The works and subsequent operations associated with the Project can be undertaken with navigational safety related risks reduced to ALARP given the following controls, identified throughout this report, are put in place:

- NTM are released as required to advise mariners of the nature and location of the works.
- Local NTM published on the AT web site to advise local recreational mariners of the nature and location of the works.
- The Harbourmaster be requested to seek to formalise the sailing exclusion zone and have this shown on the LINZ charts.
- The Harbourmaster be requested to review the Waitematā Harbour speed uplift boundaries to consider if any changes are necessary for vessels berthed at the new Bledisloe North Wharf.
- Navigational safety included in the CMP, covering:
  - Procedures for operational communications.
  - Details of any navigational safety risk controls to be implemented or adhered to.
  - Lighting and demarcation requirements for construction activities.
  - An outline of the sequencing of works and activities.
  - Roles and responsibilities.
- Shore lighting on wharves to be designed to prevent glare nor cause interference with safe navigation (in accordance with MNZ guidelines and IALA).
- Confirm the sectored light on Fergusson North Wharf is correctly set up and not disturbed during the works.
- LINZ informed of the actual location of the sectored light currently charted as being on the western end of Fergusson North Wharf.
- Information of as-built foot-print and key features, including details of any navigational lighting and marks passed to LINZ for charting and including in the New Zealand List of Lights.
- Wharf design is compliant with all relevant Codes and Standards.

9 Conclusion

Provided the new wharf at Bledisloe North and wharf extension at Fergusson North and mooring arrangements are designed to current standards and maritime requirements, the proposed works present no new or unique risks to navigation and the safety of water users.

The exact boundaries of the speed-control zones are not particularly clear. It is suggested that the Port, Harbourmaster and ferry companies review the boundaries to indicate the preferred clearances to a large berth vessel and publish a revised and clear chart of these.

Where the risk profile has materially been altered by the subsequent operations, the overall risk is lowered due to a reduction in the potential risks of an adverse interaction between a cruise ship and ferry traffic in the DFB and the removal of the occasional need to anchor very large cruise ships in the inner harbour anchorages.

The general finding from the consultation of the professional mariner stakeholders consulted was that the proposed Project would act to make for simpler and more efficient operations (Ferry operations in the DFB) or have no material effect on their operations (SeaLink, RNZN).

With regard to the recreational harbour users, the only specific project related maritime issue raised during the evening consultation meeting held at the RNZYS, was that of wind shadowing from large, berthed vessels. As a result, Navigatus undertook specific research and analysis into wind shadowing effects (see Section 7).

When taking both the extent of the wind shadows and probability into account, an analysis of wind shadowing from the large vessels berthed at the new or extended wharves indicates that the impact on sail boats due to wind shadowing from the proposed wharf developments will be limited.

Overall, the proposed works are beneficial in terms of navigational safety and, given compliance with normal operational best practice, the resulting risk profile will be ALARP.

Appendix A Comparative Risk Register

ID	Phase	Location/Area	Title	Description of risk	Most likely harm consequences	Worst credible harm consequences	Comparative risk without further mitigation	Comment on change in risk	New controls	Comparative risk once new controls applied	ALARP?
1	Status Quo	Downtown Ferry Basin	Interaction between cruise ship and ferry manoeuvring within DFB.	Congested ferry basin with frequent arrivals and departures. Imperative to keep to schedule. Potential for conflicted water-space during manoeuvring of cruise ships. Increased likelihood of incident.	Close quarters situation	Serious collision between ferry and cruise ship, resulting in multiple fatalities	Baseline	Currently managed by deconflicting ferry operations with cruise ship arrivals/departures.	None required	N/A	✓
	During Works						No change				✓
	Post-work Operations						Lower	Proposed plan sees a reduction in the number of large cruise ships manoeuvring in the DFB. This results in a reduced likelihood of interaction between ferries within the DFB and cruise ships berthing/departing Princes Wharf.			✓
2	Status Quo	Downtown Ferry Basin	Interaction between ferries operating within DFB.	Compressed ferry schedule with frequent arrivals and departures during peak periods. Imperative to keep to schedule. Potential for conflicted water-space during / post manoeuvring of cruise ships. Increased likelihood of incident.	Close quarters situation	Serious collision between ferries, resulting in multiple fatalities	Baseline	N/A	None required	N/A	✓
	During Works						No change				✓
	Post-works Operations						Lower	Reduced large cruise ship use of DFB results in reduced likelihood of ferry interactions due to conflicting schedules and operations.			✓
3	Status Quo	Inner harbour anchorages (large vessel)	Interaction between recreational vessel / ferry and stationary cruise ship whilst maintaining position in designated anchorage.	Designated anchorage positions lie adjacent to busy ferry crossings, and in an area heavily utilised by recreational traffic. Stationary cruise ship under DP/anchored in anchorage diverts traffic flow and creates variance from routine – potential for small vessel to collide with stationary cruise ship.	Close quarters situation.	Serious collision between ferry and cruise ship, resulting in multiple fatalities.	Baseline	N/A	None required	N/A	✓
	During Works						No change				✓
	Post-works Operations			Need for cruise ships to DP in the inner harbour anchorages removed.	N/A	N/A	Lower	Reduced risk of collision or close quarters situations developing due to the absence of larger cruise ships DP'ing in the inner harbour.			✓

ID	Phase	Location/Area	Title	Description of risk	Most likely harm consequences	Worst credible harm consequences	Comparative risk without further mitigation	Comment on change in risk	New controls	Comparative risk once new controls applied	ALARP?
4	Status Quo	Inner harbour anchorages (large vessel)	Cruise ship tender operations	Risk of interaction between tenders and other vessels operating within inner harbour. Additional risk of a person falling overboard from tender (most likely during embarkation or disembarkation)	Close quarters situation. Person overboard.	Serious collision between harbour traffic and tender, resulting in multiple fatalities.	Baseline	N/A	None required	N/A	✓
	During Works						No change				✓
	Post-works Operations			Need for cruise ship tenders in the inner harbour anchorages removed.	N/A	N/A	Lower	Reduced risk of collision or close quarters situations developing due to the absence of tenders being used to transport cruise passengers to/from shore.			✓
5	Status Quo	Inner harbour anchorages	Interaction between two or more recreational vessels or ferries.	Designated anchorage positions lie adjacent to busy ferry crossings, and in an area heavily utilised by recreational traffic. Stationary cruise ship under DP in anchorage diverts traffic flow and creates variance from routine – potential for small vessels or ferries to collide one another.	Close quarters situation	Serious collision between two or more ferries and recreational vessels, resulting in multiple fatalities.	Baseline	N/A	None required	N/A	✓
	During Works						No Change				✓
	Post-works Operations			Need for cruise ship tenders in the inner harbour anchorages removed.	N/A	N/A	Lower	Reduced risk of collision or close quarters situations developing due to the absence of larger cruise ships dynamically positioning in the inner harbour.	None required	N/A	✓
6	Status Quo	Inner harbour / approach to Princes Wharf	Interaction between recreational vessel or ferry and cruise ship during berthing or approach.	Manoeuvring cruise ships in the approaches to Princes Wharf and the DFB creates congestion and potential for close quarters situation or collision.	Close quarters situation	Serious collision between ferry and cruise ship, resulting in multiple fatalities.	Baseline	N/A	None required	N/A	✓
	During Works						No change				✓
	Post-works Operations	Inner harbour/approach to BN Wharf.		Cruise ships berthing at Bledisloe North Wharf may still encounter ferry and recreational traffic, allowing potential for risk of collision or close quarters situations to arise.			Lower	Reduced number of large cruise ships manoeuvring in approaches to DFB/Princes Wharf. Manoeuvring for Bledisloe North Wharf further to the east and away from most congested water-space.			✓

ID	Phase	Location/Area	Title	Description of risk	Most likely harm consequences	Worst credible harm consequences	Comparative risk without further mitigation	Comment on change in risk	New controls	Comparative risk once new controls applied	ALARP?
7	Status Quo	Inner harbour/approach to FN Wharf.	Interaction between container vessel and ferry.	Potential for close quarters situation or risk of collision between container vessel and ferry during manoeuvring for approach or on departure from Fergusson North Wharf	Close quarters situation	Serious collision between ferry and container ship, resulting in multiple fatalities.	Baseline	N/A	None required	N/A	✓
	During Works						No change	Although there will be changes to the maximum size of vessels handled, the extension of Fergusson North Wharf will not materially change the risk profile for vessels operating in the area. The handling of the larger vessels will not significantly increase the likelihood or the consequences of an incident.			✓
	Post-works Operations										✓
8	Status Quo	Inner harbour/approach to FN Wharf.	Interaction between container vessel and recreational vessel.	Potential for close quarters situation or risk of collision between container vessel and recreational vessel during manoeuvring for approach or on departure from Fergusson North Wharf	Close quarters situation	Serious collision between recreational vessel and container ship, resulting in multiple fatalities.	Baseline	N/A	None required	N/A	✓
	During Works						No change	Although there will be changes to the maximum size of vessels handled, the extension of Fergusson North Wharf will not materially change the risk profile for vessels operating in the area. The handling of the larger vessels will not significantly increase the likelihood or the consequences of an incident.			✓
	Post-works Operations										✓
9	Status Quo	Inner harbour/approach to FN Wharf.	Interaction between commercial vessels arriving/departing Fergusson North and other berths.	Potential for close quarters situation or risk of collision between container vessel and other commercial traffic during manoeuvring for approach or on departure from Fergusson North Wharf	Close quarters situation	Serious collision commercial vessels, resulting in severe damage/total loss and multiple fatalities.	Baseline	N/A	None required	N/A	✓
	During Works						No change	Although there will be changes to the maximum size of vessels handled, the extension of Fergusson North Wharf will not materially change the risk profile for vessels operating in the area. The handling of the larger vessels will not significantly increase the likelihood or the consequences of an incident.			✓
	Post-works Operations										✓

ID	Phase	Location/Area	Title	Description of risk	Most likely harm consequences	Worst credible harm consequences	Comparative risk without further mitigation	Comment on change in risk	New controls	Comparative risk once new controls applied	ALARP?
10	Status Quo	Princes Wharf	Cruise vessel berthing incident	Potential for cruise ships berthing to cause damage to the vessel, infrastructure or other moored vessels through loss of control/contact or through severe wash from excessive use of thrusters/Azi-pods	Damage to ferries from cruise ship wash	Severe damage to ferries and injury to passengers from contact with manoeuvring cruise ship	Baseline	N/A	None required	N/A	✓
	During Works						No change				✓
	Post-works Operations	Bledisloe North Wharf					Lower	Reduced numbers of large cruise vessels operating in the DFB reduces the overall risk. More sea room to manoeuvre means cruise ships berthing and departing Bledisloe North Wharf are less likely to suffer an incident, and with fewer other vessels (ferries) operating in the immediate vicinity, consequences are likely to be less severe in the event of an incident.			✓
11	Status Quo	Fergusson North Wharf	Container vessel berthing incident	Potential for container vessels berthing to cause damage to the vessel or shoreside infrastructure through loss of control and heavy contact	Minor damage to vessel and wharf	Severe damage to vessel and wharf or cranes requiring significant repair and remediation	Baseline	N/A	None required	N/A	✓

ID	Phase	Location/Area	Title	Description of risk	Most likely harm consequences	Worst credible harm consequences	Comparative risk without further mitigation	Comment on change in risk	New controls	Comparative risk once new controls applied	ALARP?
	During Works					Contact between vessel and manned crane or construction equipment ashore.	New risk	During works, there is a potential minor increase in the consequence of a berthing incident at Fergusson North. Should a vessel lose control during berthing, personnel and equipment involved in construction activities may be exposed to harm.	Scheduling of container vessel movements to optimise use of FX and FZ berths. Fergusson North to be used only if required. Where operational use of Fergusson North is required, berthing and operations to be kept as far to the western side as practical and physical barriers utilised to contain construction within safe distances.	N/A	✓
	Post-works Operations					Severe damage to vessel and wharf or cranes requiring significant repair and remediation	No change	Although there will be changes to the maximum size of vessels handled, the extension of Fergusson North Wharf will not materially change the risk profile for vessels operating in the area. The handling of the larger vessels will not significantly increase the likelihood or the consequences of an incident.	None required	N/A	✓
12	Status Quo	Princes Wharf	Attendant tug related berthing incident	Tug assisting with manoeuvring of a cruise vessel has potential to cause damage to itself, the vessel being attended, infrastructure or other nearby vessels through contact or severe wash	Tug wash causes minor damage to ferry and discomfort to passengers	Severe damage to ferry and injury to passengers from contact with tug	Baseline	N/A	None required	N/A	✓
	During Works	Princes Wharf					No change				✓
	Post-works Operations	Bledisloe North Wharf			Tug suffers minor damage from contact with hull of cruise ship or wharf	Severe damage to tug, cruise ship or wharf	Lower	Reduced number of large cruise ships manoeuvring in approaches to DFB/Princes Wharf, thus reducing likelihood of incident. Manoeuvring for Bledisloe North Wharf further to the east and away from most congested water-space.			✓
13	Status Quo	Fergusson North Wharf	Attendant tug related berthing incident	Tug assisting with manoeuvring of a container vessel has potential to cause damage to itself, the vessel being attended or infrastructure	Tug suffers minor damage from contact with hull of container ship or wharf	Severe damage to tug, container ship or wharf	Baseline	N/A	None required	N/A	✓
	During Works	Fergusson North Wharf					No change				✓
	Post-works Operations	Fergusson North Wharf									✓

ID	Phase	Location/Area	Title	Description of risk	Most likely harm consequences	Worst credible harm consequences	Comparative risk without further mitigation	Comment on change in risk	New controls	Comparative risk once new controls applied	ALARP?
14	Status Quo	Princes Wharf	Mooring line failure	Cruise ship mooring line parts under tension. Various best practice mooring systems currently in place when ship alongside. Temporary fencing used to limit exposure of general public. Wind limits applied for larger cruise vessels	Threat of mooring breakout requires use of thrusters/Azi-pods, causing disruption to ferry operations	Potential fatalities or severe injuries to members of public in line of recoil.	Baseline	N/A	None required	N/A	✓
	During Works						No change				✓
	Post-works Operations	Bledisloe North Wharf			Threat of mooring breakout requires use of thrusters/Azi-pods. No disruption to other activities	Mooring breakout (see #16 below)	Lower	Bledisloe North Wharf is not accessible to the public, significantly reducing the potential for catastrophic harm in the event of a line parting under tension.			✓
15	Status Quo	Fergusson North Wharf	Mooring line failure	Container ship mooring line parts under tension	Threat of mooring breakout requires tugs to be in attendance to reduce strain on lines and risk of mooring breakout	Mooring breakout (see #17 below)	Baseline	N/A	None required	N/A	✓
	During Works						No change				✓
	Post-works Operations										✓
16	Status Quo	Princes Wharf	Mooring breakout	Strong winds, particularly from the prevailing SW direction, present a risk of mooring line failure and a cascade of effects. This can result in the ship breaking away from her berth. Ship's propulsion systems and tugs (if available) are able to be used to prevent significant harm	Minor damage to wharves (bollards) and disruption to ferry operations due to thruster and Azi-pod use. Unplanned/unscheduled	Severe damage to ship, ferries and wharves due to contact with drifting cruise ship. Potential for multiple serious injuries.	Baseline	N/A	None required	N/A	✓

ID	Phase	Location/Area	Title	Description of risk	Most likely harm consequences	Worst credible harm consequences	Comparative risk without further mitigation	Comment on change in risk	New controls	Comparative risk once new controls applied	ALARP?
	During Works				departure from berth due to breakout.		No change	N/A			✓
	Post-works Operations	Bledisloe North Wharf			Parted lines, minor damage to ship or wharf.	Uncontrolled drift of cruise vessel results in contact with another vessel or potentially grounding on a lee shore.	Lower	The reduced number of large cruise ship visits to Princes Wharf results in an overall reduction of risk of mooring breakout. The new Bledisloe North Wharf design will be specified for the larger ships that may use it and constructed to the most modern standards. Additionally, there is a higher margin of safe water to the north should a vessel be blown off Bledisloe North Wharf, resulting in a lower likelihood of an adverse outcome in the event of a mooring breakout.			✓
17	Status Quo	Fergusson North Wharf	Mooring breakout	Strong winds, particularly from the prevailing SW direction, present a risk of mooring line failure and a cascade of effects. This can result in the ship breaking away from her berth.	Parted lines, minor damage to ship or wharf.	Uncontrolled drift of cruise vessel results in contact with another vessel or potentially grounding on a lee shore.	Baseline	N/A	None required	N/A	✓
	During Works	Fergusson North Wharf					No change				✓

ID	Phase	Location/Area	Title	Description of risk	Most likely harm consequences	Worst credible harm consequences	Comparative risk without further mitigation	Comment on change in risk	New controls	Comparative risk once new controls applied	ALARP?
	Post-works Operations	Fergusson North Wharf									✓
18	Status Quo	Inner harbour / approach to berths	Large commercial vessel navigational incident	Large commercial vessels operating within the inner harbour channels risk potential grounding.	Large vessel leaves channel and makes contact with the bottom. Able to be refloated and proceed with minor disruption.	Large vessel partially leaves channel and becomes hard aground. Channel blocked, disrupting shipping operations. Major salvage operation required. Potential environmental impact from uncontrolled release of hydrocarbons.	Baseline	N/A	None required	N/A	✓
	During Works						No change				✓
	Post-works Operations										✓
19	Status Quo	Inner harbour / approach to berths	Recreational vessel / ferry navigational incident	Recreational vessels and ferries operating within the inner harbour channels risk potential grounding or collision with navigation mark, wharf or other structure.	Small vessel collides with navigation mark, wharf or other structure. Moderate injuries, potentially people in water requiring rescue.	Passenger ferry collides with navigation mark, wharf or other structure at high speed. Multiple serious injuries/fatalities. Potentially people in water requiring rescue	Baseline	N/A	None required	N/A	✓
	During Works						No change				✓
	Post-works Operations										✓

ID	Phase	Location/Area	Title	Description of risk	Most likely harm consequences	Worst credible harm consequences	Comparative risk without further mitigation	Comment on change in risk	New controls	Comparative risk once new controls applied	ALARP?
20	Status Quo	Captain Cook Wharf and approaches	Interaction between car carrier vessel and ferry traffic during approach to or departure from Captain Cook Wharf	Manoeuvring car carriers in the approaches to Captain Cook Wharf cross an area of heavy use for ferry traffic, adding to congestion and potential for close quarters situation or collision.	Close quarters situation	Serious collision between ferry and cruise ship, resulting in multiple fatalities.	Baseline	N/A	None required	N/A	✓
	During Works						No change				✓
	Post-works Operations						Lower	The new Bledisloe North Wharf will remove the need for RoRo vehicle carrier vessels at Captain Cook Wharf. The manoeuvring for Bledisloe North Wharf is further to the east of Captain Cook and takes place further from the most congested areas of ferry usage. This reduces the likelihood of an interaction between a ferry and car carrier on approach to or departure from the berth.			✓
21	Post works	Whole of harbour	Changed navigational features	Changed feature (physical and aids to navigation) not as currently charted or communicated	Master loses situational awareness due unexpected features	Unexpected vessel manoeuvring	Higher	While the changed footprint of the port will be limited, that a vessel could be berthed alongside the northern face of Bledisloe Terminal despite no wharf being shown on the chart may cause some confusion to a master.	Issue NTM, issues local NTM, advise LINZ of changes to Bledisloe Terminal area. Advise LINZ of new layout of Fergusson North Wharf, confirm / advise AtoN (lights) and update List of Lights.	No change from current	✓

Appendix B Analysis of Wind Shadowing by Vessels at Berths

Appendix B1. Context

Large vessels such as cruise ships, PCC RoRo vessels, and container ships which berth at or will berth at Fergusson North and Bledisloe North wharves may, under certain conditions, cause wind shadowing. Wind shadowing is a phenomenon experienced by vessels in the lee of large, upwind objects whereby the large objects disrupt the wind flow creating an area of wind vortices and lower wind speeds. This could have an impact on sailing vessels passing relatively near to the berthed vessels. As such, the scale and probability of the impacts has been assessed and is discussed in this appendix.

Appendix B2. Wind Shadow Analysis Methodology

To assess the probability and scale of wind shadows cast by vessels berthed at Bledisloe North and Fergusson North wharves, the following activities were undertaken:

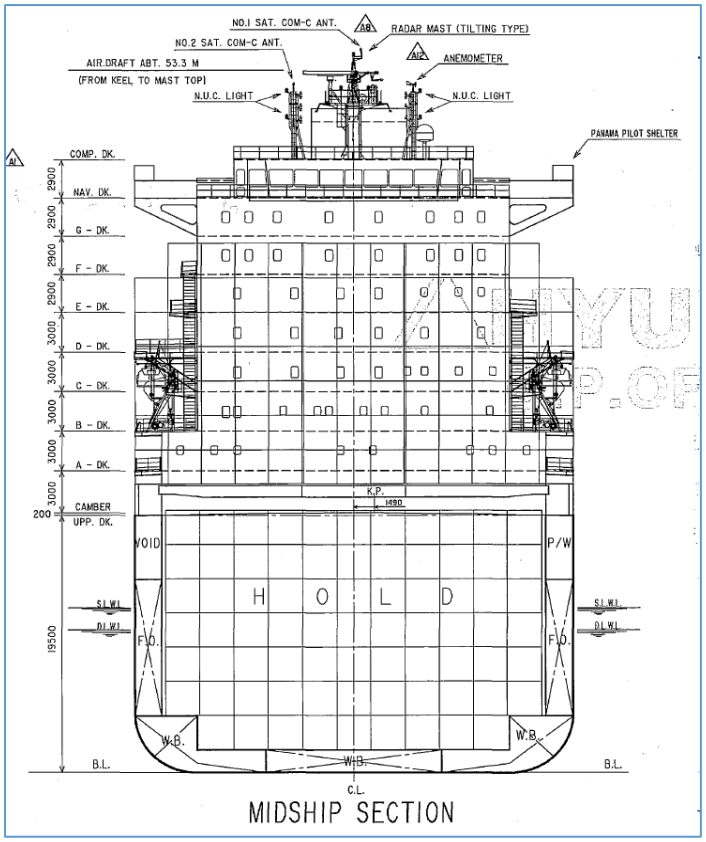
- Review of literature regarding wind shadows.

Calculation of wind shadows in highest-impact conditions for the vessels that currently routinely berth at the existing Fergusson North Wharf (represented by a 4,300 TEU vessel) and the largest that can or may berth as a result of the proposed Fergusson North Wharf extension (up to 10,000 TEU). Figure B.1 and Figure B.2 set out the specifications for the representative vessels used in this analysis.

- Calculation of wind shadows in highest-impact conditions for the largest design-case quarter-ramp RoRo and cruise ships that may berth at the proposed Bledisloe North Wharf.
- Analysis of wind data and production of wind roses to understand the likely wind conditions at the wharves and in the harbour.
- Probabilistic view of risk of wind shadows affecting sail boats.
- Discussion of the findings.

The analysis was completed with the following assumptions:

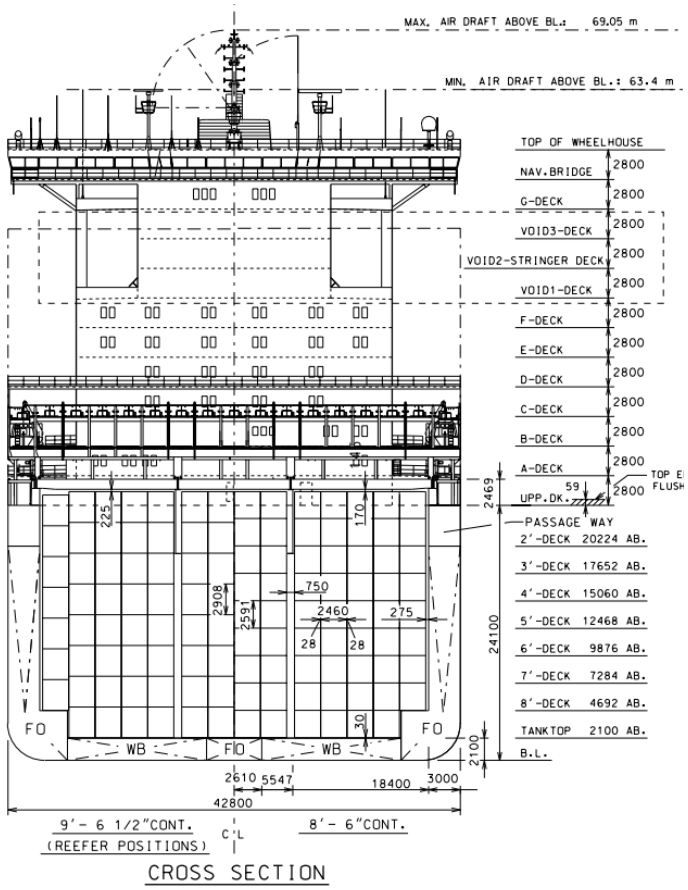
- Wind shadowing and turbulence effects from the nearby quay cranes, container stacks, city, and terrain are ignored. The layout of these objects is visible in Figure B.3.
- The wind conditions are worst-case southerly winds blowing beam-on to the berthed vessels.
- The air draught of each vessel is taken to the top of the container stacks for a container ship or the top deck of a PCC RoRo or cruise ship. In effect, each vessel is assumed to be rectangular with container ships assumed to have containers across the entire LOA (noting that in reality a small portion of the bow of the vessel is kept free of containers).



PRINCIPAL DIMENSIONS

LENGTH	O. A.	262.06 M
LENGTH	B. P.	248.00 M
BREADTH	MLD.	32.20 M
DEPTH	MLD.	19.50 M
DRAUGHT	MLD.(DESIGN)	10.80 M
DRAUGHT	MLD.(SUMMER/SCANT.)	12.50 M

Figure B.1: Part copy of representative 4,300 TEU vessel specifications.



CONTAINER VESSEL

LENGTH OVERALL ext.			346.98 m
LENGTH P.P.			331.54 m
BREADTH MOULDED			42.80 m
DEPTH MOULDED			24.10 m
DESIGN DRAUGHT MOULDED			12.20 m
SCANTLING DRAUGHT MOULDED			15.00 m
TRIAL SPEED AT PROPULSIVE POWER AND DESIGN DRAUGHT			52600 kW 24.6 kn
CONTAINER CAPACITY	ON DECK		5888 TEU
CONTAINER CAPACITY	IN HOLDS		3752 TEU
CONTAINER CAPACITY	GRAND TOTAL		9640 TEU
REEFER CONTAINERS	ON DECK		446 FEU
REEFER CONTAINERS	IN HOLDS		371 FEU
REEFER CONTAINERS	TOTAL		817 FEU
FUEL OIL CAPACITY (98%)	DENSITY: 0.98	14459 t	14754 m³
DIESEL OIL CAPACITY (98%)	DENSITY: 0.90	449 t	499 m³
BALLAST CAPACITY (100%)	DENSITY: 1.025	32334 t	31545 m³
FRESH WATER CAPACITY (100%)			420 m³
THEIR SHARE OF POTABEL WATER (100%)			264 m³

CLASSIFICATIONS:

AMERICAN BUREAU OF SHIPPING
✠ A1 (E) CONTAINERSHIP, SH, DLA;
✠ AMS; ✠ ACCU; OMBO

Figure B.2: Part copy of representative 10,000 TEU container vessel specifications.

Appendix B3. Summary of Literature on Wind Shadows

Wind shadows are a phenomenon experienced by anyone immediately downwind of a large object or structure whereby overall wind conditions are disturbed. This effect is considered in various fields including architecture, engineering, and sailing and is in effect the wake caused by the object. The following subsections summarise the key information used for this analysis.

Two key references were used for this analysis. The results from each were also compared to a sailor's 'rule of thumb' to confirm that the results were realistic. Both the references were found to produce similar and realistic results.

B3.1 Physics of Sailing

Physics of Sailing is a book by John Kimball.[45] Section 2.4 of this book discusses wind shadows as it pertains to sailing and steps through the derivation of a formula for calculating the size of a wind shadow and its effect on wind speed. This is an important subject for those interested in sail-racing where seeking to avoid disturbed winds is a key aspect of racing.

Wind shadows are experienced by sailors immediately downwind of a large object. As one moves away from the object, the wind gradually returns to its original velocity. The edges of the wind shadow are vaguely defined but the effect of the wind shadow increases towards its centre.

However, wind shadows are more complicated than just a decreased average wind speed. By interrupting the flow of air, a sail increases the swirling of wind within the wind shadow, increasing turbulent fluctuations. Sailors refer to this as 'dirty air'.

Kimball derives an equation for the distance a wind shadow extends through an estimate of a wind shadow's vitality at distance x downwind of the shadowing vessel. This is based on ideas about turbulence by Ludwig Prandtl and others in the first half of the 20th century. The resulting calculation is as follows:

$$x = \frac{L}{\propto^{\frac{3}{2}}}$$

where x is the downwind distance the wind shadow extends in metres, L is the sail width, and $\propto$ is the proportion of the wind speed that has recovered. For the purposes of this analysis, the wind shadow is calculated for the case that 75% of the wind speed has recovered.

B3.2 Wind Shadow Model for Air Infiltration Sheltering by Upwind Obstacles

I.S. Walker, D.J. Wilson, and T.W. Forest[46] developed a wind shadow model to calculate the wind sheltering effects of upwind obstacles (typically buildings in cities) for air infiltration calculations. The model is designed to deal with near wake effects as the large wind speed reductions are deemed more important than the weak far wake effects.

The authors found that the near wake extends about five times a characteristic defined as:

[45] *Physics of Sailing, J. Kimball 2010.*
[46] I.S. Walker, D.J. Wilson, T.W. Forest, *Wind Shadow Model for Air Infiltration Sheltering by Upwind Obstacles*, Vol. 2. No. 4, HVAC & R Research, October 1996.

$$R_B = D_S^{2/3} D_L^{1/3}$$

Where D_S and D_L are the smallest and largest upwind obstacle dimensions (width or height) respectively.

The authors define four regions of the wake based on the ratio $\frac{X_S}{R_B}$, where X_S is the downwind distance from the obstacle, as follows:

1. **Curved Streamlines Region ($\frac{X_S}{R_B} < 0.1$):** the region closest to the obstacle where accelerating flow around the obstacle and sub atmospheric wake static pressure causes streamline curvature.
2. **Recirculating Wake Region ($0.1 < \frac{X_S}{R_B} < 1$):** the wake width remains constant at approximately the obstacle width with a uniform velocity reduction profile until $\frac{X_S}{R_B} \approx 1$.
3. **Near Wake Region ($1 < \frac{X_S}{R_B} < 3$):** after the low-pressure region behind the obstacle has returned to ambient pressure, wake spread is dominated by obstacle-generated turbulence.
4. **Far Wake Region ($\frac{X_S}{R_B} > 3$):** after $\frac{X_S}{R_B} \approx 3$ the additional root mean square turbulence is reduced to about 10% of its initial value immediately behind the obstacle and is relatively weak compared to atmospheric shear layer turbulence. In this region, the effect of the obstacle geometry is negligible, and wake spread is dominated by atmospheric turbulence.

For the purposes of this analysis, $\frac{X_S}{R_B} > 3$ is rearranged and used to estimate the size of a wind shadow that could impact the navigational safety of sailors in the vicinity of occupied wharves.

Appendix B4. Wind Shadow Calculations

Table B.1 sets out the results of the wind shadow depth calculations for the vessels routinely utilising the existing Fergusson North Wharf (represented by a 4,300 TEU vessel) as well as a 10,000 TEU sized vessel which may use the proposed Fergusson North Wharf in the future and the largest design-case-vessels for the proposed new Bledisloe North Wharf.

These calculations assume the highest-impact conditions in which a southerly wind is beam-on to the vessels.

Table B.1: Wind shadow calculations.

Vessel type	Air draught (m)*	LOA (m)	Calculation method	Wind Shadow depth (m)
Representative 4,300 TEU container ship	29.7	262.06	Physics of Sailing	205.6
			Wind Shadow Model	167.2
Representative 10,000 TEU container ship	38.4	346.98	Physics of Sailing	275.2
			Wind Shadow Model	223.0
Representative large PCC RoRo vessel	46	265	Physics of Sailing	336.0
			Wind Shadow Model	232.8
Representative large cruise ship	46	348	Physics of Sailing	336.0
			Wind Shadow Model	255.0

*Note that for each calculation, 4m of air draught was subtracted due to the surface of the wharf deck/structures being 4 metres AMSL.

Appendix B5. Wind Conditions

Wind data was supplied by POAL from anemometers stationed at Bledisloe North Wharf and Fergusson North Wharf. It is noted that there were limitations to the Bledisloe North anemometer as it is constructed on or near to a building (and so does not read clean wind in all directions) and was compromised during renovations to that building during a considerable period within the dataset's date range. Both datasets were examined, and it was decided that the Bledisloe North anemometer could not to be used for further analysis.

The anemometer on Fergusson North Wharf is located 12 metres above pavement level on light mast L324 (Figure B.3).

Figure B.3: Location of Fergusson North Wharf anemometer (circled in yellow). Image is aligned to true north.

A wind-rose was created using data from the Fergusson North Wharf and is displayed in Figure B.4. The prevailing winds are south-west to westerly and are predominantly below 15-knots. Notably, the highest wind speeds were more frequently recorded as coming from north-east to south-east.

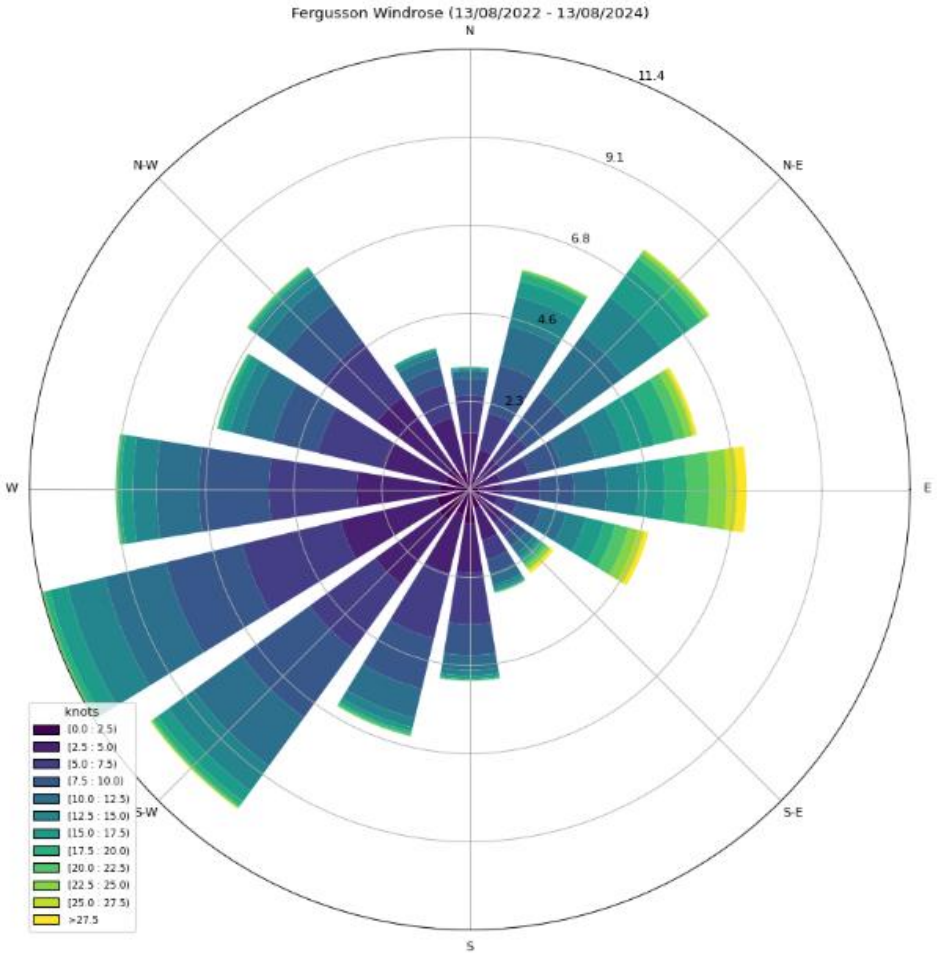


Figure B.4: Windrose for winds recorded at Fergusson North Wharf between 13/08/2022 and 13/08/2024.

Appendix B6. Likelihood of Wind Shadowing Affecting Sailors

Whilst Appendix B4 explored the potential extent of wind shadows cast by berthed vessels in the highest-impact conditions, this section explores the likelihood that such a wind shadow could be cast. To do so, the following assumptions are made:

- A wind shadow that may affect sailors will occur under winds from south-east to south-west directions.
- Royal New Zealand Yacht Squadron races occur as per the timetables available on 3 September 2024.
- Sailors only race during timetabled events.
- Berth occupancy at Fergusson North Wharf is optimised. According to POAL, optimum berth occupancy can push to 60-70% of the time.

In the Fergusson North dataset used to produce the wind-rose in Figure B.4, south-easterlies to south-westerlies comprised 27% of the dataset. Royal New Zealand Yacht Squadron timetables suggest that races occur for 22.5 hours across the week – that is 13% of the available hours in a week.

Hence, multiplying these proportions yields the probability that the berth is occupied, the wind conditions are suitable for wind shadowing across the harbour, and a race is on. The result is 2.4%.

A similar calculation can be performed for the new Bledisloe North Wharf – this produces similar results only modified by berth occupancy.

Appendix B7. Wind Shadow Analysis Discussion

B7.1 Wind Shadow Extent

The extent of wind shadows are greatest when calculated using the formula from the book *Physics of Sailing*. Paired with the smaller extents calculated using the wind shadow model derived by I.S. Walker, D.J. Wilson, and T.W. Forest, a range is produced that indicates the probable extents of wind shadows cast by vessels berthed at the proposed new Bledisloe North Wharf and Fergusson North Wharf.

The formulae from *Physics of Sailing* and the model derived by I.S. Walker, D.J. Wilson, and T.W. Forest suggest that the wind shadow extents are most sensitive to the air draught of a vessel as opposed to LOA.

There is approximately 800 metres of navigable water space between Fergusson North Wharf and the Royal New Zealand Navy Base and approximately 1000 metres of navigable water space north of Bledisloe Wharf in the Waitematā Harbour. The highest-impact scenarios for wind shadowing occur when a cruise ship is berthed at Bledisloe North and a 10,000 TEU container ship is alongside Fergusson North. In these scenarios, there is approximately 660 metres of 'clear air'[47] available opposite Bledisloe Wharf and 510 metres of water space opposite Fergusson North for sailors to utilise.

B7.2 Likelihood of Impacting Navigational Safety or Wind Power Available

The analysis in Appendix B6 finds that the probability of a berth being occupied by a large ship with a south-easterly to south-westerly wind and a Royal New Zealand Yacht Squadron racing event on low.

However, there are several assumptions and facts that make this analysis more of a worse case than it is likely to be. For example, it assumes that sailors are not mindful of the potential for wind shadows and so fail to plan to track to the north of the fairway. Similarly, it assumes that sailors will sail in any wind condition winds – from very light to very strong – and that they would not take action to avoid a potential wind shadowing (for example by failing to plan to track to the north of the fairway). Any experienced sailor – those likely to be racing, will be well aware of such affects. It is also of note that most sailors will be mindful of the shadowing from the city, the port structures and funnelling from the larger city buildings, so will experience wind shadow effects even when ships aren't using the berths.

As a result, the analysis may report a higher likelihood of wind shadowing affecting sailing than would be experienced in practice.

Appendix B8. Wind Shadow Analysis Conclusion

When taking both the extent of the wind shadows and probability into account, we can conclude that in the rare, highest-impact situation that a cruise ship and container ship are alongside at Bledisloe and Fergusson North wharves with a steady south-easterly to south-westerly wind blowing, there is still at least 510 metres of clear-air in the fairway for a sailing

[47] The term 'clear air' is used here to refer to air where the wind speed has recovered from the disturbance to at least 75% of the original wind speed, turbulence has stabilised, and no vortices will be present.

vessel to continue to sail through the Waitematā Harbour. The analysis indicates that the impact on sail boats due to wind shadowing from the proposed wharf developments will be limited.