Port of Melbourne – Container Capacity Review

Final Report

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The capacity modelling undertaken as part of this study is limited to the information provided to Black Quay, with the assumptions contained within the model detailed within the following sections.

It should be noted that the modelling is restricted to a static model only. Whilst every attempt has been made to capture the variation in operational parameters at each terminal, unseen variations can occur, not captured in static analysis.

The report supersedes all other versions of this report sent to date.

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Glossary

ASC	Automated Straddle Crane
BITRE	Bureau of Infrastructure and Transport Research Economics
Black Quay	Black Quay Maritime Consulting Pty Ltd.
DPWA	Dubai Port World Australia
LOA	Length Overall
GMPH	Gross Moves Per Hour (Crane)
OCR	Optical Character Recognition
PCEP	Port Capacity Enhancement Program
PIANC	World Association for Waterborne Transport Infrastructure
PoM	Port of Melbourne
SDE	Swanson Dock East
SDW	Swanson Dock West
STS	Ship-to-Shore (Crane)
TEU	Twenty Foot Equivalent Unit (container)
VICTL	Victoria International Container Terminal Limited
WDE	Webb Dock East
WDW	Webb Dock West
WSIT	West Swanson Intermodal Terminal
UNCTAD	United Nations Conference on Trade and Development

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Executive Summary

Black Quay Maritime Consulting Pty Ltd. (Black Quay) has been commissioned by Port of Melbourne (PoM) to provide an independent assessment of container handling capacity at the Port of Melbourne (the Port).

This includes analysis and review of all three (3) international container terminals at the Port; namely Swanson Dock East (SDE), Swanson Dock West (SDW), and Webb Dock East (WDE).

Key Modelling Inputs

The capacity modelling has been based upon container trade forecasts and fleet forecasts to 2050, as provided by PoM. A number of modelling inputs were agreed with PoM. These are broadly summarised as follows:

- TEU:box ratio of 1.60, increasing to 1.70 by 2030 under some scenarios
- Terminal operating hours 24 hours per day, 360 days per year
- A capacity factor of 15% to be applied to maximum capacity calculations to allow for peaking and fluctuations, in order to determine optimum annual capacity
- Capacity to be established based on existing terminal berthlines, yard storage and operating regimes, with the inclusion of the 71m extension of WDE berthline currently underway
- An average of two (2) Ship-to-Shore (STS) cranes work on vessels up to 5,000 TEU, three (3) cranes on vessels between 5,000-9,000 TEU, and four (4) cranes on vessels over 9,000 TEU
- Whilst the actual number of STS cranes and deployment is a commercial decision by stevedores and assumed to not be a limiting factor, there is a practical limitation to crane spacing and STS crane annual productivity. This is assumed to be as follows:
    - Minimum achievable crane spacing of 90m
    - Maximum STS crane productivity of 140,000 to 180,000 TEU/crane/annum tested under varying scenarios
- A gross STS crane rate of 27gmph to reflect current Pom-wide rates, with additional scenarios tested under increased rates in the future
- Total time at berth consists of vessel productive time (as per above) as well as an assumed three (3) hours of non-productive time for each vessel visit for mooring/de-mooring etc.
- Yard utilisation assumed to be 80%
- Dry stack heights assumed as 3.2 (straddle) and 5 (ASC). This reflects the ability for straddle terminals to convert to 1 over 3 straddles at some stage. Reefer stack heights assumed to be 2 (straddle) and 5 (ASC).
- The following values have been assumed for dwell times which are considered reflective of an efficient gateway terminal.
    - Import (Full): 1.5 - 2.5 days (Scenarios assume 2 days)
    - Export (Full): 4 - 6 days (Scenarios assume 5 days)

- Empties: 2 - 4 days (Scenarios assumes 3 days)
- Transhipment: 2 days

> Gate modelling has been undertaken assuming existing gate infrastructure, and processing times of 60-90 seconds/truck at in-gates. However, as requested by PoM, gate capacity is not considered a limiting factor due to the relative ease of increasing gate numbers.

Maximum Berth Utilisation

A key factor in any assessment of throughput capacity over a quay line is the realistic berth occupancy threshold (or 'berth utilisation') before vessel queuing becomes 'unacceptable' by the customer (shipping lines).

PIANC WG158 provides industry accepted guidance on the capacity evaluation of port terminals and is typically utilised by port industry professionals when calculating port capacity in a static manner. Typically, the maximum berth utilisation is based on the number of berths present and the ability/tolerance of the customer to wait. This is measured as a ratio of wait time: service time (WT:ST).

However, as part of this engagement, Black Quay has been requested to review available literature and specific PoM data (where available) to determine if any alternative berth occupancy rates (to those in PIANC WG158) should be adopted in the context of the Port of Melbourne.

In order to conduct the review, Black Quay has reviewed the following:

> Whether a WT:ST time ratio of 0.10 (as proposed by PIANC WG158) is appropriate or, alternatively, if a different ratio should be applied

> Regarding the WT:ST ratio confirmed in the previous point, what corresponding maximum berth utilisation level should be adopted.

Black Quay identified three industry-recognised guidance documents (over and above PIANC WG158) which provided quantitative guidance. These are as follows:

> *The Capacity in Container Port Terminals*, presentation by Valenciaport Foundation at UNCTAD AD Hoc Expert Meeting on Assessing Port Performance, 2012 (and its supporting document *Sea Port Capacity Manual*, Monfort et al 2011)

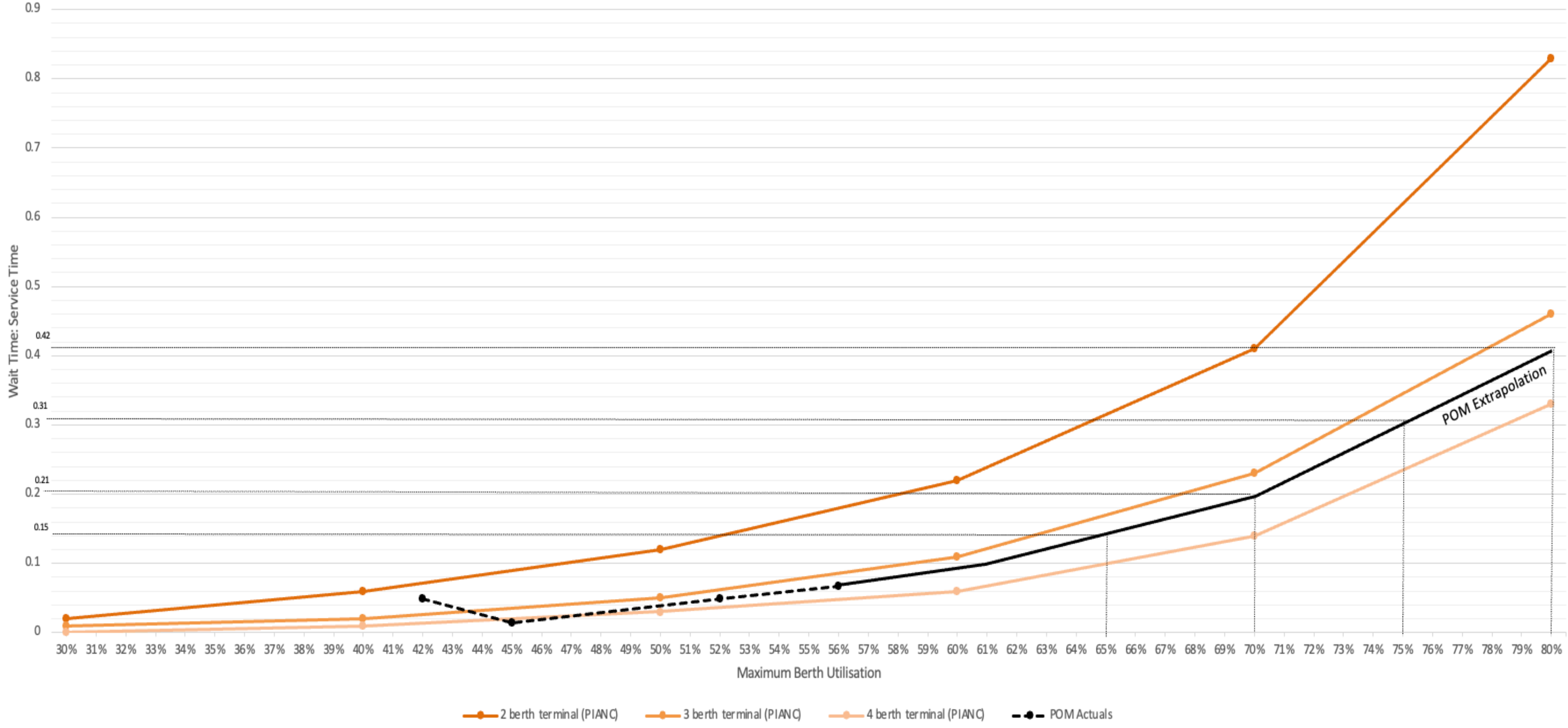
> *Planning and Design of Ports and Marine Terminals*, Agerschou, 2004

> *Port Designer's Handbook*, Thoreson 2014 (Third Edition).

The guidance provided by PIANC WG158 and all three of the above documents support the adoption of a WT:ST of 0.1 for container terminals.

In terms of relating this to maximum berth utilisations appropriate for PoM, a review of the suggested maximum berth utilisations for 1-4 berth facilities provided by PIANC WG158 was carried out, against the actual WT:ST profile implied by PoM-wide statistics contained within BITRE Waterline 67. This is depicted below.

Figure 1 Forecast Service impacts at Higher Berth Utilisations (Black Quay, 2022)



On the basis of this review, PIANC WG158 was considered slightly conservative, and the following maximum berth utilisations were proposed to be adopted. It was however noted that the BITRE data on time at anchorage has been used as a proxy for wait time. Other measures taken by shipping lines due to congestion such as slow steaming, waiting outside of port limits and/or skipping a port due to congestion is not captured and therefore the calculated WT:ST may not capture all congestion issues. This results in a potential for underestimation of the WT:ST.

Figure 2 Proposed Berth Occupancy Levels (for WT:ST = 0.1)

	Number of Berths			
	1 Berth	**2 Berths**	**3 Berths**	**4 Berths**
Monfort et al	31%	53%	63%	70%

It was recognised that a decrease in the reliability of vessel arrival times has been experienced in recent history impacted by the Covid19 pandemic. Whilst information contained within the Productivity Commission Draft Report suggests that there has not yet been an increase in vessel reliability post-2020, it is possible that this might occur as the lingering effects of the pandemic ease.

Therefore, scenario testing within the capacity analysis has also considered increased utilisation of 65% for a 3-berth terminal and 60% utilisation for a 2-berth terminal where vessel reliability improves in the future and/or shipping lines accept higher levels of congestion.

Individually, terminal operators may elect to pursue a higher berth utilisation level. However, this would likely be to the detriment of service level and result in customer dissatisfaction and potential loss of the service to another terminal and/or port (assuming a competitive environment). This is not dissimilar to what has been observed in Sydney recently.

Modelling Overview

The capacity model has been established in accordance with the guidance contained within PIANC WG158 for calculating annual terminal capacity. Optimum annual capacity has been calculated for each of berth, yard, gate (road) at each of the terminals.

In order to provide sensitivity testing on the key assumptions made within the model, modelling was undertaken of three (3) scenarios. The premise of these scenarios is outlined below.

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Figure 3 Scenarios Modelled

	Scenario A	Scenario B1	Scenario B2	Scenario B3	Scenario C
Description	**Current Productivities**	**Increased TEU Ratio**	**Increased Crane Rate**	**Increased Berth Utilisation**	**Increased TEU Ratio & Crane Rate & Utilisation**
Gross Crane Rate	27gmph average across all three (3) terminals	27gmph average across all three (3) terminals	WDE 26gmph SD Terminals: 30gmph	27gmph average across all three (3) terminals	WDE 26gmph SD Terminals: 30gmph
TEU Ratio	1.60	Increasing from 1.60 to 1.70 by 2030	1.60	1.60	Increasing from 1.60 to 1.70 by 2030
Berth Utilisation	53% (2-berth) 63% (3-berth)	53% (2-berth) 63% (3-berth)	53% (2-berth) 63% (3-berth)	60% (2-berth) 65% (3-berth)	60% (2-berth) 65% (3-berth)
Maximum Crane Productivity	140,000 TEU/crane/annum	150,000 TEU/crane/annum	155,000 TEU/crane/annum	140,000 TEU/crane/annum	165,000 TEU/crane/annum
Dependent on	SD Terminal operators invest in 1 over 3 strads as required to increase yard capacity	SD Terminal operators invest in 1 over 3 strads as required to increase yard capacity TEU factor continues to increase to 1.70	SD Terminal operators invest in 1 over 3 strads as required to increase yard capacity Improvements in DPW productivity to 30gmph noting that this would likely require improvements in DP World's industrial framework as per DPW submission to the Productivity Commission	SD Terminal operators invest in 1 over 3 strads as required to increase yard capacity Increased berth utilisation through vessel schedule reliability increases and/or increased wait time tolerance by shipping lines	TEU factor continues to increase to 1.70 Increased berth utilisation through vessel schedule reliability increases and/or increased wait time tolerance by shipping lines SD Terminal operators invest in 1 over 3 strads as required to increase yard capacity Improvements in DPW productivity to 30gmph noting that this would likely require improvements in DP World's industrial framework as per DPW submission to the Productivity Commission

The capacity modelling considers practical operational and spatial limitations of STS handling equipment operating at maximum crane numbers along the berth (referred to as a 'crane cap). Upon stakeholder feedback, Black Quay also included the 'unconstrained' capacity under each of the five (5) scenarios.

This would rely on increased crane deployment over and above what has been assumed in Section 4.5 of the report and/or a higher proportion of berth productive hours than all Port of Melbourne terminals or any other Australian port are currently achieving. Black Quay consider this to be an unlikely scenario.

The modelling indicated that the future combined capacity of the terminals is between 3,780,000 - 4,766,000 TEU/annum, dependent on five (5) different scenarios as outlined in the following figure.

All, but one scenario falls between 3,780,000 to 4,455,000 TEU/annum. The outlying scenario (4,766,000 TEU/annum) relies on multiple parameters improving, including an uncapped crane productivity.

Figure 4 PoM Optimum Capacity Results (Peak Figures Presented)

	Scenario A		Scenario B1		Scenario B2		Scenario B3		Scenario C	
	Crane Cap	Unconstrained	Crane Cap	Unconstrained	Crane Cap	Unconstrained	Crane Cap	Unconstrained	Crane Cap	Unconstrained
Swanson Dock East	1,260,000	1,401,333	1,350,000	1,479,526	1,395,000	1,539,665	1,260,000	1,471,958	1,485,000	1,677,074
Swanson Dock West	1,400,000	1,459,620	1,500,000	1,541,069	1,550,000	1,603,712	1,400,000	1,522,914	1,650,000	1,765,721
Webb Dock East	1,120,000	1,199,119	1,200,000	1,267,338	1,158,351	1,158,351	1,120,000	1,357,493	1,320,000	1,386,192
POM Total	3,780,000	4,007,130*	4,050,000	4,231,598*	4,098,779*	4,250,794*	3,780,000	4,292,431*	4,455,000	4,766,717*
Dependant On	SD terminal operators invest in 1 over 3 strads as required to increase yard capacity		SD terminal operators invest in 1 over 3 strads as required to increase yard capacity TEU Factor continues to increase to 1.70		SD terminal operators invest in 1 over 3 strads as required to increase yard capacity Improvements in DPW productivity to 30gmph noting that this would likely require improvements in DPW's industrial framework as per DPW's submission to the Productivity Commission		SD terminal operators invest in 1 over 3 strads as required to increase yard capacity Increase berth utilisation through vessel reliability increases and/or increased wait time tolerance by shipping lines		TEU factor continues to increase to 1.70 Increase berth utilisation through vessel reliability increases and/or increased wait time tolerance by shipping lines SD terminal operators invest in 1 over 3 strads as required to increase yard capacity Improvements in DPW productivity to 30gmph noting that this would likely require improvements in DPW's industrial framework as per DPW's submission to the Productivity Commission	

Note: *Timing of SDE, SDW and WDE peak capacities is not coincident and therefore the peak optimum capacity of PoM as a whole is slightly lower than the sum of the peak capacities of each terminal.

However, the time at which this cap is reached varies. The actual capacity in any given year is heavily driven by the fleet profile, crane deployment and crane productivity, and the capacity cap may not be reached until a future point in time.

Essentially, the point at which the capacity cap is reached is dependent on a number of assumptions, including fleet deployment, crane working rates and crane allocation.

Regardless of scenario, the review of development of capacity over time against base trade forecasts indicated that by 2034, additional capacity would be required at Port of Melbourne. The requirement would be brought forward where crane rates, TEU ratio and berth utilisation do not all increase (as per Scenario C) or should the high trade case eventuate.

The following observations were noted in relation to the above results.

- The berth capacity of each terminal is ultimately dictated by a cap formed by the assumed minimum crane spacing and maximum annual crane productivity. The point at which this cap becomes apparent is dependent on assumptions around crane productivity, crane allocation, berth utilisation and the forecast fleet
- The quay line productivity of each terminal under Scenario A falls within the limits that could be reasonably expected of an origin-destination port. The quay line productivities under Scenario B1 - C are considered reasonable into the future providing that future productivity enhancements are realised.
- Under Scenario A, the optimum terminal capacity is reached in the following years (subject to assumptions made, including fleet profile, crane deployment etc):
  - Webb Dock East - 2041
  - Swanson Dock East - 2022
  - Swanson Dock West - 2029
- The ability to reach the quoted capacities prior to these dates would require variation to the assumed modelling inputs, particularly in relation to crane deployment by vessel size.
- In Scenarios B1 to B3, changes were individually tested considering three different parameters. The parameter that had the largest impact was the crane rate which increased total Port capacity by up to 320,000 TEU/annum.
- In Scenario C, an increase in crane rate, berth utilisation and TEU ratio was tested. Under this scenario, the maximum terminal capacity is indicatively reached in the following years (subject to assumptions made including fleet profile, crane deployment etc):
  - Webb Dock East - 2043
  - Swanson Dock East - 2025
  - Swanson Dock West - 2029
- All scenarios assume that Swanson Dock operators will convert to 1 over 3 straddles as required to increase yard capacity.
- Scenarios B and C are dependent on a combination of the following:
  - TEU factor continuing to increase to 1.70
  - Vessel schedule reliability improves
  - DPW productivity improves to 30gmph noting that this would likely require improvements in DP World's industrial framework as per DPW's submission to the Productivity Commission

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Suggested Performance Metrics

The capacity modelling indicates that the capacity at all three (3) of the PoM container terminals is predominately dictated by the productivity achieved at berth.

In order to monitor terminal capacity at each of the terminals and any surplus capacity that exists, the following performance metrics are suggested when monitoring terminal capacity (to be measured at each terminal):

- Actual wait time:service time ratios experienced by the fleet
- Berth utilisation figures
- Berth productivity in terms of containers/hour
- Actual dwell times in the yard
- Average yard utilisation figures
- Peak yard utilisation figures
- Average truck turnaround times (taken from truck arrival/scheduled window time)

These figures should be measured over a suitable time period (quarterly is recommended) so as to provide an accurate picture of terminal operations and not be distorted by short-term anomalies.

1 Report Introduction

1.1 Overview

Black Quay Maritime Consulting Pty Ltd. (Black Quay) has been commissioned by Port of Melbourne (PoM) to provide an independent assessment of container handling capacity at the Port of Melbourne (the Port).

The assessment includes comprehensive capacity analysis at all three (3) international container terminals located at the Port. Whilst the study is desktop based, each terminal has been assessed using exclusive Black Quay capacity models and substantial investigations.

It is noted that the study of capacity does not consider the structural capacity of the infrastructure, including particular wharves to cater for increased vessels and crane loadings.

Various discussions were held with Port of Melbourne staff to assess the validity and suitability of the data and information provided by the Port. A Draft Report was included in a package of documentation released by PoM for stakeholder/industry feedback in September 2022.

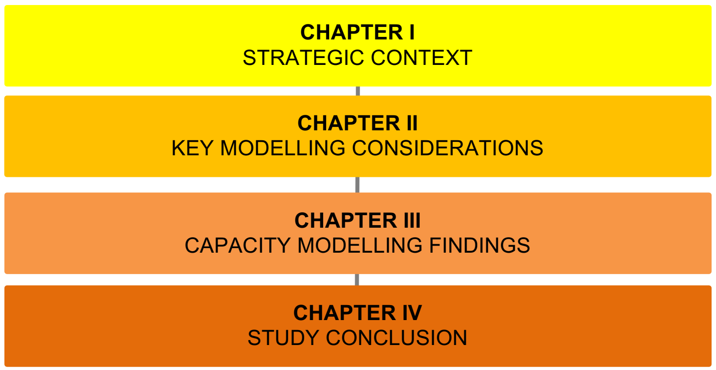
Upon release of the draft report, the stakeholder/industry consultation process invited feedback from stakeholders on the modelling inputs, assumptions and associated outputs. The process included one on one interviews with two of the three container stevedores[1] in which these parties were encouraged to request clarification on the model inputs and process to assist in their written submissions.

Written submissions were received from all three container stevedores as well as a variety of other stakeholders, including shipping lines and the Maritime Union of Australia (MUA).

Black Quay has reviewed the feedback received by the various parties and revised the report and modelling where deemed appropriate, as well as provided written responses to any queries raised by them.

1.2 Report Structure

The study chapters are illustrated below.



[1] The third stevedore declined an invite for an interview.

1.3 Hierarchy of Documents

Where conflicting information exists within the documentation that has been provided, the following hierarchy of documents has been applied:

1. Clarifications provided directly by PoM
2. PoM Provided Trade and Fleet Forecasts
3. BITRE Waterline 67
4. Other PoM and Stevedore (Operator) Supplied material
5. Other Publicly accessible documentation

1.4 Port Concession Deed Definitions

Throughout this document, reference is made to the inputs and assumptions underlying the assessment of capacity of each of the three (3) container terminals.

The Port Concession Deed, signed between the Victorian Government and Port of Melbourne, defines the Actual Capacity as follows:

PoM Actual Capacity means the aggregate of:

(a) the number of TEUs that facilities on the PoM Lease Land are capable of loading from Vessels in accordance with Good Operating Practice; and

(b) the number of TEUs that facilities on the PoM Lease Land are capable of unloading from ships in accordance with Good Operating Practice,

in any given period, taking into account:

(c) the effective berth, crane and yard capacity available to service the facilities during the period;

(d) the capacity of road and rail infrastructure inside the Port during the period and that is relevant to moving TEUs to and from the facilities when that road and rail infrastructure is managed, operated and maintained in accordance with good industry practice and the terms of the Transaction Documents;

(e) applicable Laws (including those regulating safety and the environment) and Approvals in force during the period; and

but excluding any TEUs the loading and unloading of which is attributable to:

(f) the handling and logistics services used or provided during the period at a level or efficiency that (having regard to technical, labour, Cost and safety factors and applicable Laws and the conditions of applicable Approvals) exceeded the levels that could reasonably be expected to be sustained (applying good industry practice) continuously for a period of five consecutive years; or

(g) the use of equipment or labour in that period which is not permanently available for handling of TEUs (other than labour mobilised to respond to increased TEU traffic at the Port in the two months prior to 25 December).

Good operating practice is defined as:

(a) adherence to a standard of practice which includes the exercise of that degree of skill, diligence, due care, prudence and foresight which would reasonably be expected of a reasonably experienced, competent, prudent and qualified operator of the Port (where that standard and that degree are not to be read down or limited at any time based on the fact that the Transaction Documents and Port Lessee and Port Manager's occupation of the Port have a finite term); and

(b) without limiting paragraph (a) of this definition, provision of appropriate services and facilities for the ease of access to, expeditious and safe movement in and efficient use of the Total Concession Area and Core Port Infrastructure by Vessels, vehicles and other users of the Port (where what is appropriate is not to be read down or limited at any time based on the fact that the Transaction Documents and Port Lessee and Port Manager's occupation of the Port have a finite term).

When determining appropriate input assumptions for the capacity modelling, particularly those informed by historic figures, Black Quay has had regard to the definitions above, in particular, good operating practice and productivities which could reasonably be expected to be sustained over a period of five (5) consecutive years.

Chapter I: Strategic Context

Port of Melbourne - Container Capacity Review

2 Containerisation and the Port of Melbourne

2.1 The Global Container Trade Industry

In its 60-year history, containerization has continued to increase its domination as the primary transport mechanism in shipping.

The international shipping industry is today responsible for the transportation of approximately 90% of world trade, and this is marginally increasing despite the evolution of aviation as a partial alternative.

Approximately 5,400 container ships vessels are registered in the world today, and in 2020, transported approximately 811million TEU's in goods across the globe (UNCTAD, 2020).

In the 1950's it was recognised that the creation of a standardised and stackable method to transport goods of all types, would provide sizeable efficiencies, not only in the unloading and loading of vessels, but in the transfer to landside transport too.

From the establishment of the first container vessel (a converted oil tanker capable of carrying 58 TEU), container shipping quickly took hold as considerable time and cargo rate reductions were realised.

Although the modern concept was invented in the United States, the world's first purpose built cellular container vessel was built in Australia (MV Kooringa) in 1964.

The gains realised resulted in the establishment of ISO standards for the dimensions and characteristics of containers. The standardisation also enabled more aggressive investment in ships and container-handling equipment, which in turn facilitated further efficiency gains.

The driver in the widescale adoption and astronomic growth in container shipping since this time is primarily due to the combinations of efficiencies and standardisation (in vessels, ports, handling equipment and landside transport) that containerisation enables.

In addition, containerised shipping has driven large-scale changes in the industries that it services. Just-in-time manufacturing became viable due to the now more predictable nature of the shipping task, and the movement of both manufacturing materials and finished products could be controlled more efficiently.

2.2 Australian Containerised Cargo

International containerized cargo to Australian ports in 2020/21 is depicted in Figure 5. The combined Ports of Sydney (Port Botany) and Melbourne account for approximately 68% of all container traffic in Australia, clearly demonstrating the link between the country's two largest cities and the trading fortunes of the entire country.

Furthermore, the combined east coast container trade (based around Sydney, Melbourne and Brisbane) accounted for approximately 85.4% of Australian containerised trade.

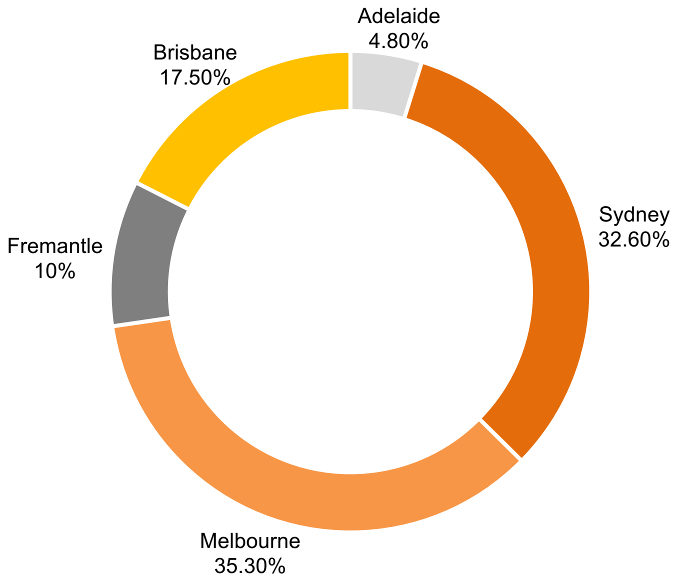
Port of Melbourne is currently the largest primary international container port in Australia, representing over 35% of the nation's task.

Figure 5 Australian Primary International Container Terminals (Black Quay, 2022)

* 2020/21 Figures as per ACCC data

The approximate market shares of the nation's top ports are illustrated in Figure 6. Melbourne's share has increased slightly since 2019.

Figure 6 Australian Container Port Market Share 2020/21 (ACCC, 2020/21)



2.3 The Container Terminal Regime

Container terminals are highly specific operational regimes, governed by dedicated infrastructure elements, which operating collectively, represent the system.

There is a common misconception that elements within the system are the cause of either high performance or poor performance. Whilst an element might prove to be the weakest or strongest link, it is the performance of the entire system that is affected. In other words, the performance of each element within a container terminal system is only as good as all others that make up the system.

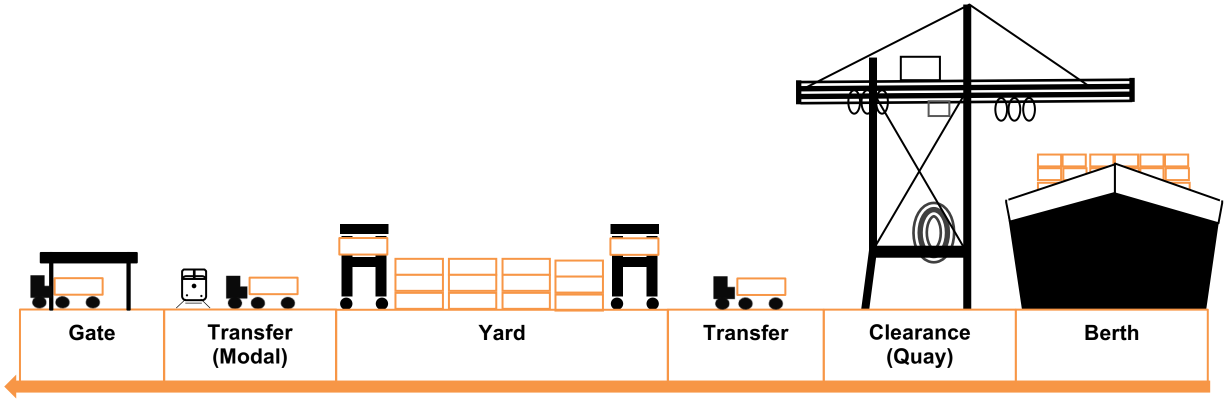
The regimes adopted in different terminals around the world differ significantly depending on the port type, port task and the subsequent infrastructure regime employed. Infrastructure and operational regime trends in the world's major transhipment ports for instance are significantly different from primary spoke ports such as those in Australia.

This is largely because of the volumes involved at transhipment ports, and more importantly, due to the operational requirement for transfer of low dwell time containers from one ship to another. In contrast, the spoke ports can experience higher and more variable dwell times due to the pick-up or drop-off periods generated by the wider supply chain.

However, the basic system of throughput can be generalized in order to understand the general objective of a terminal.

The following figure illustrates the basic container terminal module based around imports. An export regime generally mirrors this in basic terms.

Figure 7 Basic Container Terminal Module: Import Focused (Black Quay Consulting, 2015)



2.4 Port of Melbourne Overview

Port of Melbourne is currently the largest container port in Australia by throughput, handling approximately 8,000 TEU per day and around 3million TEU per year.

Container trade at the port is predominately international import and export related to and from Victoria, but it also handles Trans-Tasman trade along with some interstate trade (Southern New South Wales and South Australia).

The Port is home to three (3) international container terminals, with two located within the Swanson Dock Precinct, and the third at Webb Dock. These are the terminals assessed and modelled as part of this study and are described below.

2.4.1 Swanson Dock East[2]

Swanson Dock East (SDE) is operated by Patrick Terminals and is the largest container terminal by yard area in the Port (approximately 40ha). The terminal operates using a manual straddle regime and will have direct rail access (upon completion of the port rail transformation project).

It includes 884m of Berthline within the quay serviced by seven (7) STS gantry cranes and an alongside depth of 14.6m, facilitating a maximum draught of 14.0m[3]. It is operated as a three (3) berth facility and can reportedly accommodate vessels up to 10,000 TEU in size.

Total throughput in FY21 was 981,000 TEU.

2.4.2 Swanson Dock West (DPW)[2]

The Swanson Dock West (SDW) terminal is operated by DP World Australia (DPWA) with a terminal area of approximately 37ha (excluding West Swanson Intermodal Terminal (WSIT)), also using manual straddles. It is located opposite SDE within the Swanson Dock Precinct and has direct rail access.

With Coode Road West now closed, DPWA utilise this area for the West Swanson Intermodal terminal. It is understood that where required, DPWA use this area to the terminal's north for storing empty containers to alleviate pressure on the yard.

The terminal includes 944m of berthline[4], operating as a three (3) berth terminal, with an alongside depth of 14.6m (facilitating a maximum draught of 14.0m)[3] serviced by seven (7) STS gantry cranes. The terminal can reportedly accommodate vessels up to 10,000 TEU in size.

The terminal had a FY21 throughput of 1,048,000 TEU.

[2] Terminal information sourced from PoM-supplied information and terminal operator websites.
[3] From current Harbour Master Directions, December 2021

[4] PoM-supplied material indicates that the first 35m of SDW is impacted because of swing basin manoeuvring restrictions.

2.4.3 Webb Dock East (VICTL) [2]

The Webb Dock East (WDE) terminal is located in the Webb Dock Precinct and was developed as the Port's third container terminal. It includes 35.4ha of total terminal area (partially undeveloped) and is operated as an automated terminal, including an ASC and ACC yard regime.

It includes 660m of berth with an alongside depth of 14.6m[3], which can reportedly accommodate vessels up to 347m LOA (indicatively 12,000 TEU in size) and 14.0m draft. This is expected to be increased as part of future Webb Dock works to allow access to vessels up to 14,000TEU (at 14.0m draft). It currently operates as a two-berth terminal utilising five (5) STS gantry cranes.

The terminal had a FY21 throughput of 898,000 TEU.

2.5 Planned Melbourne Terminal Developments

The capacity modelling is based on the existing terminals only and does not consider wider container capacity projects.

However, it is understood that PoM is currently undertaking, or intending to undertake, the following capacity improvement initiatives to the existing terminals and these have been included within the capacity modelling, where relevant.

Figure 8 Container Related Development Strategy Projects

Terminal	Scope	Indicative Delivery Timing*
SDE and SDW Berth Upgrades	– Berth and Crane Beam Remediation to support larger cranes – Bollard upgrade for larger vessels – Trials for larger vessels, vessel simulations and berth aid installation to optimise navigation	Approx. 2025-2027[5]
Port Rail Transformation Project	– Improvement of rail access at Swanson Dock through the development of a new East Swanson Rail Terminal and delivery of upgraded rail access, connections, and sidings within the Port. – Closure of Coode Rd East which is expected to be complete within 18 months.	FY21-FY23
WDE Extension/Upgrade	– Extension of WDE Berth 4 by around 71m to the north (with removal of Berth 3 knuckle area) to provide WDE with around 731m of serviceable container berth length. This will be supported by a mooring dolphin to the south, which is understood will provide a serviceable berth length of 746m thus enabling the operation of two large container vessels concurrently. – Increased terminal area for VICT of approximately 2%. This is expected to allow an increase of 5 ASC yard blocks when required with 3 of these blocks assumed to be online in 2023.	FY22-FY23

[5] Modelling assumes delivery in 2025

Chapter II: Key Modelling Considerations (Model Inputs)

Port of Melbourne - Container Capacity Review

3 General Terminal Planning Criteria

3.1 Container Trade Forecasts

Port of Melbourne container trade forecasts to 2050 were provided by Port of Melbourne, dated November 2022. The forecasts were broken down across full, empty, import, export and transhipment volumes, including both international and Bass Strait trade. Bass Strait trade was excluded.

An upper, lower and baseline forecast was included within the provided forecasts. The baseline trade forecasts were utilised for Black Quay's modelling.

The trade forecasts do not provide expectations of the anticipated rail proportion over time. Port of Melbourne has clarified that it should be assumed that the road gate can cater for full volumes.

Trade forecasts also do not provide itemisation of dry versus reefer containers. Port of Melbourne has clarified that, for Swanson Dock, differentiation between these categories is not required as the Swanson Dock operators will take short and long-term measures when they exceed their fixed reefer capacity. For Webb Dock, no differentiation has been made, however can be incorporated into the model where this information is provided.

3.2 Container Fleet Forecasts

Fleet forecasts to 2050 were obtained from the Port of Melbourne.

For the capacity analysis, the fleet forecasting information was required to understand how the berthline at each of the terminals would operate over time under the changing forecast fleet.

As an example, in the current year, a particular berthline may equate to three (3) full berths for the current fleet. However, with the expectation of a changing fleet in the future, this berthline may act more like a 2-berth facility for a certain proportion of the time.

Whilst actual vessel visitation in the future may vary from the forecasts provided, it is assumed that visitation will still reflect the fleet profile provided in the Port of Melbourne forecasts.

The forecasts provide information on each anticipated service to each dock (Swanson Dock and Webb Dock) over time to 2050. Dimensions assumed for each vessel size have been taken from the fleet forecasts and summarised in the following table.

It was assumed that the anticipated fleet calling at Swanson Dock is divided equally between SDE and SDW.

Figure 9 Assumed Vessel Dimensions by Size (PoM Provided Fleet Forecasts, 2022)

Reference Vessel Size Class Dimensions	PoM Dock	Dimensions - LOA x Beam (m)	Vessel Name (& Operator)	TEU	Year of Build
<1,000 TEU	SD&WD	L 158 x B 22	Kokopo Chief (Swire)	981	1991
1,000-1,999 TEU	SD&WD	L 176 x B 27	Hansa Freyburg (ANL)	1,740	2003
2,000-2,999 TEU	SD&WD	L 225 x B 30 / L 217 x B 32	Porto (Zim)	2,790	2010
3,000-3,999 TEU	SD&WD	L 254 x B 32	Spirit of Singapore (HSud)	3,630	2007
4,000-4,999 TEU	SD&WD	L 294 x B 32 / L 255 x B 37	Hyundai Integral (HMM)	4,728	2008
5,000-5,999 TEU	SD&WD	L 277-281 x B 40	CMA CGM Chopin (CMA)	5,782	2004
6,000-6,999 TEU	SD&WD	L 304-306 x B 40	Al Rawdah (HL)	6,921	2008
7,000-7,999 TEU	SD&WD	L 300-323 x B 43	Santa Catarina (Maersk)	7,154	2011
8,000-8,999 TEU	SD&WD	L 335 x B 43 / L 300 x B 48	OOCL Miami (OOCL)	8,888	2013
9,000-9,999 TEU	SD&WD	L 328-337 x B 45-46 / L 300 x B 48	MSC Susanna (MSC)	9,178	2005
10,000-10,999 TEU	SD&WD	L 300 x B 48	CMA CGM Ural (CMA CGM)	10,622	2015
11,000-11,999 TEU	WD	L 330-334 x B 48	Ever Fame	11,888	2021
12,000-12,999 TEU	WD	L 366 x B 48	Rome Express (Hapag-Lloyd)	12,552	2010
13,000-13,999 TEU	WD	L 366 x B 51	ONE Manchester (ONE)	13,870	2015
14,000-14,999 TEU	WD	L 366-369 x B 51	COSCO Shipping Denali	14,500	2018

3.3 TEU to Box Ratio

The TEU to box ratio factor is the ratio of TEU to actual containers handled.

BITRE Waterline 68 highlights a TEU to box ratio of approximately 1.60 across the PoM container terminals (January to June 2021). Waterline 68 highlights that whilst the TEU factor has grown since 2019, it has remained relatively constant at 1.60 over the last 3 reporting quarters (Dec 2020, Mar 2021 and June 2021).

In the absence of any forecast changes to the TEU ratio contained within the trade forecasts, Black Quay has adopted two scenarios for the capacity modelling with consideration of the BITRE data and stakeholder feedback:

1. A constant ratio of 1.60 is adopted across the forecast period
2. An assumed increase of the TEU factor to 1.70 by 2030 (and remaining at 1.70 beyond this time)

With reference to the capacity formula included within Section 8, it is noted that the TEU factor holds a proportional relationship.

3.4 Considered Terminal Operating Times

Regarding terminal operating times, the following has been assumed for the model:

- Terminal operating hours has been taken as 24 hours per day.
- Terminal operating days have been taken as 362.7 days/year. This allows for standard closures from 14:00 Christmas Eve to 06:00 Boxing Day, and 14:00 New Year's Eve to 06:00 New Year's Day.

It is noted that the terminal operating hours above do not allow for unplanned stoppages including extreme weather and industrial action. However, an additional factor has been added to calculated capacities (refer to Section 3.5) for unforeseen events and peaking.

3.5 Optimum versus Maximum Annual Capacity

When conducting container terminal analysis, it is considered prudent for the calculated capacities to consider fluctuations in trade over time.

The reasons for this are reasonably straightforward. If ultimate (or maximum) capacities are considered for planning purposes, this could present significant risks to terminal productivity in the first instance, as well as potential safety risks.

To explain this further, when a terminal is working at maximum capacity, even minor deviations from perfect operating conditions result in a declining chain-effect. The entire terminal system is worked so hard that it can have the opposite effect, where inefficiencies develop, and in turn, a reduction in capacity and productivity is experienced.

Accordingly, the analysis described throughout the report allows for a factor of 15% applied to the maximum annual capacity to determine the optimum annual capacity. This factor is consistent with modern port planning principles and considers two elements:

> Allowance for fluctuations such as terminal shutdowns (e.g. industrial relations related, severe weather disruption) and major shipping events.

> Allowance for expected fluctuations across the course of the year, such as seasonal peaking.

In confirming this factor in the PoM context, Black Quay reviewed historic information provided by PoM in relation to industrial action, bad weather and peaking.

The information in relation to industrial action is presented in the following figure and demonstrates an average of 1% but up to 3% terminal closure time over the last 5 years.

Figure 10 Historic PoM Industrial Action Related Closure (Port of Melbourne)

	Patrick	DPW	VICT
FY18	16	19	294
FY19	6	8	0
FY20	4	248	0
FY21	88	199	44
FY22	150	0	0
Average Hours per Annum	52.8	94.8	67.6
% of total hours	1%	1%	1%
Maximum Hours per Annum	150	248	294
% of total hours	2%	3%	3%

Historic closures in relation to bad weather are presented in the following figure. This demonstrates an average weather-related shutdown of over 1% at Swanson Dock terminals and up to 3.5%. This appears consistent with feedback provided by Patrick who indicated 2% per annum.

Figure 11 Historic PoM Weather-Related Closures (Port of Melbourne)

	Patrick	DPW	VICT
FY18 hours	153	N/A	N/A
FY19 hours	123	240	N/A
FY20 hours	98	309	N/A
FY21 hours	N/A	144	N/A
FY22 hours	N/A	47	N/A
Average Hours per Annum	74.8	148	N/A
% of total hours*	1%	2%	N/A
Maximum Hours per Annum	153	309	N/A
% of total hours*	2%	4%	N/A

In terms of seasonal peaking, figures of up to 27% were experienced in recent history[6], which is expected to be due to pandemic-related disruptions.

Therefore, pre-pandemic data in 2019 was reviewed (refer to the following figure) which demonstrates that seasonal peaking appeared to typically be between 10-14% (varying by Operator).

Figure 12 Historic PoM Peaking - 2019 (Port of Melbourne)

Berth Moves	VICT	Patrick	DPW	All
Month 1	24,944	60,219	67,425	152,922
Month 2	20,904	53,125	62,366	136,473
Month 3	24,320	59,886	45,273	129,680
Month 4	26,239	57,873	55,454	139,841
Month 5	24,243	57,060	61,762	143,230
Month 6	23,808	53,618	55,720	133,204
Month 7	26,598	57,613	56,201	140,464
Month 8	21,378	52,836	58,824	133,142
Month 9	28,428	55,342	65,525	146,321
Month 10	27,935	59,102	67,871	155,235
Month 11	36,371	49,600	61,361	147,617
Month 12	34,356	41,872	63,120	139,447
Sum	319,524	658,146	720,902	1,697,576
Peak	36,371	60,219	67,871	155,235
Peaking Factor	1.37	1.10	1.13	1.10
Peaking Factor for VICT (months 1-10)[1]	1.14			

Note: 1. Given that VICT's volumes for the last 2 months of the year were substantially higher than previous months, peaking was also calculated without these months which appears to be closer to Port of Melbourne's overall value and in line with values from other Stevedores.

On the basis of the above noted industrial action (average 1%), weather incidents (average 1-2%) and peaking information

[6] Figure provided by DPW during stakeholder feedback process

(average 10-14%), a factor of 15% appears reasonable in the PoM context.

Taking this into account, the optimum annual capacity is calculated as equal to:

$$\frac{\textit{Maximum Capacity}}{(1+15\%\ \textit{factor})}$$

The following should be noted in relation to this factor:

- The magnitude of the factor is not an exact science and reflects a balance of managing risk versus over-investment. For example, a greater factor could be adopted which assumes the occurrence of maximum seasonal peaks, industrial relations related events and major shipping events all at once. However, the likelihood of this occurring is considered low and the investment required to cater for this contingency would likely be unacceptable by terminal operators as it would lead to underutilisation of assets and high cost exposure.
- This factor is relevant to both berth and yard operations. With respect to berth operations, it should not be confused with the berth utilisation factor (discussed in Section 4.10). The berth utilisation factor arises from the reliability of vessel schedule/variability in arrival times and the need to manage queueing outside of the berth to acceptable levels. In contrast, the 15% factor allows for variability due to a range of events such as weather, industrial action and shipping seasonality and the constraints/limitations these place on the berth infrastructure (STS cranes in particular).
- Whilst there may be points in time that a terminal can achieve a throughput above its optimum capacity (and closer to its maximum capacity), this is not considered to be a sustainable level of operation. In instances where optimum capacity is exceeded, it would be expected that productivity, efficiency, reliability and safety may all be negatively impacted.

4 Berth Capacity Criteria

4.1 General Accessibility

The fleet forecasts make assumptions on fleet distribution across the terminals to 2050. It is understood that key principles and constraints behind the future fleet distribution are as follows:

> Air draft for SDE and SDW is restricted due to the Westgate Bridge. These restrictions are 50.7m as per the current Harbourmaster's Directions (edition 12.1), with any air drafts 50.1-50.7m requiring Harbourmaster clearance. PoM has advised of a general maximum vessel size restriction to 10,000 TEU at Swanson Dock. Whilst air draft does vary across vessels and depends on the laden conditions of the vessel, this has been considered as a general guide.

> The Port Phillip Heads restrict the max vessel size to 14,000TEU.

> Draft restrictions exist which may also be a constraining factor for larger vessels. Draft restrictions are a maximum of 14m at WDE and as per the Harbourmaster's restrictions at SDE and SDW. The 14m draft restriction may limit WDE to vessels in the 10,000 – 12,500 TEU range, depending on their laden conditions.

It is understood that the fleet forecasts assume certain infrastructure investments to accommodate larger vessels at WDE and multiple large vessels at Swanson Dock, beyond current capacity.

The fleet forecasts and associated assumptions on vessel accommodation across the terminals have largely been adopted in the modelling. Comment has been made on this within Chapter III.

4.2 Container Terminal Berth Dimensions

SDE and SDW each have four (4) notional berths on a continuous berth line. In practice, however, it is understood that these terminals typically operate as three (3) berth terminals given the size of the visiting vessels. WDE operates as a two-berth terminal, again on a continuous berth line.

A summary of the current berth lengths at each terminal is provided below.

Figure 13 Port of Melbourne Container Berth Lengths

Terminal	Quay Length (m)	Nominal Berths	Length per Berth (m)
Swanson Dock East	884m	3	294.7m
Swanson Dock West	944m	3	303m[7]
Webb Dock East	660m	2	330m

[7] It is understood from PoM-suppled material that 35m at the southern end is impacted due swing basin movements, therefore 909m of berthline has been utilised in this calculation

In addition to the berth lengths outlined above, restrictions are placed upon the SDW and SDE operators due to the width at Swanson Dock and the constraints that this poses to vessels passing between two larger vessels berthed on opposite sides of the dock.

Noting that the lateral distance between fenders of East Swanson and West Swanson is 210m, the current Harbourmaster directions (VicPorts, 2021) state that “If the total available lateral distance between the 2 ships moored at the berth is less than 3 times the beam of the passing ship and provided there is a minimum of 40 m distance available on either side of the passing ship”, additional conditions will apply subject to the approval by the Harbourmaster. These conditions include headline towage, maximum wind speeds and limitations on vessels berthed south of the 20m chainage mark on SDE.

In addition to the above requirement, the Harbourmaster’s directions state that “When a vessel with an LOA of 290 m or greater is to berth at Swanson Dock, the southernmost 50 m of the berth at Swanson Dock 1 West should be unoccupied”. A risk assessment and decision process should be applied if this is not the case.

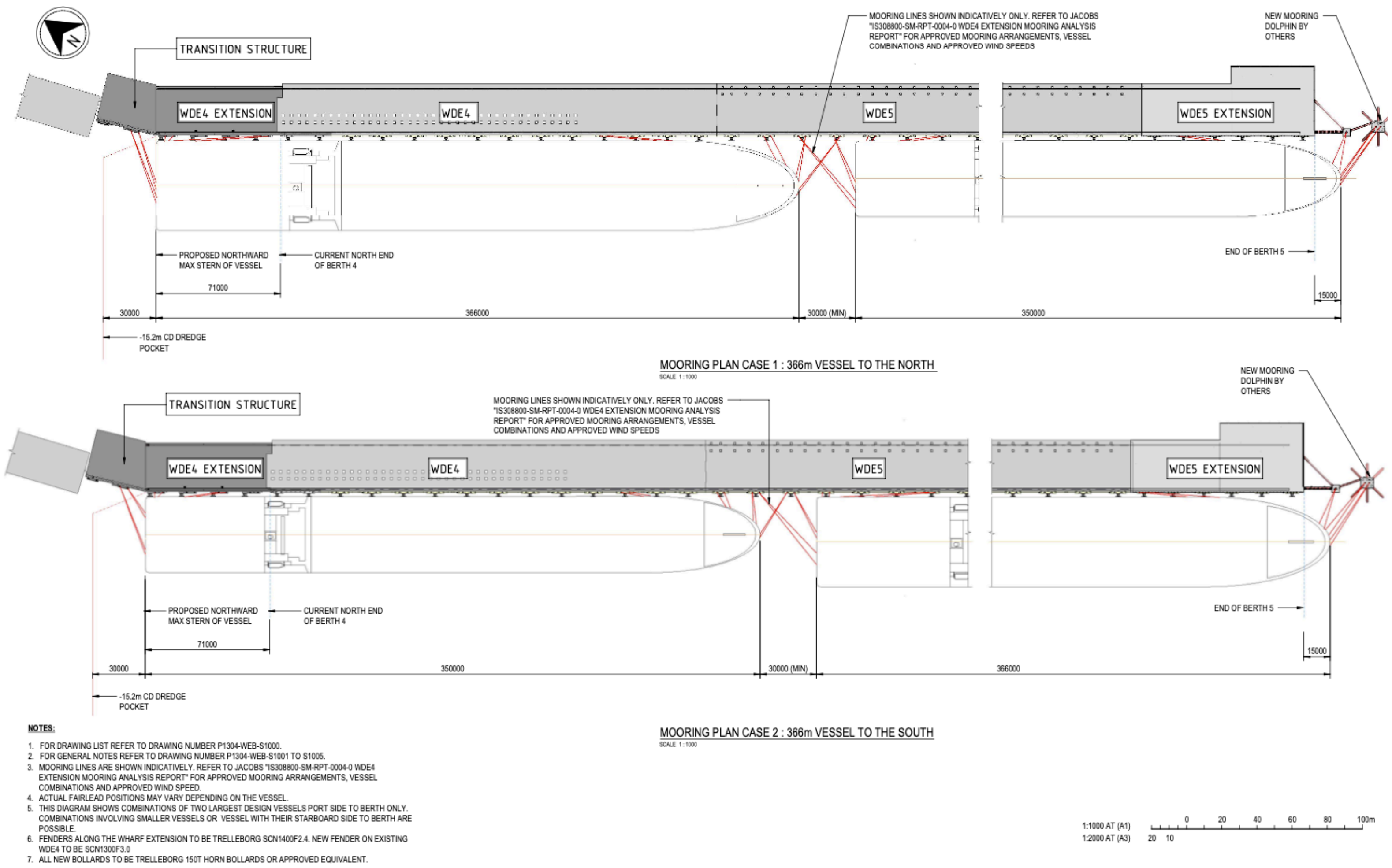
Other restrictions at Swanson Dock contained within the Harbourmaster’s directions are as follows:

- Vessels with a beam greater than 32.5 m are not permitted to berth at 1 West Swanson
- Vessels with a beam greater than 42.9 m are not permitted to berth at 1 East Swanson
- Vessels with a beam greater than 45.6 m must berth at 3 East / West Swanson
- East Swanson southernmost 200 m is to be unoccupied for Arrival and Departure of vessels over 310m LOA and/or 42.9m beam with crane booms up
- West Swanson southernmost 50 m (for arriving vessels with LOA 310- 325 m) or southernmost 200 m (for arriving vessels with LOA equal to or greater than 325 m) is to be unoccupied for arrival and departure with crane booms up

The numerous restrictions at Swanson Dock require careful management, planning and scheduling between Swanson Dock operators and the VicPorts Harbour Master/Port Control Centre. The capacity analysis assumes that this co-operation, management and scheduling will continue between all parties to maximise the use of Swanson Dock and manage inefficiencies.

At Webb Dock, the following figure outlines the useable berth area post-knuckle removal, with vessels at WDE able to operate right up to the end of the berth.

Figure 14 WDE Mooring Plan (post-knuckle removal) (Source: Jacobs)



4.3 Consideration of Temporary Works

PoM has noted that DPWA will be undergoing extensive berth remediation in the coming years which will temporarily reduce their berth availability for this period.

The capacity modelling will depict the intended design capacity across this period.

4.4 Calculation of Effective Berths

The calculation of the number of effective berths for each terminal factors the nominal berth numbers with consideration to the forecast fleet (over time).

Whilst this can be most effectively modelled within a dynamic analysis, in a static analysis, guidance provided by UNCTAD (UNCTAD Ad Hoc Expert Meeting on Assessing Port Performance Room, “The Capacity in Container Port Terminals”) has been adopted.

This guidance calculates the number of effective berths ‘n’ as follows:

$$n = \frac{Total\ berthline}{Average\ vessel\ length\ x\ \left(100\% + separation\ distance^{8}\right)}$$

[8] Refer to Mooring Gap Assumptions in Section 4.6

[9] Historic information contained within BITRE Waterline 68 and the Productivity Commission Draft Report, suggest average cranes per vessel varied between 2.3-2.6 across 2019-2020. In Q1 2021, average cranes/vessel dropped to 2.1. The assumed Black Quay crane allocation results in an average of 2.5 cranes per vessel in 2022 (based on the forecast fleet) and is therefore deemed appropriate.

4.5 Ship-to-Shore Crane Considerations

It is understood that a total of 19 Ship-to-Shore (STS) cranes currently exist across the terminals, with 7 operational cranes at each of SDE and SDW and 5 at Webb Dock East.

The following has been assumed with regards to STS cranes:

- Cranes will be replaced by operators at the end of their useful life and/or where they are unsuitable to serve the evolving fleet (e.g. reach); whichever comes first
- Cranes are flexible to work across each respective berthline.
- For the purposes of calculating indicative time at berth (to inform effective berths), it is assumed that an average of two (2) cranes can work on vessels up to 5,000 TEU, three (3) cranes on vessels between 5,000-9,000 TEU, and four (4) cranes on vessels over 9,000 TEU[9]. The actual number of cranes on vessels will vary on a variety of factors including crane availability and stowage plans.

It is noted that the actual number of cranes and deployment of cranes is a commercial decision undertaken by the stevedores, and it is assumed that cranes will be deployed by them as required by changing trade levels.

That said, in the capacity modelling, Black Quay has assumed that there is a maximum number of cranes that can be deployed on any one berthline. This is dictated by the following assumptions:

- The absolute minimum achievable crane spacing on any berthline over time is 90m
- There is a maximum practical STS crane productivity for each crane annually. This is described in further detail in Section 4.9.

In consideration of the above, the berthlines outlined in Section 4.2, and the WDE extension works, the maximum number of cranes assumed at each terminal are as follows:

- Swanson Dock East – 9 STS cranes maximum
- Swanson Dock West – 10 STS cranes maximum
- Webb Dock East – 8 STS cranes maximum

4.6 Mooring Gap Assumptions

Based upon the Harbourmaster's directions and clarifications provided by PoM, the minimum clearances between berthed vessels have been assumed as follows:

- Swanson Dock East and Swanson Dock West: 22 m
- Webb Dock East (berths 4 and 5): 30 m

It is understood that the northern offset limit at the head of Swanson Dock from the end of the berth to vessel stern should also be considered as 22m.

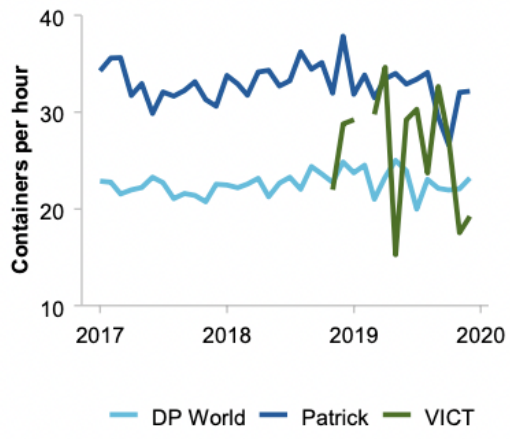
4.7 Gross Crane Rate

Gross Crane Rate is defined as the total productivity container lifts by the STS cranes from the start of the first lift to the end of the last lift, including breaks and downtimes. This factor has been utilised within the model in conjunction with crane allocation to calculate the time at berth for each vessel anticipated under the fleet forecasts.

Historic crane productivities for the Port of Melbourne by terminal is contained within the Australian Government Productivity Commission *2022, Lifting productivity at Australia's container ports: between water, wharf and warehouse, Inquiry Draft Report, Canberra, September 2022 (herein referred to as "Productivity Commission Draft Report")*.

Terminal quayside productivity by operator across 2017-2019 is presented in the figure below.

Figure 15 Quayside Productivity Melbourne (Source: Productivity Commission Draft Report, 2022)



Over the period 2017-2019 the average monthly gross crane rate by terminal operator was 26.1gmph (VICT), 22.6gmph (DPW Melbourne) and 32.9gmph (Patrick Melbourne). Patricks' cranes ranged between 27gmph and 38gmph and averaged 10 more moves in an hour than cranes at DP World's terminal, noting that these terminals have similar levels of automation.

The Productivity Commission Draft Report notes that "reasons for these variations in performance are not clear, but restrictive work practices that make it less likely that each job in a container terminal is filled by the most appropriate person, are a clear candidate".

Further in the Productivity Commission Draft Report, both DPW and Qube (shareholder of Patrick) note the difficulties in increasing productivity:

- DP World submitted that "flaws in DP World's industrial framework impose the most urgent and significant drag on competition and productivity within Australian ports".
- QUBE observed that "The strong bargaining position of the Union and its ability to cause significant damage to customers in particular makes the achievement of improved productivity and efficiency extremely difficult".

In considering to the above, and feedback provided by PoM Stevedores within their own modelling (provided post-submission of the draft capacity report), the following gross crane rates have been adopted within Black Quay's model:

> Scenario 1 –27gmph average across all three (3) terminals[10].

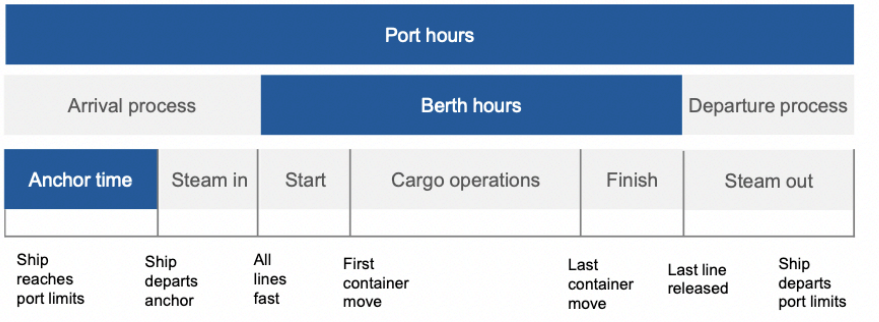
> Scenario 2 – SDW increases average productivity to 30gmph, WDE productivity remains at 26gmph and SDE productivity is at 30gmph which is consistent with crane productivity assumptions in provided modelling summaries undertaken by Terminal Operators.

[10] This considers recent BITRE data with the maximum crane rate over recent years around 31nmph and assuming a crane working time from time of first lift to completion of last lift of approximately 87.5% (31*87.5% = 27gmph).

4.8 Vessel Productive Time

The vessel productive time factor considers the average time that a vessel is worked, as a percentage of its total time at berth. With reference to the figure below, it is equivalent to Cargo Operations divided by the Berth hours.

Figure 16 Vessel Productive Time (Source: Productivity Commission Draft Report, 2022)



An assumption of three (3) hours per vessel has been made for start & finish processes (as per the figure above), with the remaining time at berth (depicted as 'Cargo Operations' in the figure) calculated based on container exchange size (which have been provided within the fleet forecasts), crane deployment and productivity assumptions outlined in Sections 4.5 and 4.7.

This assumption of 3 hours for start & finish processes appears reasonable when reviewing the Productivity Commission Draft Report which provides actuals for 2019 for Melbourne of 1.3 hours (Start) and 1.8hours (Finish), amounting to a total of 3.1 hours.

4.9 Maximum Practical STS Crane Productivity

The maximum practical STS crane productivity per annum recognises the limitations of STS cranes. It is based on consideration of crane productivity rates (refer Section 4.7), TEU factor, achievable crane utilisation and available berth time. Any change in these factors can significantly impact the achievable crane productivity.

It is important to recognise the relationship between the number of cranes on the berthline and maximum crane productivity. In instances where fewer cranes are on the berthline, it is not uncommon for cranes to be utilised (or 'worked') harder and across berths. However, where terminals are operating closer to their capacities, operators typically forego higher crane utilisations by providing more cranes in order to improve vessel turnaround times.

Therefore, whilst it is noted that the existing PoM terminals have historically achieved figures above those presented in the following figure at times, into the future it is anticipated that additional cranes will be required at the terminals due to increasing vessel sizes (up to a maximum number of cranes dictated by the berthline length and minimum crane spacing). Where additional cranes are introduced, it is expected that individual cranes will not be worked as hard and annual productivities would fall within the levels depicted in the figure.

In establishing reasonable crane productivity thresholds for the analysis, Black Quay has tested the impact of changing factors such as TEU factor and crane rates within the context of the discussions contained within other parts of this section. This is also depicted in the following figure.

With respect to the crane utilisation, the figures tested (37-40%) were deemed reasonable when considering maximum crane numbers on the berthline[11]. This will however be dependent on ultimate fleet profiles and crane deployment patterns.

Figure 17 Maximum STS Crane Productivity Levels Based on Differing Input Scenarios

	Scenario A Current Crane & TEU Factor	Scenario B1 Increased TEU Ratio	Scenario B2 Increased Crane Rate	Scenario B3 Increased Berth Utilisation	Scenario C Increased TEU Ratio & Crane Rate & Berth Utilisation
Days	362.7	362.7	362.7	362.7	362.7
Hours	24	24	24	24	24
Total Operating Hours/Year	8,705	8,705	8,705	8,705	8,705
TEU Factor	1.60	1.70	1.60	1.60	1.70
Crane Rate (gmph)	27	27	30	27	30
Crane Utilisation (%)	37%	37%	37%	37%	37%
Crane Productivity at Maximum Crane Numbers (TEU/annum/Crane)	139,782	148,518	154,597	139,782	164,260

Note: The table shows tested maximum annual crane productivities at 37% crane utilisation. Therefore, a change in berth utilisation (Scenario B3) does not alter the results.

[11] Crane utilisation figures vary dramatically between terminals and depend on total berth numbers (therefore achievable berth utilisation), fleet size, crane deployment patterns for varying vessel sizes, the total number of cranes on the berthline and the crane density. It is therefore challenging to establish realistic crane utilisation targets through benchmarking alone as no two terminals are the same. Actual utilisation figures for PoM terminal cranes are anticipated to change markedly when operating with full STS crane deployment and under a future fleet profile. In establishing a realistic crane utilisation figure, Black Quay considered (a) research sponsored by the USACE Institute for Water Resources & Cargo Handling Cooperative Program in 2012 which contained utilisation rates of 18 U.S Mainland Ports of varying sizes (*Container Port Capacity and Utilisation Metrics*, The Tioga Group, 2012), as well as (b) a review of forecast 2050 operating parameters at the PoM terminals.

4.10 Berth Utilisation Factor Review

A key factor in any assessment of throughput capacity over a quay line (regardless of product handled) is the realistic berth occupancy threshold (or 'berth utilisation') before vessel queuing becomes 'unacceptable' by the customer (shipping lines)[12].

Threshold berth occupancy rates are a function of the number of berths at a terminal, and perceived acceptable wait time to service time (WT:ST) thresholds. Put simply, the more berths present, the higher the berth utilisation can be before unacceptable queueing results.

Queueing theory helps quantify this function.

4.10.1 PIANC Guidance

PIANC[13] WG158 provides industry accepted guidance on the capacity evaluation of port terminals and is typically utilised by port industry professionals when calculating port capacity in a static manner.

PIANC WG158 acknowledges that the acceptable wait time to service time ratios vary between commodities[14] with a recommendation to base design occupancies on the following average WT:ST ratios (PIANC, 2014):

- Less than 0.3 for bulk terminals
- Less than 0.2 for general cargo operations
- Less than 0.1 for container terminal operations.

A number of queuing theories exist, which are either based on random arrivals or a pattern of distributed arrivals. PIANC WG158 provides for two (2) approaches:

- Random Arrivals (based on a M/E2/n pattern)
- Erlang 2 distributed arrivals (based on UNCTAD[15] E2/E2/n pattern).

The 'Erlang 2' distributed arrivals philosophy is typically deemed the most acceptable of these theories by port industry professionals for the assessment of container terminals. Whilst it may be marginally conservative for container terminals, it is generally considered the most appropriate for a static analysis.

[12] Where queueing becomes unacceptable by shipping line operators, calls may be lost to competing terminals within the port, or to a competing port. As an example of this, the ACCC Stevedoring Report 2020-21 highlighted that as a result of recent congestion in Sydney, 'some of the shipping lines have chosen to skip Sydney altogether rather than wait in queue'.

[13] PIANC is the World Association for Waterborne Transport Infrastructure. PIANC technical reports are developed by committees of leaders in the global waterborne transport community with expert guidance, recommendations, and technical advice.

[14] Tolerable wait time to service time ratios typically differ between commodities based upon the 'acceptance' of delays by shipping lines, which is a function of the type of service (liner or chartered), the cost of demurrage and the type of cargo. In general, liner ships (such as container vessels) work to a tight schedule and if no berth is available within a reasonable time of call, they may need to cancel the call or shift cargo to another port (where possible). In contrast, chartered ships are usually able to tolerate some degree of delay to berthing.

[15] From UNCTAD 'Port Development, A Handbook for Planners in Developing Countries', 1985

Based upon the guidance contained within PIANC WG158, and an average WT:ST ratio of 0.1 as outlined above, container terminal berth occupancies can be considered as follows:

Figure 18 Benchmark Berth Occupancy Levels (PIANC Erlang 2 Distributed arrivals)

	Number of Berths			
Terminal Type	**1 Berth**	**2 Berths**	**3 Berths**	**4 Berths**
Container Terminal	25%	47%	58%	65%

Source: PIANC Report No 158-2014 Table 6.2

Notes: 1. Values have been linearly interpolated and/or extrapolated where required from PIANC guidelines

4.10.2 Literature Review

As part of this engagement, Black Quay has been requested to review available literature and specific PoM data (where available) to determine if any alternate berth occupancy rates should be adopted in the context of the Port of Melbourne.

In order to conduct the review, Black Quay has reviewed the following:

> Whether a WT:ST time ratio of 0.10 (as proposed by PIANC WG158) is appropriate to be adopted or, alternatively, if a different ratio should be applied

> Regarding the WT:ST ratio confirmed in the previous point, what corresponding maximum berth utilisation level should be adopted.

Numerous scholarly papers exist in relation to queueing theories at ports, however very few of these provide definitive planning guidance on WT:ST ratios and appropriate corresponding berth utilisation levels.

However, three industry-recognised guidance documents were identified (over and above PIANC WG158) which provided quantitative guidance. These are as follows:

> *The Capacity in Container Port Terminals*, presentation by Valenciaport Foundation[16] at UNCTAD AD Hoc Expert Meeting on Assessing Port Performance, 2012 (and its supporting document *Sea Port Capacity Manual*, Monfort et al 2011)

> *Planning and Design of Ports and Marine Terminals*, Agerschou, 2004

> *Port Designer's Handbook*, Thoreson 2014 (Third Edition).

Thoreson states that the "ratio of the average waiting time or congestion time to the average berth service time (should be) not higher than 5–20%". This guidance does not, however, differentiate between terminal types.

[16] The Valenciaport Foundation for Research, Promotion and Commercial Studies of the Valencian region ('Valenciaport Foundation') was established to expand the reach of the logistics - ports community by serving as a research, training and cooperation centre of excellence. It has a board comprising of twenty trustees from 17 different organisations, including port authorities, shipping lines, terminal operators and university.

Agerschou provides more precise guidance of a wait time to service time of 0.1 for container terminals which references ‘experience from many economic feasibility studies’.

Whilst not in conflict with this recommendation, Monfort et al provides more context to this figure by relating the wait time to service time ratio (or ‘relative wait time’) to levels of service at a port.

It also acknowledges that the perceived level of service (that is, the measure of the quality perceived by customers) is not only based upon relative wait time, but also the productivity of the vessel loading/unloading once it is berthed.

This guidance is presented in the following figure.

Figure 19 Relationship between wait time and productivity to levels of service (UNCTAD 2012, excerpt from Monfort 2011)

LEVEL OF SERVICE	Relative waiting time	LEVELS OF SERVICE			
D	> 0,2	-	-	-	-
C	0,1 - 0,2	-	CC	BC	AC
B	0,05 - 0,1	-	CB	BB	AB
A	up to 0,05	-	CA	BA	AA
		< 35	35-50	50-65	> 65
		Annual average productivity of vessel at berth (P) (cont./h)			
		D	C	B	A
		LEVEL OF SERVICE			

With consideration to these documents, Black Quay has surmised the following in relation to WT:ST:

> BITRE Waterline information on actual POM historic ship rates suggests that average lifts per ship hour at berth generally falls within 'Service B' level for productivity under the Monfort guidance

> It is reasonable to assume that PoM terminal operators wish to maintain a level of service of at least 'B' in terms of relative wait time due to the competitive nature of the Port (between terminal operators). That is, where a terminal operator slips to 'Level C or D' service, they may risk losing a shipping line/call to another operator/terminal.

> Given this, it could be expected that a maximum relative wait time of 0.1 would be considered acceptable, in accordance with the guidance provided by Monfort 2011. This corresponds to an overall level of service of 'BB'.

> Guidance provided by PIANC WG158, Agerschou and Thoreson support the adoption of a WT:ST of 0.1 for container terminals.

In relation to berth occupancy, the guidance provided by each of the guidance documents for a WT:ST of 0.1 is provided in the following table.

Figure 20 Literature Review - Indicative Berth Occupancy Levels

	Number of Berths			
	1 Berth	**2 Berths**	**3 Berths**	**4 Berths**
PIANC WG158	25%	47%	58%	65%
Monfort et al	31%	53%	63%	70%
Agerschou	17%	40%	52%	60%
Thoreson[1]	45%	50%	55%	65%

Source: Thoreson, Agerschou, Monfort and PIANC

Notes:

1. Utilisation based upon 'high' control of ship arrival
2. It is expected that the high variance in recommendations for a one-berth terminal is in a large part due to the variance between control of ship arrival times at small facilities with single berths

4.10.3 Port of Melbourne Context

Little information has been provided on historic shipping arrival patterns, vessel wait times and berth utilisations at Port of Melbourne, particularly at a terminal level.

However, recent port-wide statistics contained within BITRE Waterline 67 enables some understanding of actual shipping delays and utilisations experienced at Port of Melbourne. This information is presented in the following table.

In viewing this data, it should be recognised that information contained within the Productivity Commission Draft Report, 2022 supports anecdotal information provided by stevedores that vessel schedule integrity (or proportion of on-schedule arrivals) has reduced dramatically since the start of the Covid-19 pandemic in 2020. The information contained within the Productivity Report suggests that this trend has not yet reverted back to pre-pandemic levels.

Therefore, the data presented in the figure is based on vessel arrivals with poorer vessel scheduling than has been experienced at the Port pre-pandemic. This point is revisited later in this section.

It should also be noted that the BITRE data on time at anchorage has been used as a proxy for wait time. Other measures taken by shipping lines due to congestion such as slow steaming, waiting outside of port limits and/or skipping a port due to congestion is not captured and therefore the calculated WT:ST may not capture all congestion issues. This results in a potential for underestimation of the WT:ST.

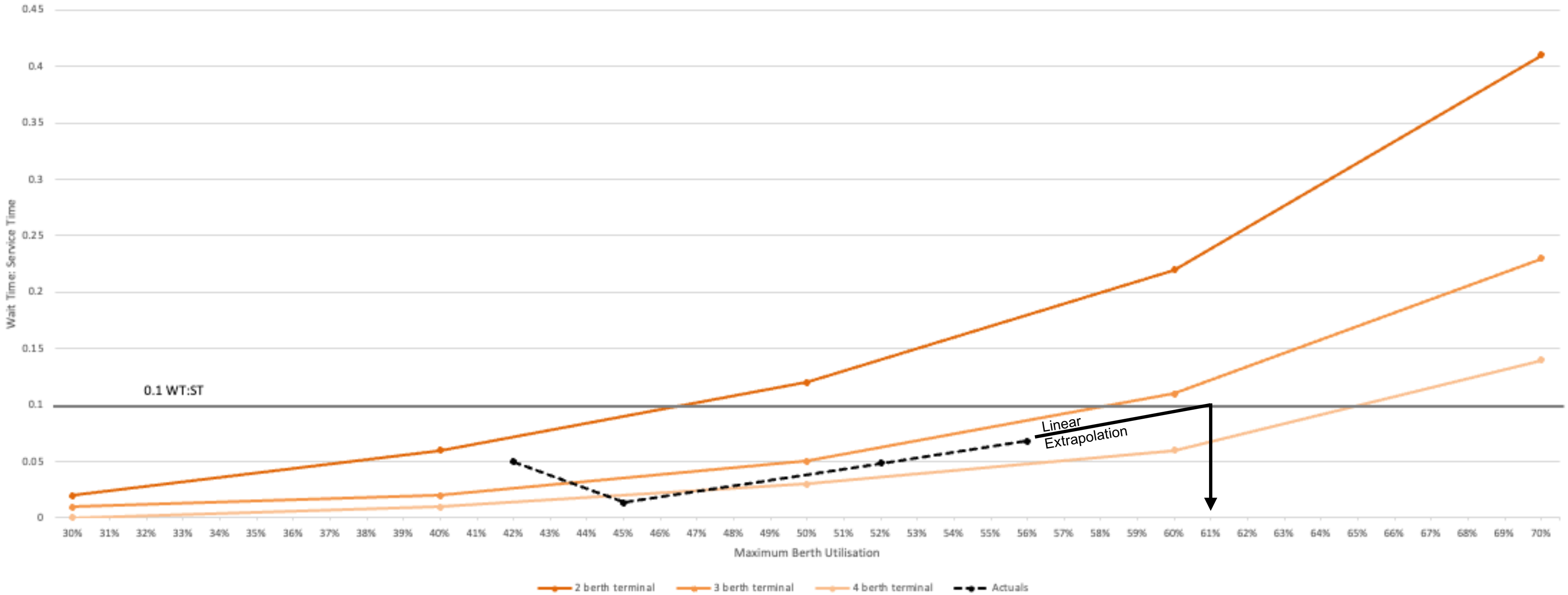
Figure 21 Recent Port of Melbourne Shipping Data (BITRE Waterline 67)

	2020			
	Mar Qtr	Jun Qtr	Sep Qtr	Dec Qtr
Percentage of ships waiting at anchorage for more than 2 hours (%)[1]	4.1	5.4	9.0	9.0
Median waiting time at anchorage (hours)[1]	14.4	37.3	26.1	36.3
Median of ship turnaround time (hours)[1]	42.4	40.5	48.8	48.0
Total time ships spent at berth (hours)[1]	7,780	7,396	9,027	9,723
Total number of Berths[2]	8	8	8	8
Total berth hours[2,3]	17,472	17,472	17,472	17,472
Median waiting time at anchorage (all vessels)[2]	0.6	2.0	2.4	3.3
Median wait time: service time[2]	0.014	0.050	0.048	0.068
Total berth utilisation[2]	45%	42%	52%	56%

Notes:
1. Information directly from BITRE Waterline 67
2.Information calculated from BITRE data
3.Assumes 91 days at 24 hours per day in a quarter

Black Quay has plotted this information against the PIANC WG158 information on ratio of queuing time to service time for varying berth numbers and berth occupancy in the following figure.

Figure 22 PIANC Ratio of Queue Time to Service time (Erlang Distribution) vs. Port of Melbourne actuals (Black Quay, 2022)



Whilst the terminals at Melbourne have between 2 and 3 berths, the graph above suggests that a berth utilisation profile for Port of Melbourne as a whole sits between PIANC recommendations for a 3-berth and a 4-berth terminal. This is to be expected given that PIANC note that their profile is slightly conservative for a container terminal.

In reviewing this, within the second half of 2020, various works on the Swanson Dock berthlines (both SDE and SDW) resulted in both acting as 2 berth terminals temporarily. In fact, reflecting on the information supplied by PoM, in the second half of 2020, SDE operated with an average of 2.1 effective berths, and SDW with an average of 2.8 effective berths.

Therefore, it could be expected that the achievable berth utilisation for a 3-berth terminal would be slightly higher than 61% as mapped, and lower than 61% for a 2-berth terminal.

4.10.4 Recommended Berth Utilisation Factor

The review demonstrates that whilst the PIANC WG158 guidelines are considered a sound general basis for port planning, actual 2020 figures from BITRE indicate that these are slightly conservative when forecasting the relationship between WT:ST and berth utilisation at Port of Melbourne. This is not unexpected given that PIANC acknowledge the Erlang 2 distributed arrivals profile is likely to be conservative for container terminals.

This must be balanced with an understanding that the BITRE data may underestimate congestion to some degree given time at anchorage has been used as a proxy for wait time, as previously mentioned in Section 4.10.3[17].

Given this and the alternative profiles presented in the literature review, it is suggested that the Monfort berth utilisation profile (for 0.1 WT:ST) is the most appropriate for this study. This is the less conservative of the profiles reviewed.

Therefore, the following berth utilisations have been adopted for the capacity analysis, assuming vessel schedule integrity remains at current levels.

Figure 23 Proposed Berth Occupancy Levels (for WT:ST = 0.1)

	Number of Berths			
	1 Berth	2 Berths	3 Berths	4 Berths
Monfort et al	31%	53%	63%	70%

Note: Where the number of effective berths falls between these figures, berth occupancy has been interpolated.

As previously outlined, a decrease in the reliability of vessel arrival times has been experienced in recent times due to the Covid19 pandemic. Whilst information contained within the Productivity Commission Draft Report suggests that there has not yet been an increase in vessel reliability post-2020, it is possible that this may occur as the lingering effects of the pandemic ease.

Therefore, scenario testing within the capacity analysis has also considered increased utilisation to 65% for a 3-berth terminal and

[17] Refer to Section 10 for proposed approach to accurately capture congestion and queueing going forward

60% for a 2-berth terminal which reflects a scenario where vessel reliability improves in the future or where a slight increase in WT:ST ratio (from the 0.1 assumed as per the review in Section 4.10.2) is considered acceptable by shipping lines.

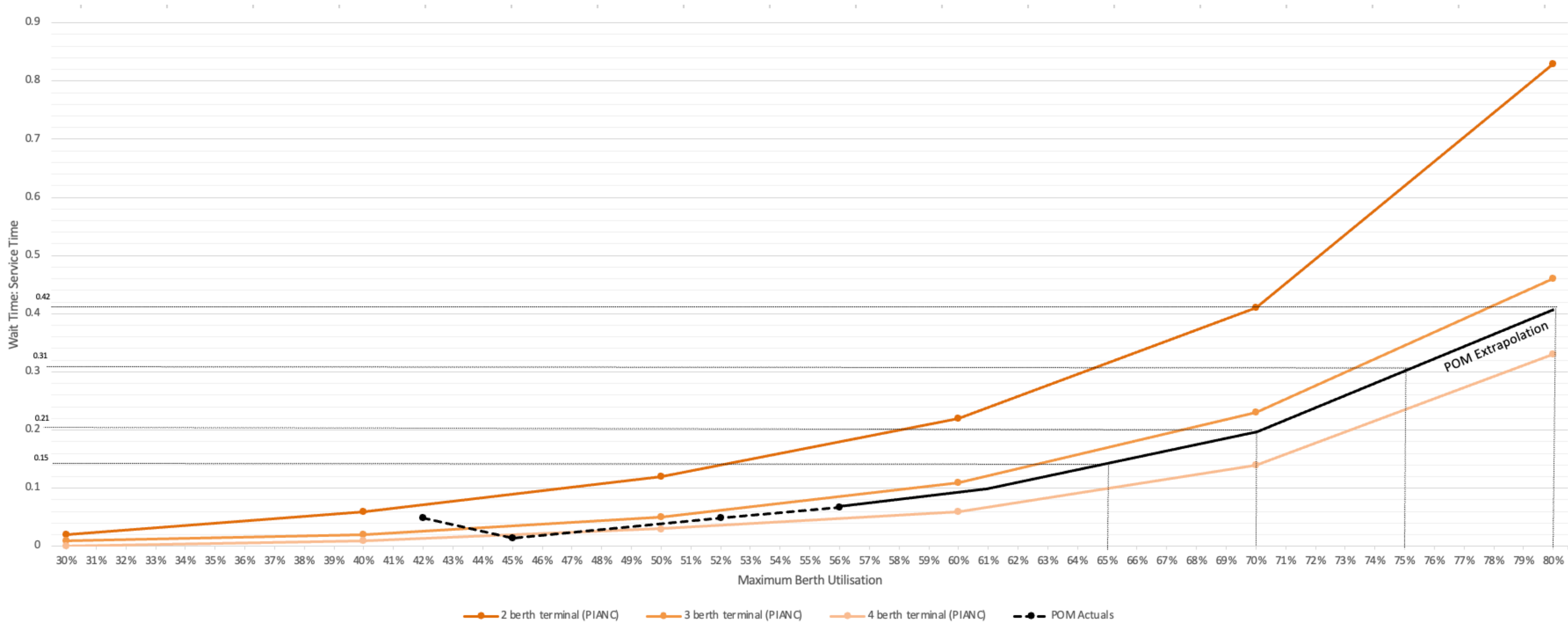
It is worth noting that the scenarios above assume that the terminal operators would wish to maintain a minimum service level of 'BB' as defined by Monfort in Figure 19. This level is consistent with maintaining a 0.1 WT:ST ratio (refer Section 4.10.2 for review of appropriateness of this factor) and reflects productivities at berth which would be considered the minimum requirement for the fleet size forecast to visit Port of Melbourne.

Individually, terminal operators may elect to pursue a higher berth utilisation level. However, this would likely be to the detriment of service level and result in customer dissatisfaction and potential loss of the service to another terminal and/or port (assuming a competitive environment). This is not dissimilar to what has been observed in Sydney recently (refer Footnote 12).

To further highlight this point and with extrapolation of the PoM-wide profile contained within Figure 22, it could be expected that the level of queueing at Melbourne could increase to 0.21WT:ST at 70% utilisation and 0.42 WT:ST at 80% utilisation.

This is depicted in the figure below.

Figure 24 Forecast Service impacts at Higher Berth Utilisations (Black Quay, 2022)



4.10.5 Wider Impacts Related to Berth Utilisation

In addition to providing a poor level of service to customers, high levels of berth utilisation and associated high wait times, can also cause the following issues within a terminal, including:

- Once vessel queueing increases to a certain level, it can be difficult to clear due to the ongoing nature of arrivals, and this becomes a compounding issue.
- Where high vessel queueing exists, this also impacts on yard congestion. In essence, the increased failure in calls meeting their scheduled timeslot (i.e. increased delay) has an impact on containers in the yard (particularly export), which greatly increases dwell time. This can also have a compounding effect in the yard. It should be noted that into the future, the requirements of IMO 2023 in relation to slow steaming may further exacerbate delays and decrease the ability for shipping lines to make up time.

Beyond the terminal, high berth utilisations can also impact the wider supply chain. In line with the above points on impacts within the port gates, impacts outside the gates are typically compounded from inner terminal congestions.

The weaknesses and vulnerabilities in the modern global supply chain have been exposed in recent times. The Covid-19 pandemic is typically blamed for the unsustainable congestion and cost impacts on the global system. However, rather than being the root cause of failures, the issues surrounding the global supply chain, including the Australian system, are systemic and a result of multiple factors, merely exacerbated by the Pandemic (albeit to a unique extent), including:

- Insufficient or poorly placed infrastructure investment across multiple nodes of the supply chain (varies widely by region and applies both inside and outside the port gate)
- Increasing just-in-time demand on ports and the wider system
- Increasing vessel sizes, altering service frequencies and relative times at berth
- Changing industrial demands and shifting global manufacturing and consumerism
- Inability of the system to absorb trade fluctuations and associated logistical changes

This has meant that the current system and its wide-ranging infrastructure (waterside and landside) had for the most part, already reached high utilization levels, even in better times. The Covid-19 pandemic then was simply a final match to an already overstretched and in many cases, unsuitable system, rather than a one-off hit.

Berth utilisation impacts on the wider supply chain can be summed up as a result of compounding congestion and reduced reliability. The effects though are more complex. They are highlighted below:

- Knock-on inner terminal capacity impacts on near-gate transport operations, including truck queuing. The impacts of this alone are highly complex when issues like lost time, fuel, wages etc are considered

- Environmental impacts associated with the above (emissions)
- Financial impacts due to increasing handling costs. This impacts both full and empty container handling. Ultimately, this drives up the cost-per-box and in turn increases the cost of containerised trade.
- Economic impacts because of reduced competitiveness and reliability. In the worst case, this could amount to lost trade and all the implications associated with that.
- Increased time associated with delivery which, aside from the financial costs mentioned above, could have wider impacts in terms of agglomerated trade (multiple suppliers negatively impacted due to uncontrollable third-party supply chain issues). Current shipping congestion in some western countries has seen a container delivery time increase by more than 80%.
- Reduced predictability around labour requirements and shift timings (effects both inside and outside the port gates).

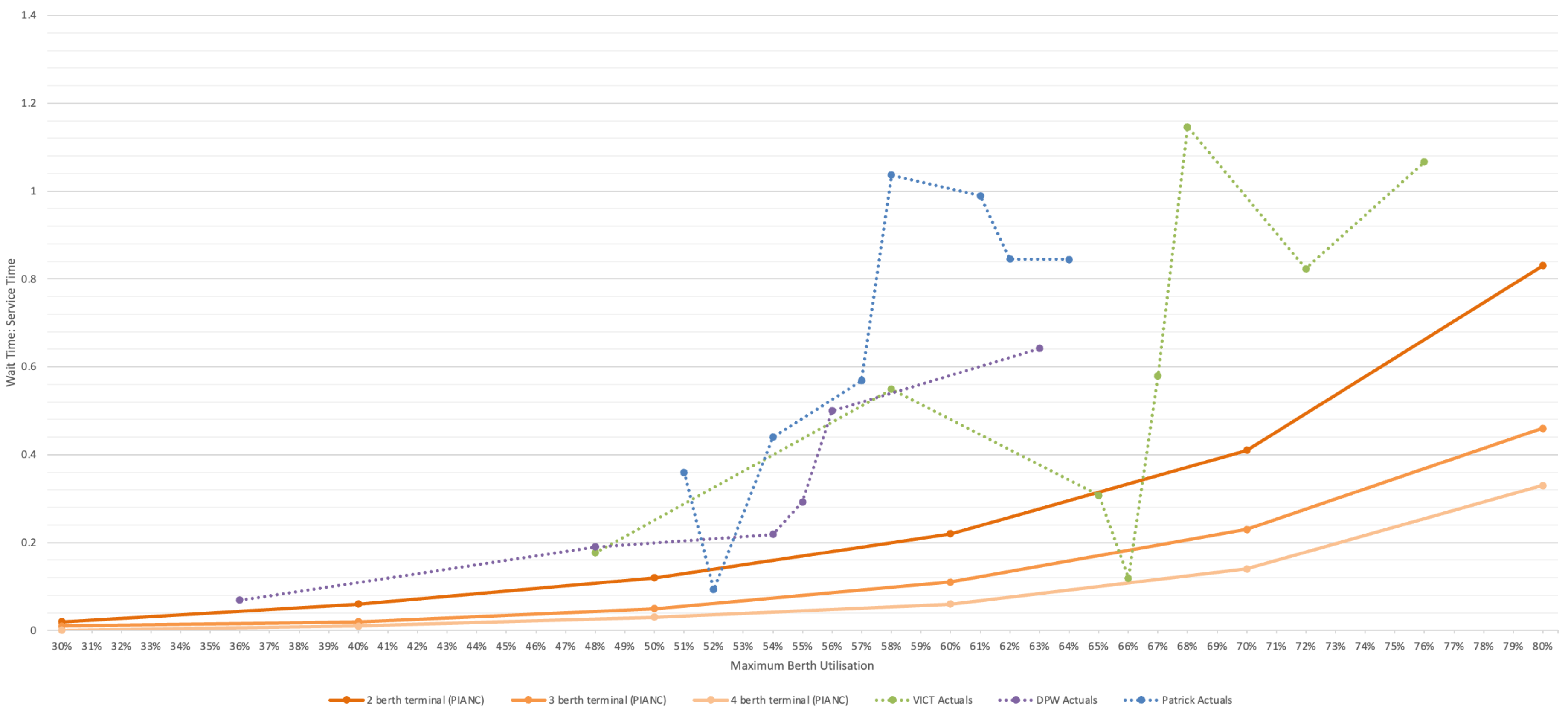
Whilst the supply chain, including the system serving Melbourne and wider Victoria will likely adapt to some extent as a result of these unsustainable and increasing pressures, the sensitivities associated with berth utilization at the port will continue to have both direct and consequential impacts on container reliability and costs.

4.10.6 Recent Melbourne Actuals

Weekly vessel wait data and utilisation by terminal for October 2021 to May 2022 has also been provided. Across this period, the data indicates that extensive vessel queueing and wait times have been experienced (refer to Figure 25). These levels are beyond what would be expected by the PoM curve and associated recommendations contained within Figure 24.

It is understood from PoM that these unexpected delays are due to increased arrivals out of window due to Covid. Whilst more detailed data would be required to confirm it, it is expected that this increased variability has caused compounded queueing and the inability to clear. Whilst these figures are beyond what would typically be expected of more reliable arrivals, they do demonstrate that levels of utilisation beyond those recommended are not without impact to the level of service (i.e. wait time) received by shipping lines.

Figure 25 Port of Melbourne Wait Time to Service Time Actuals, Oct 2021 – May 2022 (Black Quay, 2022)



5 Yard Capacity Criteria

5.1 Yard Storage Assumptions

The static yard storage in each of the three container terminals is summarised in the table below.

Figure 26 Port of Melbourne Yard Storage (PoM supplied data, 2021)

Terminal	Dry slots (TGS)	Reefer (TGS)
Swanson Dock East	5,642	664
Swanson Dock West	4,482	513[1]
Webb Dock East	2,780	820[2]

Note:
1. This is clarified as being suitable for a total of 1,300 TEU.
2. This is total reefer points with 425 slots that can only take 40' containers

As detailed in Section 2.5, yard expansion at the WDE terminal is planned when required in the future and estimated to consist of five (5) additional ASC blocks. For the purposes of the modelling, it was assumed that this increased yard storage by 1,390 dry ground slots and 410 total reefer points based on a pro-rata of the existing 10-block yard capacity.

The model does not consider fixed block delineations within the yard between export, import and empties. It has been assumed that yard allocation can be flexible in response to the trade mix.

5.2 Yard Utilisation Assumptions

The maximum utilisation of yard storage in order to maintain productivity, is assumed to be as follows:

- Straddle Blocks: 80 %
- Reefer Areas: 80%
- ASC's: 80%

5.3 Yard Equipment Operations

The yard operating regimes for each of the terminals is understood to be as follows:

- Swanson Dock East - 1 over 2 Straddle Carriers
- Swanson Dock West - 1 over 2 Straddle Carriers
- Webb Dock East - Automated Straddles/ASC's

As with STS cranes, straddles are not considered to be a limiting factor on capacity, and it has been assumed that where additional yard handling equipment is required, Terminal Operators would invest in further straddles. This includes the ability to convert their yards to 1 over 3 straddle operations if and when required due to yard capacity constraints.

This is not true for ASC's where the number of ASC's is limited by the yard blocks present at the terminal. It is understood that WDE currently has 10 ASC blocks, which accommodate 20 ASC's.

In terms of ASC operations, the following assumptions have been made:

- Gross ASC Working Time: 80%
- Proportion of Housekeeping moves undertaken: 45%[18]
- ASC Gross Moves per Hour: 18gmph (assuming relatively efficient movements)

5.4 Stack Heights

The following maximum stacking heights have been adopted within the models.

Figure 27 Maximum Stacking Heights (# of containers)

Terminal	Dry slots	Reefer
Swanson Dock East	3.2[1]	2
Swanson Dock West	3.2[1]	2
Webb Dock East	5	5

Note:

1. Based on a maximum stacking height of 4 and based on stevedore feedback on 1 over 3 operations

[18] Assumption based on information published by Port Technology International "Improving Terminal Performance" (J. Achterkamp) noting that actual figures of ASC terminals indicate that ASC's are spending 40-50% of their moves on housekeeping.

5.5 Dwell Times

Dwell time, expressed in days and fractions thereof, is the average time that containers remain in the container yard. This includes the time from when the containers are initially stacked to the time that they are taken out for transport.

The following values have been assumed which are considered reflective of an efficient gateway terminal.

- Import (Full): 1.5 - 2.5 days (Scenarios assume 2 days)
- Export (Full): 4 - 6 days (Scenarios assume 5 days)
- Empties: 2 - 4 days (Scenarios assume 3 days)
- Transhipment: 2 days

6 Road Gate Capacity Criteria

Road gate capacity has been included in the modelling for completeness and include an estimate of capacity. However, it is noted that PoM has clarified that road gate capacity should not be considered a capacity limiter, as additional gate capacity can be added relatively easily.

The below outlines the road gate assumptions made in the modelling.

6.1 Gate Operating Hours per Day

The number of hours that the truck gates are opened are assumed to be as follows (based on information contained on the VICT terminal and assumes that SDE and SDW operate in a similar manner):

- Monday: Friday: 24 hours
- Saturday: Midnight to 14:00
- Sunday: 06:00 to Midnight

It is assumed that the gates operate 360 days per year.

6.2 Road Gate Numbers

The road gates for each of the terminals are assumed to be as follows:

- SDE – 3 in-gates
- SDW – 6 in-gates
- WDE – 2 OCR gates, 11 in-gates

The gates for Swanson Dock terminals are based on review of satellite imagery. WDE gates are based upon information contained on the VICT website.

6.3 Gate Processing Rate: In-Gate/Out-Gate

The gate processing rates, expressed in minutes per truck, is the rate for a single gate lane to process one truck.

In the absence of terminal-specific gate information, the following in-gate processing times per truck have been assumed.

- OCR (WDE): 10 seconds/truck
- In-gate: 60-90 seconds/truck

6.4 Average Truck Parcels

It assumed that the average truck parcel[19] is 2.7 TEU's per truck (1.7 containers per truck), as per information contained within BITRE Waterline 67.

It is noted that, based upon BITRE definitions, this figure includes consideration of backloaded trucks.

[19] Parcel is defined as the number of TEUs per truck visit to the PoM. BITRE data clarified that it is calculated from the count of TEUs through the VBS/TAS systems divided by the total number of VBS/TAS trucks used

7 Rail Gate Capacity Criteria

Current rail share of TEU’s through the Port of Melbourne terminals is approximately 5-7% (BITRE Waterline 67, 2020).

Little information has been provided on the operational detail of the rail terminals at Swanson Dock and the proposed rail facilities at Webb Dock.

However, PoM has confirmed that it should be assumed that the road gate for all terminals should be able to handle 100% of trade.

Therefore, detailed modelling of rail capacity has not been undertaken, unless the road gate capacity of a terminal was identified as the capacity limiter.

Chapter III: Capacity Modelling Findings

Port of Melbourne - Container Capacity Review

8 Model Overview

The capacity model has been established in accordance with the guidance contained within PIANC WG158 for calculating annual terminal capacity. Optimum capacity has been calculated for each of berth, yard, gate (road) at each of the three (3) terminals.

Berth capacity has been calculated as per guidance within PIANC WG158 as follows:

$$C_B = P \times f_{TEU} \times N_{cb} \times n_{hy} \times m_b \times n$$

Where:

C_B = Maximum Annual Capacity of Berth (TEU/year)

P = gross productivity per crane (moves/hour)[20]

f_{TEU} = TEU factor (refer Section 3.3)

N_{cb} = average number of cranes per vessel[21]

N_{hy} = number of operational hours per year[22]

m_b = berth occupancy factor[23]

n = number of effective berths (refer Section 4.4)

For the straddle terminals (Swanson Dock), yard capacity has been calculated as a function of yard slots, dwell times and achievable utilisation and stack heights as follows:

$$C_Y = S \times \frac{n_{dy}}{t_d} \times m_s$$

Where:

C_Y = Maximum Annual Capacity of Yard (TEU/year)

S = static capacity of yard[24]

t_d = average dwell time (refer Section 5.5)

m_s = estimated storage occupancy (refer Section 5.2)

N_{dy} = number of operational days per year (refer Section 3.4)

For the ASC terminal (Webb Dock), yard capacity has been calculated based on the minimum of the following:

- The capacity of the yard as per the equation above.
- The capacity of the ASC's servicing it, calculated as follows:

[20] Gross productivity is factored to account for start and finish processes. That is, P = G x V, where G = gross crane rate (refer Section 4.7) and V = vessel productive time (refer Section 4.8).

[21] Calculated based on the assumptions contained within Section 4.5 on crane allocations by vessel size and with consideration to the forecast fleet to establish an average number of cranes per vessel in any given year

[22] Calculated based on the sum of operational hours per day x operational days per year as per Section 3.4

[23] As per Figure 23 and noting that where the number of effective berths falls between these figures, berth occupancy has been interpolated.

[24] Static yard capacity is calculated as the product of total ground slots multiplied by average stack height as per Sections 5.1 and 5.4

$$C_{ASC} = n_{hy} \times n_{wasc} \times P_{asc} \times m_{asc} \times (1-h)$$

Where:

C_{ASC} = Maximum Annual Capacity of ASC's (TEU/year)

N_{hy} = number of operational hours per year[25]

n_{wasc} = number of waterside ASC[26]

P_{asc} = gross productivity of ASC's (moves/hour) (refer Section 5.3)

M_{asc} = gross working time of ASC's (refer Section 5.3)

h = housekeeping proportion (refer Section 5.3)

It should also be noted that the assumed timing of additional ASC blocks was driven by the ability of the yard to support peak STS crane operations. That is, how many waterside ASC's are required to support all STS cranes operating at once.

Gate capacity has been calculated as the minimum of ingate and outgate capacity, with the capacity of each ingate and outgate calculated as follows:

$$C_G = n_{hy} \times P_{gate} \times n$$

Where:

$$P_{gate} = {}^{3600}/_{p} \times m_{gate} \times f_{truck}$$

And:

C_G = Maximum Annual Capacity of Gate (TEU/year)

N_{hy} = number of operational hours per year (refer Section 6.1)

P_{gate} = maximum hourly throughput per gate (TEU/hour/gate)

n = number of gates (refer Section 6.2)

p = processing time at gate (secs/truck) (refer Section 6.3)

m_{gate} =maximum gate utilisation, assumed at 80%

f_{truck} = average TEU/truck (refer Section 6.4)

For all components, a 15% factor has been applied to differentiate between maximum annual capacity and optimum annual capacity (refer to Section 3.5).

Within the following sections, all references to calculated capacity relate to 'optimum capacity' unless noted otherwise.

It should also be noted that the definition of capacity refers to the measure of volume which can be handled by a port or terminal at a defined quality of service. There may be instances where volumes above the optimum capacity may be handled, however these would be expected to have impacts on terminal operations and queueing beyond those which are considered a reasonable level of service, as explained previously.

[25] Calculated based on the sum of operational hours per day x operational days per year as per Section 3.4

[26] In line with the planned yard increases outlined within Section 2.5

8.1 Scenarios Assessed

With consideration to the input criteria provided within Sections 4 to 6, and the potential for future improvements, five (5) scenarios were established for modelling. The first (Scenario A) represents a scenario where no change in input parameters is experienced over time.

The second, third and fourth scenario (Scenario B1 – B3) test the potential capacity under future circumstances with single input parameters changing. The final scenario (Scenario C) tests the capacity, when all three (3) of the input parameters tested in Scenarios B1 to B3 change. It is noted that all scenarios are dependent on a number of future eventualities.

The scenarios and dependencies are outlined in the following figure.

Figure 28 Scenarios Modelled

	Scenario A	Scenario B1	Scenario B2	Scenario B3	Scenario C
Description	**Current Productivities**	**Increased TEU Ratio**	**Increased Crane Rate**	**Increased Berth Utilisation**	**Increased TEU Ratio & Crane Rate & Utilisation**
Gross Crane Rate	27gmph average across all three (3) terminals	27gmph average across all three (3) terminals	WDE 26gmph SD Terminals: 30gmph	27gmph average across all three (3) terminals	WDE 26gmph SD Terminals: 30gmph
TEU Ratio	1.60	Increasing from 1.60 to 1.70 by 2030	1.60	1.60	Increasing from 1.60 to 1.70 by 2030
Berth Utilisation	53% (2-berth) 63% (3-berth)	53% (2-berth) 63% (3-berth)	53% (2-berth) 63% (3-berth)	60% (2-berth) 65% (3-berth)	60% (2-berth) 65% (3-berth)
Maximum Crane Productivity	140,000 TEU/crane/annum	150,000 TEU/crane/annum	155,000 TEU/crane/annum	140,000 TEU/crane/annum	165,000 TEU/crane/annum
Dependent on	SD Terminal operators invest in 1 over 3 strads as required to increase yard capacity	SD Terminal operators invest in 1 over 3 strads as required to increase yard capacity TEU factor continues to increase to 1.70	SD Terminal operators invest in 1 over 3 strads as required to increase yard capacity Improvements in DPW productivity to 30gmph noting that this would likely require improvements in DP World's industrial framework as per DPW submission to the Productivity Commission	SD Terminal operators invest in 1 over 3 strads as required to increase yard capacity Increased berth utilisation through vessel schedule reliability increases and/or increased wait time tolerance by shipping lines	TEU factor continues to increase to 1.70 Increased berth utilisation through vessel schedule reliability increases and/or increased wait time tolerance by shipping lines SD Terminal operators invest in 1 over 3 strads as required to increase yard capacity Improvements in DPW productivity to 30gmph noting that this would likely require improvements in DP World's industrial framework as per DPW submission to the Productivity Commission

8.2 Quay Line Sensibility Check

To provide a sensibility check on the berth capacity calculations, the resultant quay line productivity (or TEU/metre of berthline per annum) has also been charted.

TEU per metre of berthline is a metric which provides an indication of quay line performance.

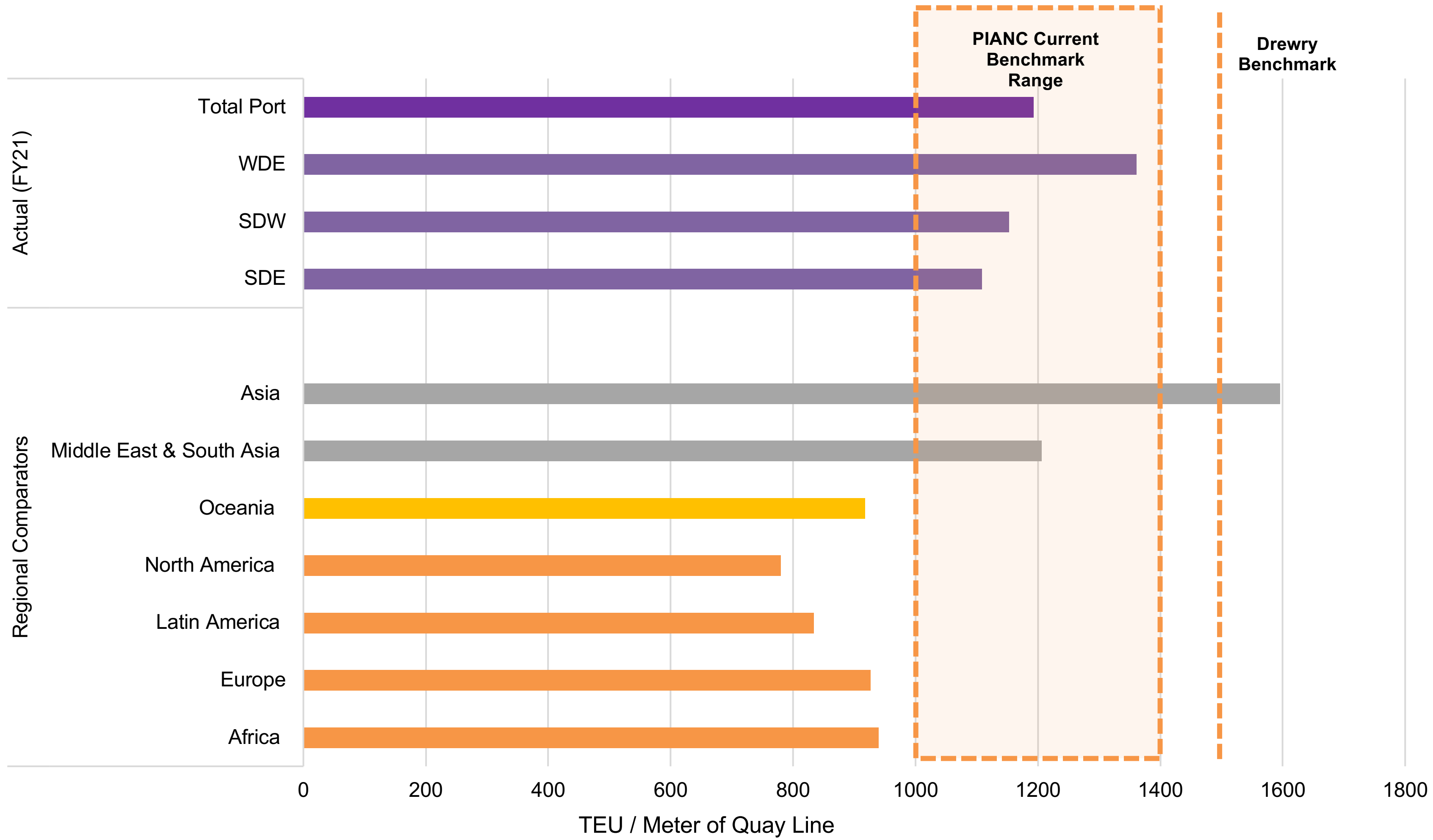
It is generally accepted that a quay line productivity of 1,100 to 1,500 TEU/m/annum is currently considered reasonable for origin-destination ports and that high-capacity transhipment ports can achieve at or over 2,000 TEU/m/annum.

PIANC WG158 provides some guidance on this facto, noting that this factor may increase to 1,600-2,000 TEU/m/annum in time, pointing out that this industry benchmark is appropriate for well-planned and well-equipped facilities handling large mainline container vessels.

Information provided by PoM provides quay line productivity comparisons. This is depicted in the figure below and demonstrates that current quay line productivity at the Port of Melbourne is around 1,100 – 1,400 TEU/m/annum.

The quay line productivity that results at each of the PoM terminals is depicted in the following sections. When viewing these, it should be noted that there are several ways in which the same quay line performance can be achieved. For example, the maximum cranes on the berthline at 140,000 TEU/crane/annum can be produce similar quay line productivity rates to fewer cranes at higher levels of crane utilisation.

Figure 29 Quay Line Productivity Comparisons in TEU/m/annum (reproduced from PoM supplied data)



9 Model Findings

Each of the scenarios were modelled over the period 2022-2050. The results of the scenario modelling for each of the terminals are depicted in Figure 30 to Figure 35.

Unless otherwise noted, key inputs to the model as detailed within Chapter 2, remain unchanged across the modelling timeframe with the exception of the following inputs, which vary over time as a result of the forecast trade mix and fleet profile (both provided by PoM):

- Effective number of berths
- Vessel productive time

It should be noted that calculated capacities for each of the terminals fluctuated over time due to the following factors:

- Effective berths decreasing over time in response to growing fleet profile (impacting berth capacity)
- Maximum achievable berth utilisation decreasing over time in response to decreases in effective berth numbers (impacting berth capacity)
- Fluctuations in vessel productive time at berth owing to its calculations being derived from first principle calculations based on forecast container exchange sizes and crane rates (impacting berth capacity)
- Average cranes per vessel increasing over time due to growing fleet and crane allocations (impacting berth capacity)
- Trade profile changes over time (impacting berth and yard capacity).

Reference should be made to Appendix B - D for model inputs in any given year.

9.1 Swanson Dock East Capacity

The calculated Swanson Dock East capacity (under the five scenarios) is depicted in Figure 30.

Under the Scenario A set of parameters, the Swanson Dock East limiting capacity is 1,260,000 TEU/annum and it is the berth that is the limiting factor.

In particular, it is the spatial limitation of a maximum of 9 STS cranes on the berthline (indicative crane spacing of 98m) and a maximum STS crane productivity of 140,000 TEU/annum (as per the assumptions contained in Section 4.9 under Scenario A) that limits the capacity.

At this capacity of 1,260,000 TEU/annum, the overall quay line productivity is 1,425 TEU/annum, which is considered reasonable for a well-planned, efficient gateway terminal currently (as per the discussion in Section 8.2). It is noted that the yard capacity is calculated only slightly higher at approximately 1,345,000 TEU based upon the assumed dwell times.

During the stakeholder feedback, Patrick provided some information in relation to actual dwell times within the terminal (timeframe over which is unclear). These were as follows:

- Import (Full): 2.1 days
- Export (Full): 3.8 days
- Import (Empty): 3.3 days
- Export (Empty): 1.9 days
- Transhipment: 5.9 days laden, 6.7 days empty

Utilising the dwell times provided by Patrick, the yard capacity is calculated at 1,480,000 TEU.

Under Scenarios B1 to C, the overall terminal capacities range between 1,260,000 to 1,485,000 TEU/annum (capped by crane productivity). It is important to note that to achieve these capacities, additional capacity in the yard may be required, dependent on whether Patrick can regularly and reliably achieve the dwell times provided within the stakeholder feedback. Where these cannot be achieved, it is possible that increased yard capacity could be achieved through the introduction of 1 over 3 straddles, facilitating an average stack height of 3.2 containers.

In addition, Scenarios B1 to C would be dependent on improvements in other productivities (as noted in Section 8.1) such as the TEU factor continuing to increase to 1.70 and vessel schedule reliability improving and/or shipping lines accepting lower service levels/increased waiting time.

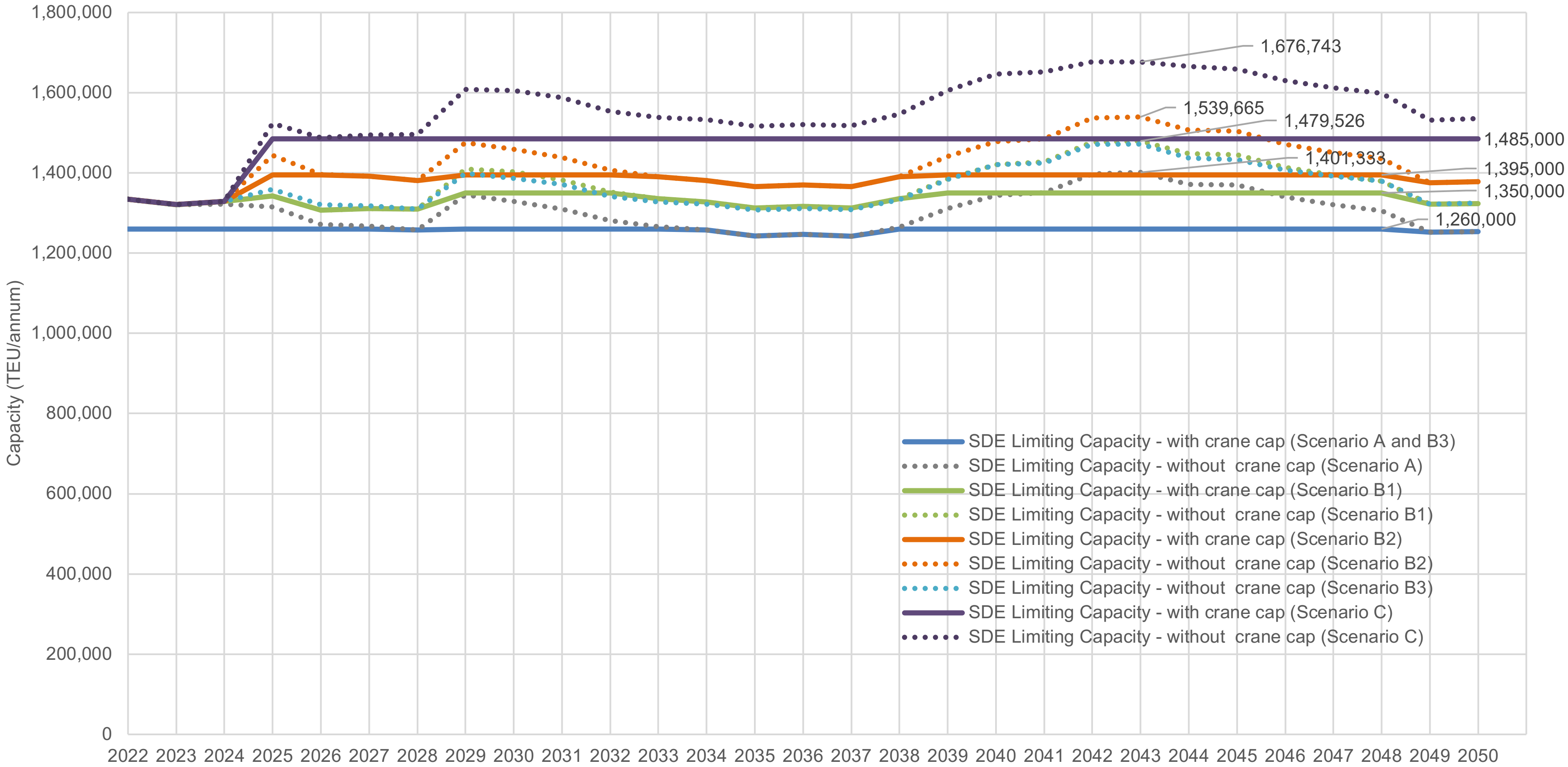
Under Scenarios B1 to C, the berthline productivity increases to a maximum of 1,680 TEU/m. This remains within the bounds of what is considered reasonable in the future based on achieving all productivity improvements.

In addition, Black Quay has also provided modelling for terminal capacities without consideration of maximum crane spacing and productivities (as per Section 4.9). This results in an increased capacity of 1,401,000 TEU/annum under Scenario A and between 1,479,000 – 1,677,000 TEU/annum under Scenarios B1 to C. It is noted however that achieving these levels would require either

increased crane deployment per vessel or increased crane productive time.

Over time the calculated effective berths at SDE reduce from 3.0 to approximately 2.7, and the average cranes per vessel increase from 2.5 to a high of 2.8 in response to the changing fleet profile.

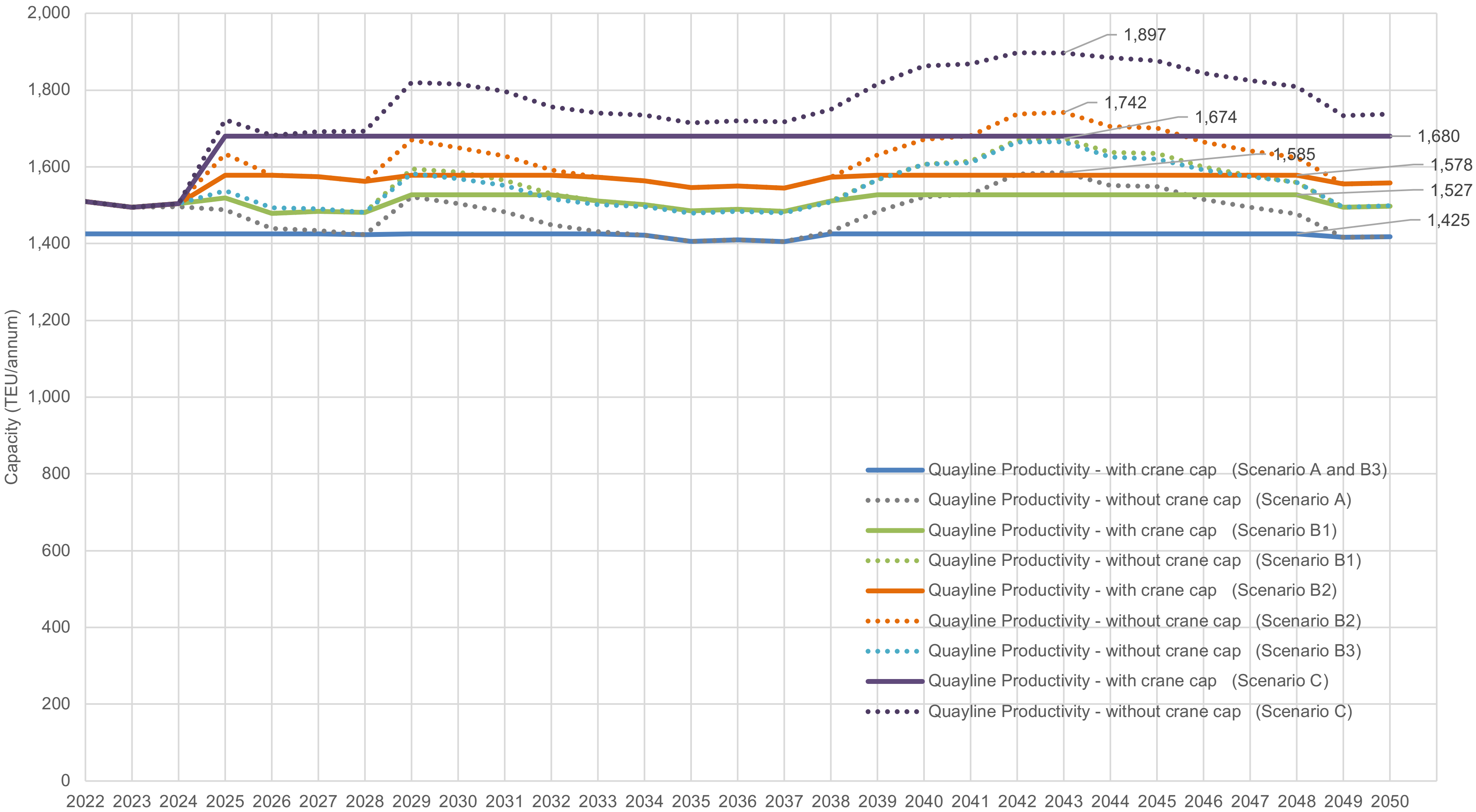
Figure 30 Calculated Capacity – Swanson Dock East[1]



Note:

1. SDE limiting capacity is driven by limiting berth capacity, however it is noted that yard capacity improvements, such as conversion to 1 over 3 straddles (assumed no earlier than 2025) may be required under all Scenarios except Scenario A and B3 with the crane cap.

Figure 31 Calculated Quayline Productivity – Swanson Dock East



9.2 Swanson Dock West Capacity

The calculated Swanson Dock West capacity is depicted in Figure 32.

Under Scenario A, the berth capacity is approximately 1,400,000 TEU/annum and it is the yard that limits overall capacity at SDW to approximately 1,090,000 TEU/annum (without any capacity improvements). Where 1 over 3 straddles are introduced, this increases the yard capacity to approximately 1,360,000 TEU/annum.

It is noted that DPWA have historically handled volumes in excess of 1,090,000 TEU within the yard at SDW. Anecdotally, this is understood to have involved off-site storage and just-in-time delivery of empty containers. Additionally, it is understood that the West Swanson Intermodal Terminal was utilised during peak periods.

It is expected that such measures could be taken in Scenario A (in addition to or in replacement of 1 over 3 straddles) to match berth capacity at 1,400,000 TEU/annum.

Under Scenario B1, B2 and C, the berth capacity ranges from 1,500,000 to 1,650,000 TEU/annum. In order to facilitate this, the yard would need to increase capacity through introduction of 1 over 3 straddles and reduction of empty container storage to 0.5 days dwell (replicating the previous operational measures taken).

The overall capacity modelling for SDW depicted in Figure 32 assume that these measures are taken and therefore the terminal remains berth constrained.

However, the capacity depicted in Scenario B1 to C, is also dependent on the following future eventualities (as per Section 8.1):

- TEU factor continuing to increase to 1.70
- Vessel schedule reliability improving and/or shipping lines accepting lower service levels/increased waiting time
- Improvements in DPW productivity to 30gmph noting that this would likely require improvements in DP World's industrial framework as per DPW's submission to the Productivity Commission

Under Scenarios B1 to C, the berthline productivity increases to a maximum of 1,815 TEU/m. Whilst high, this remains within the bounds of what is considered reasonable in the future based on achieving all productivity improvements.

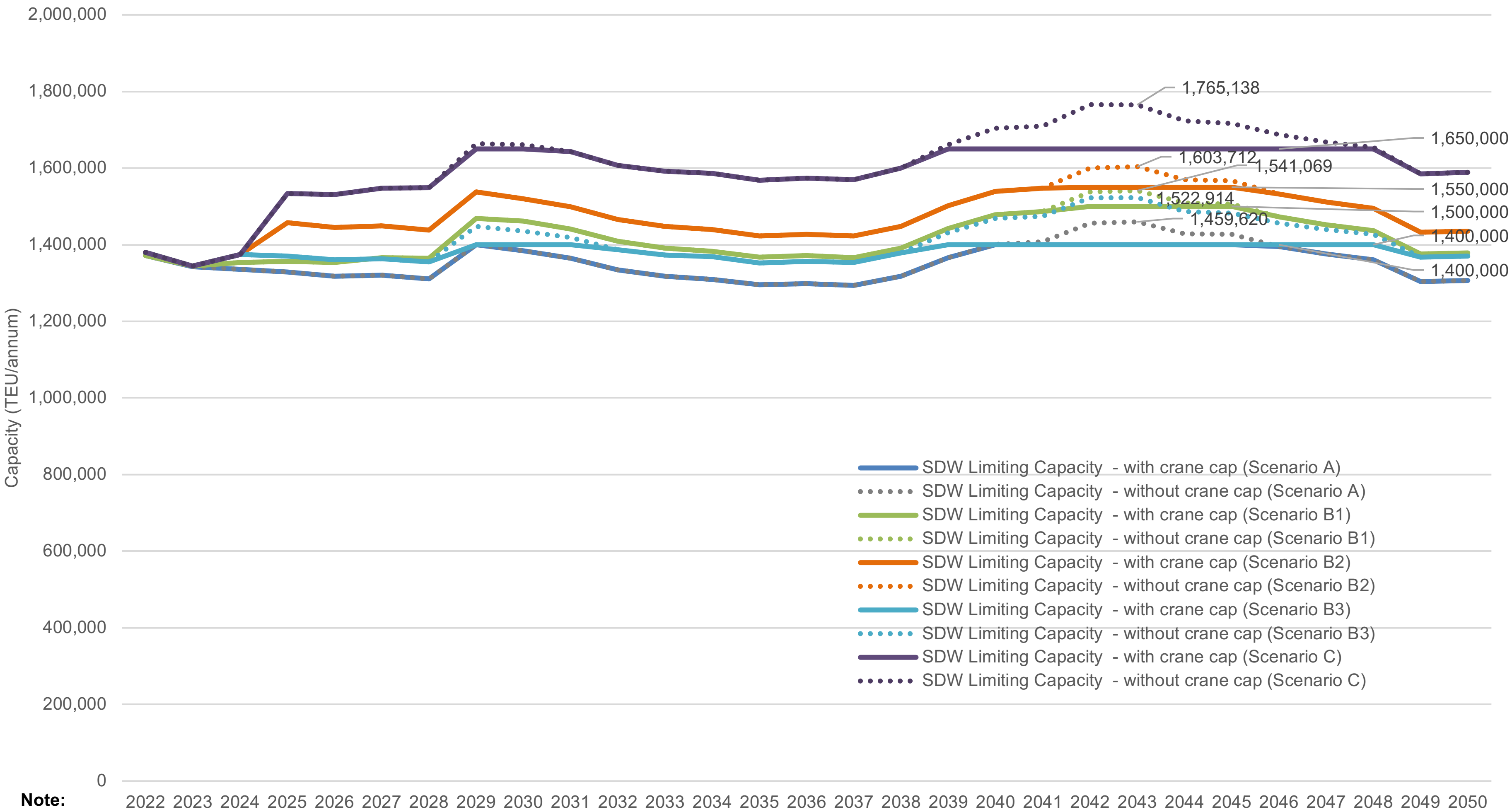
It is important to highlight that this is dependent on improvements in DPW's productivity which, as previously mentioned, is understood to be constrained by the current industrial framework.

In addition, Black Quay has also provided modelling for terminal capacity without consideration of maximum crane spacing and productivities (as per Section 4.9). This results in an increased capacity of 1,459,000 TEU/annum under Scenario A and between 1,522,000 – 1,765,000 TEU/annum under Scenarios B1 to C. It is noted however that achieving these levels would require either

increased crane deployment per vessel or increased crane productive time.

Over time, the calculated effective berths at SDW reduce from 3.0 to approximately 2.8, and the average cranes per vessel increase from 2.5 to a high of 2.8 in response to the changing fleet profile.

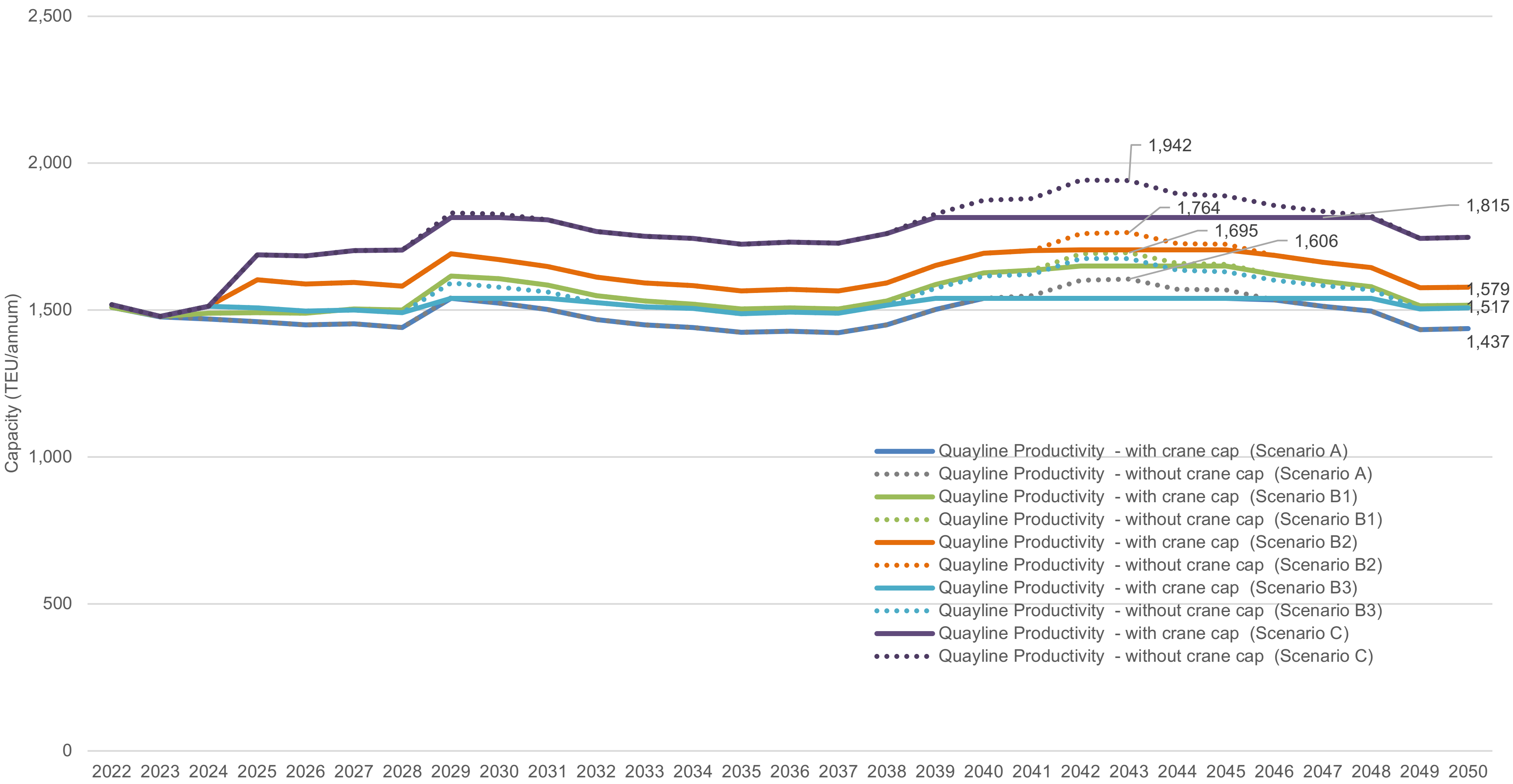
Figure 32 Calculated Capacity – Swanson Dock West



Note:

1. SDW limiting capacity depicted above is based on berth capacity and assumes certain operational measures implemented in the yard to increase yard capacity. This includes conversion to 1 over 3 straddles (all scenarios and assumed no earlier than 2025), reduced dwell times where necessary (Scenario A uncapped, B1 capped and uncapped, B2 caped and uncapped, B3 uncapped and C) and/or increased slots whether that be at WSIT or otherwise (Scenario C with no crane cap). Where these measures are not taken within the yard, yard capacity will dictate and depicted capacities may not be achievable.

Figure 33 Calculated Quayline Productivity – Swanson Dock West



9.3 Webb Dock East Capacity

The calculated Webb Dock East capacity is depicted in Figure 34.

Under all scenarios, the terminal was determined to be berth constrained based on the expected yard expansion as outlined in Section 2.5.

Yard capacity of the existing 10-block ASC yard was calculated at approximately 952,000 TEU/annum, which is driven by the limitations of the ASC's rather than the static yard capacity.

It is understood that expansion of the WDE yard is expected in the near term and will include 13 blocks, and ultimately up to 15 blocks. The calculated capacity of the expanded yard (again driven by ASC limitations) was calculated at approximately 1,246,000 TEU/annum (13 blocks) and 1,438,000 TEU/annum (15 blocks).

It is worth noting that the yard-side capacity is heavily influenced by the assumptions around housekeeping moves (assumed to be 45%). Over time, it is reasonable to expect that the Terminal Operator will test stacking strategies in order to reduce moves as much as practicable. Should this be achieved, the yard capacity would increase accordingly.

With respect to terminal capacity and assuming the yard developments as per above, under Scenario A the Webb Dock East limiting capacity was 1,120,000 TEU/annum which was a cap set by the minimum STS crane spacing and maximum productivity per STS crane.

This would result in a berthline productivity of 1,532 TEU/m/annum.

It should be noted that, on the basis of the modelling assumptions, this capacity of 1,120,000 TEU/annum would not be reached until the 2040's. The reason for this is that berth capacity is calculated as a function of crane allocation (based on fleet size) and productivity rates as previously outlined in the report. It is only around 2041 that productivity rates reach the assumed STS crane annual productivity cap.

Under Scenarios B1 - C, the terminal capacity is increased to 1,200,000 to 1,320,000 TEU/annum respectively.

It should be noted that the capacity depicted in Scenario B1 - C, is also dependent on the following future eventualities:

- TEU factor continues to increase to 1.70
- Vessel schedule reliability improving and/or shipping lines accepting lower service levels/increased waiting time

Under Scenarios B1 - C, the berthline productivity increases to a maximum of 1,806 TEU/m. Whilst high, this remains within the bounds of what is considered reasonable in the future based up achieving all productivity improvements.

Additionally, Black Quay has also provided modelling for terminal capacity without consideration of maximum crane spacing and productivities (as per Section 4.9). This results in an increased capacity of 1,199,000 TEU/annum under Scenario A and up to 1,386,000 TEU/annum under Scenario C.

It is noted however that achieving these levels would require either

increased crane deployment per vessel or increased crane productive time.

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Figure 34 Calculated Capacity – Webb Dock East

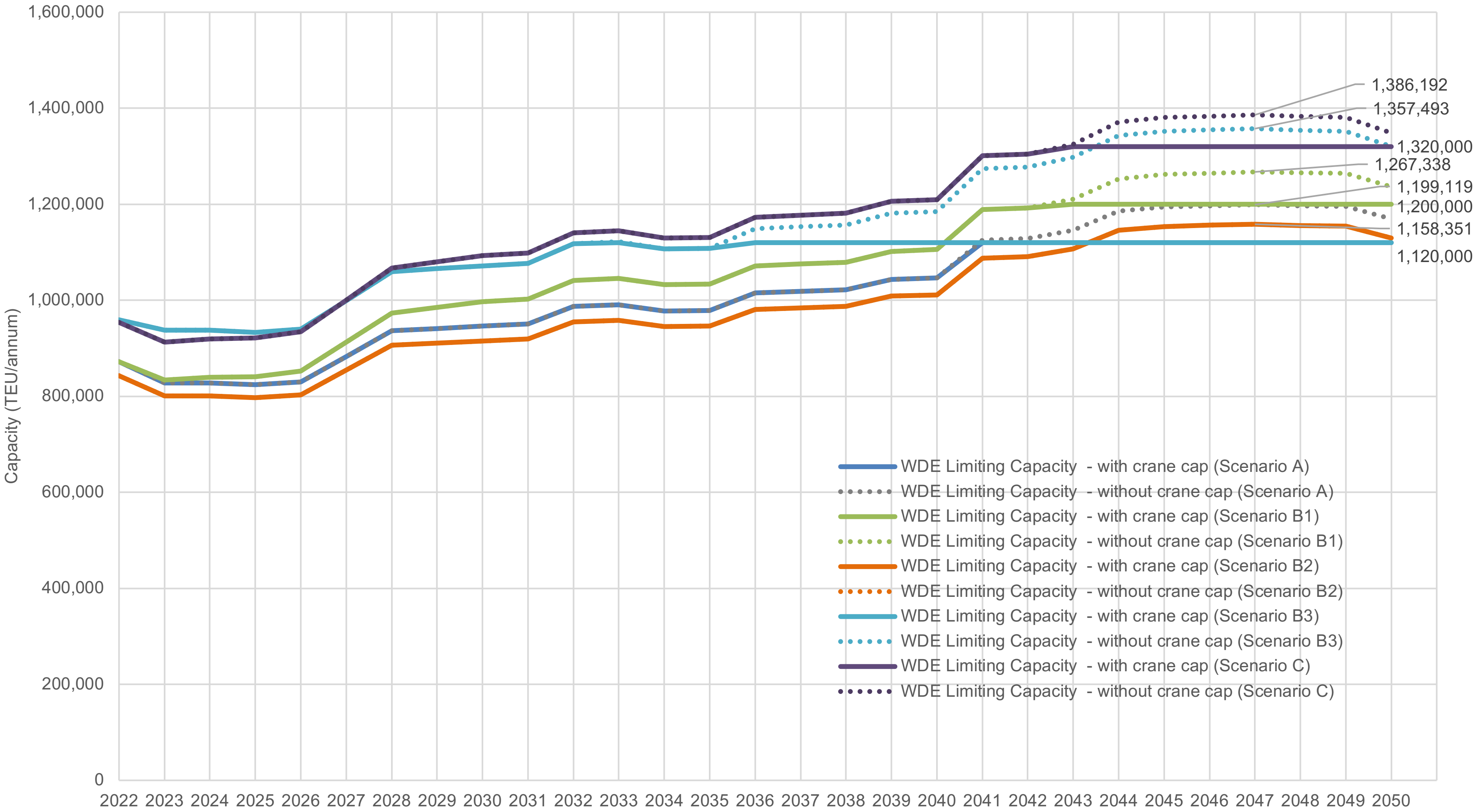

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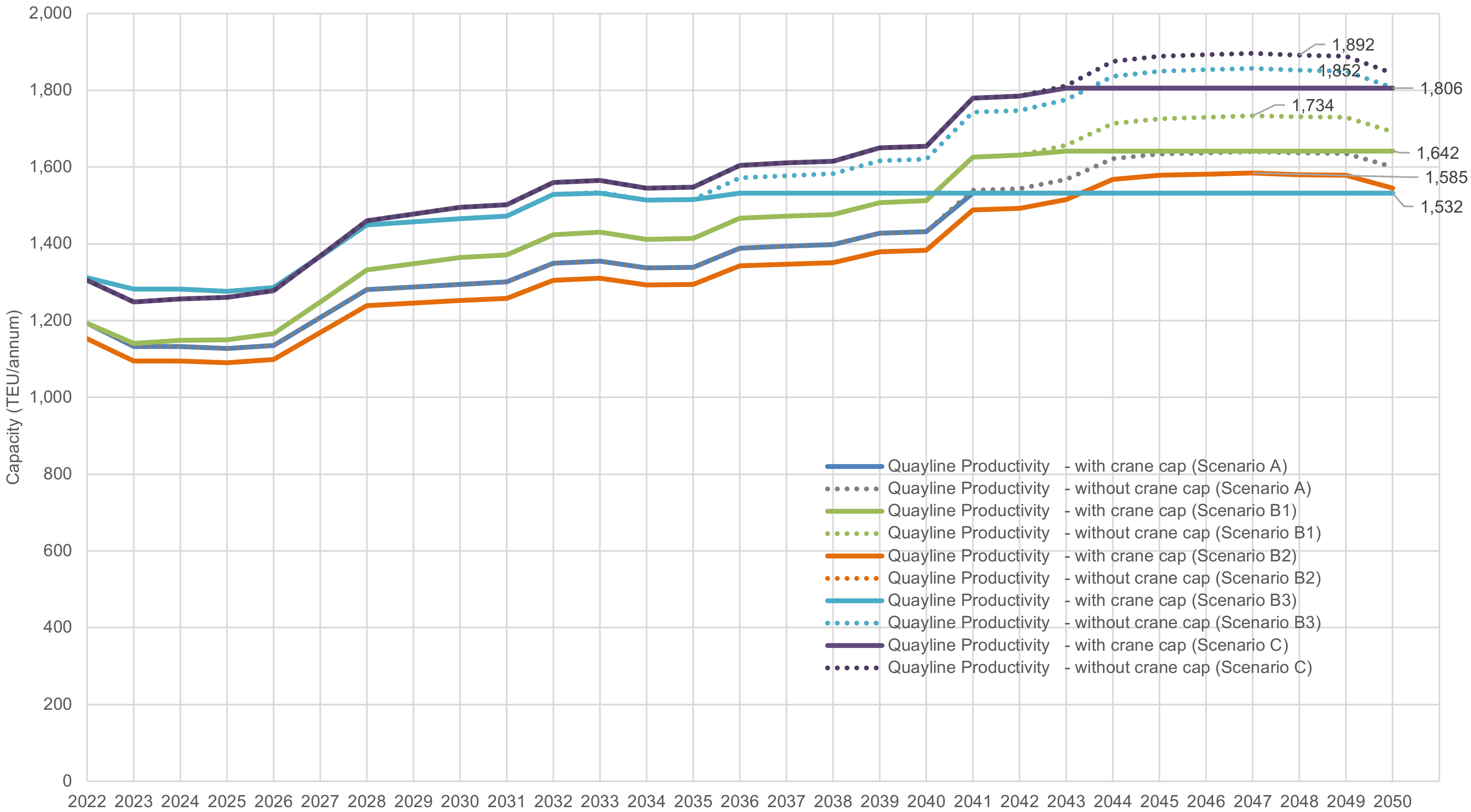
Figure 35 Calculated Quayline Productivity– Webb Dock East



9.4 Port of Melbourne Overall Capacity

The optimum capacity across the three (3) PoM terminals has been modelled and is presented in the figure below against forecast baseline trade.

As demonstrated in the graphs above and Figure 41 below, the calculated capacities within the berths and yards fluctuate over time with trade and vessel mixes.

The optimum terminal capacities are as presented in Figures 36 to 40 across five (5) year increments. It is noted that the point at which the peak optimum capacity is reached depends on both the future fleet profile and crane deployment.

It is noted that the trade contained within the figure below is the baseline forecast provided by PoM. Planning of port infrastructure development should be undertaken on baseline or upper forecasts to provide adequate contingency.

Lower forecasts should not be relied upon for the timing and introduction of new infrastructure. In the event that upper trade forecasts eventuate, this will bring forward the need for additional capacity.

Figure 36 PoM Optimum Capacity – Scenario A

		Scenario A					
Terminal		**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Swanson Dock East	Crane Cap	1,260,000	1,260,000	1,243,275	1,260,000	1,260,000	1,253,978
	Uncapped	1,315,457	1,329,113	1,243,275	1,344,595	1,369,437	1,253,978
Swanson Dock West	Crane Cap	1,328,286	1,384,666	1,294,943	1,400,000	1,400,000	1,305,924
	Uncapped	1,328,286	1,384,666	1,294,943	1,400,303	1,426,573	1,305,924
Webb Dock East	Crane Cap	824,150	946,038	978,884	1,046,515	1,120,000	1,120,000
	Uncapped	824,150	946,038	978,884	1,046,515	1,194,240	1,169,489
PoM Total	**Crane Cap**	**3,412,436**	**3,590,704**	**3,517,103**	**3,706,515**	**3,780,000**	**3,679,901**
	Uncapped	**3,467,893**	**3,659,816**	**3,517,103**	**3,791,413**	**3,990,250**	**3,729,391**

Figure 37 PoM Optimum Capacity – Scenario B1

		Scenario B1					
Terminal		**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Swanson Dock East	Crane Cap	1,342,867	1,350,000	1,312,739	1,350,000	1,350,000	1,324,030
	Uncapped	1,342,867	1,402,513	1,312,739	1,419,975	1,445,527	1,324,030
Swanson Dock West	Crane Cap	1,355,772	1,461,137	1,367,296	1,478,809	1,500,000	1,378,882
	Uncapped	1,355,772	1,461,137	1,367,296	1,478,809	1,505,841	1,378,882
Webb Dock East	Crane Cap	841,149	997,202	1,033,583	1,105,460	1,200,000	1,200,000
	Uncapped	841,149	997,202	1,033,583	1,105,460	1,261,921	1,236,936
PoM Total	**Crane Cap**	**3,539,787**	**3,808,339**	**3,713,617**	**3,934,269**	**4,050,000**	**3,902,912**
	Uncapped	**3,539,787**	**3,860,852**	**3,713,617**	**4,004,245**	**4,213,289**	**3,939,848**

Figure 38 PoM Optimum Capacity – Scenario B2

		Scenario B2					
Terminal		**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Swanson Dock East	Crane Cap	1,395,000	1,395,000	1,366,169	1,395,000	1,395,000	1,377,914
	Uncapped	1,444,177	1,458,911	1,366,169	1,477,976	1,504,025	1,377,914
Swanson Dock West	Crane Cap	1,457,293	1,519,894	1,422,949	1,539,215	1,550,000	1,435,000
	Uncapped	1,457,293	1,519,894	1,422,949	1,539,215	1,566,782	1,435,000
Webb Dock East	Crane Cap	797,097	915,331	946,146	1,011,257	1,153,779	1,129,230
	Uncapped	797,097	915,331	946,146	1,011,257	1,153,779	1,129,230
PoM Total	**Crane Cap**	**3,649,390**	**3,830,225**	**3,735,264**	**3,945,472**	**4,098,779**	**3,942,144**
	Uncapped	**3,698,567**	**3,894,136**	**3,735,264**	**4,028,448**	**4,224,586**	**3,942,144**

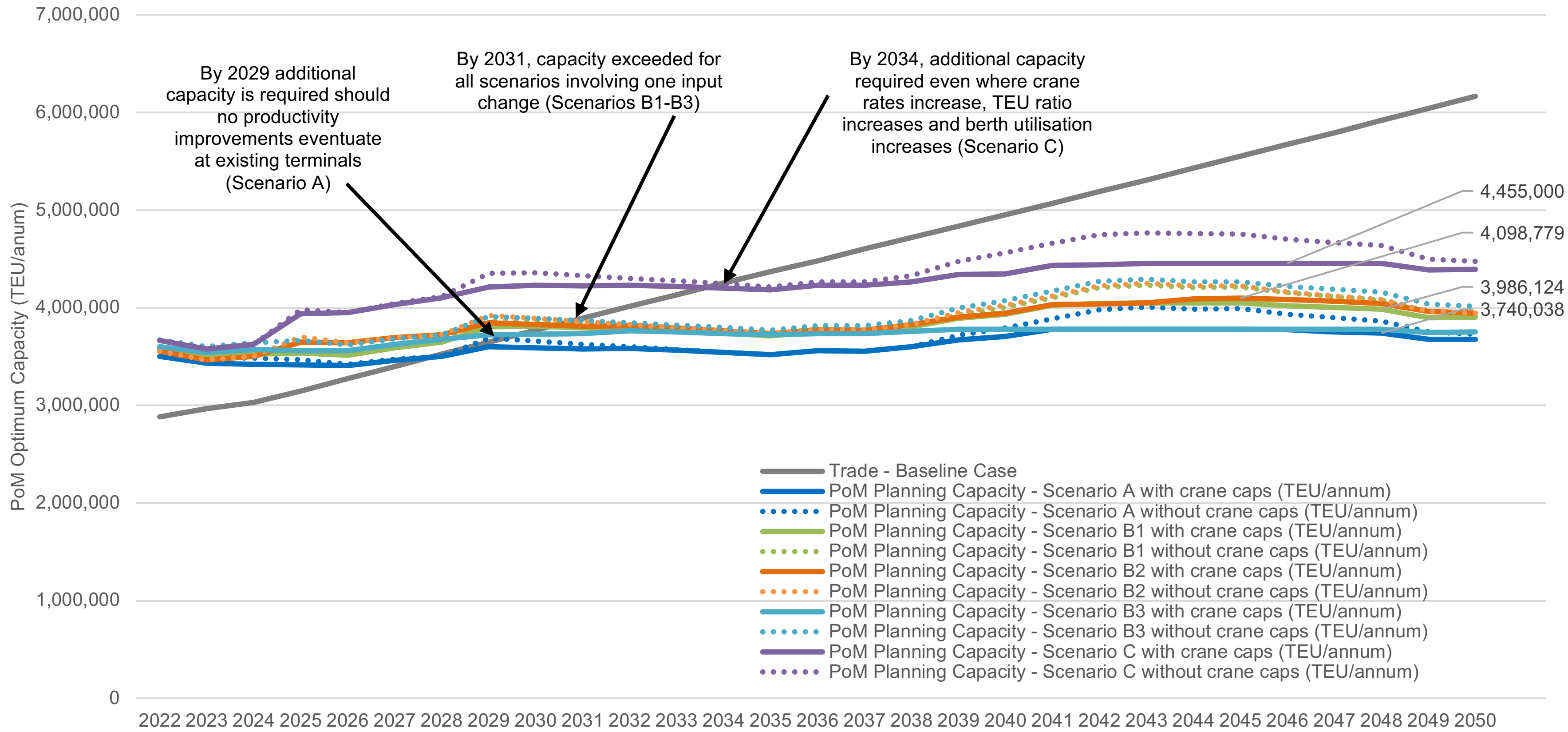
Figure 39 PoM Optimum Capacity – Scenario B3

Terminal		2025	2030	2035	2040	2045	2050
		Scenario B3					
Swanson Dock East	Crane Cap	1,260,000	1,260,000	1,260,000	1,260,000	1,260,000	1,260,000
	Uncapped	1,359,408	1,386,673	1,307,509	1,420,014	1,432,338	1,324,561
Swanson Dock West	Crane Cap	1,370,454	1,400,000	1,352,740	1,400,000	1,400,000	1,370,262
	Uncapped	1,370,454	1,434,871	1,352,740	1,469,014	1,482,048	1,370,262
Webb Dock East	Crane Cap	933,000	1,070,986	1,108,171	1,120,000	1,120,000	1,120,000
	Uncapped	933,000	1,070,986	1,108,171	1,184,734	1,351,970	1,320,360
PoM Total	**Crane Cap**	**3,563,454**	**3,730,986**	**3,720,911**	**3,780,000**	**3,780,000**	**3,750,262**
	Uncapped	**3,662,862**	**3,892,530**	**3,768,420**	**4,073,762**	**4,266,356**	**4,015,183**

Figure 40 PoM Optimum Capacity – Scenario C

Terminal		2025	2030	2035	2040	2045	2050
		Scenario C					
Swanson Dock East	Crane Cap	1,485,000	1,485,000	1,485,000	1,485,000	1,485,000	1,485,000
	Uncapped	1,522,941	1,604,756	1,515,774	1,647,061	1,659,089	1,535,490
Swanson Dock West	Crane Cap	1,534,269	1,650,000	1,568,216	1,650,000	1,650,000	1,588,475
	Uncapped	1,534,269	1,660,542	1,568,216	1,703,902	1,716,677	1,588,475
Webb Dock East	Crane Cap	921,069	1,092,547	1,131,196	1,209,540	1,320,000	1,320,000
	Uncapped	921,069	1,092,547	1,131,196	1,209,540	1,380,446	1,348,658
PoM Total	**Crane Cap**	**3,940,338**	**4,227,547**	**4,184,411**	**4,344,540**	**4,455,000**	**4,393,475**
	Uncapped	**3,978,279**	**4,357,845**	**4,215,185**	**4,560,503**	**4,756,213**	**4,472,623**

Figure 41 PoM Optimum Capacity 2022-2050 (Black Quay, 2022)



Notes:

1. Scenarios B1, B2, B3 and C are dependent on the future eventualities outlined in Section 8.1. This includes TEU factor continued to increase to 1.70, vessel schedule reliability improved post-covid and improved productivity at SDW.
2. WDE capacity includes expansion to 13 ASC blocks as planned in 2023 and further expansion to 15 ASC blocks by 2030 where required by scenario.
3. SDW capacity is based on assumed improvements in yard capacity over time including introduction of 1 over 3 straddles, reduction of empty container dwells and/or increased slots through use of WSIT or otherwise.
4. Gate capacity at each terminal is based on an assumption of efficient gate operations with booking systems to alleviate peaking. Where this doesn't occur, gate capacities will be reduced.
5. The 'Crane Cap' scenarios provide a berth capacity based upon limitations on crane minimum spacing and assumed annual productivity as per Section 4.9.

9.5 Key Observations

The following observations should be noted in relation to the above results:

- The berth capacity of each terminal is ultimately dictated by a cap formed by the assumed minimum crane spacing and maximum annual crane productivity. The point at which this cap is effective is dependent on assumptions around crane productivity, crane allocation, berth utilisation and the forecast fleet
- The quay line productivity of each terminal under Scenario A falls within the limits that would be reasonably expected of an origin-destination terminal. The quayline productivities under Scenario B1-C are also considered reasonable into the future where future productivity enhancements are realised.
- Under Scenario A the optimum terminal capacity is reached in the following years (subject to assumptions made, including fleet profile, crane deployment etc):
    - Webb Dock East - 2041
    - Swanson Dock East - 2022
    - Swanson Dock West - 2029
- The ability to reach the quoted capacities prior to these dates would require variation to the assumed modelling inputs, particularly in relation to crane deployment by vessel size.
- Under Scenario B1 to B3, individual changes under three different parameters were tested. The parameter that had the largest impact was the crane rate which increased total Port of Melbourne capacity by up to 320,000 TEU/annum.
- In Scenario C, an increase in crane rate, berth utilisation and TEU ratio was tested. Under this scenario, the optimum terminal capacity is indicatively effective in the following years (subject to assumptions made including fleet profile, crane deployment etc):
    - Webb Dock East - 2043
    - Swanson Dock East - 2025
    - Swanson Dock West - 2029
- All scenarios assume that Swanson Dock Operators will convert to 1 over 3 straddles as required to increase yard capacity.
- Scenarios B and C are dependent on a combination of the following:
    - TEU factor continues to increase to 1.70
    - Vessel schedule reliability improves and/or shipping lines accepting lower service levels/increased waiting time
    - Improvements in DPW productivity to 30gmph noting that this would likely require improvements in DP World's industrial framework as per DPW submission to the Productivity Commission

10 Suggested Performance Metrics

The modelling indicates that the capacity at all three of the PoM container terminals is dictated by the productivity achieved at berth and the level of service expected to be required by customers.

Volumes can exceed the level of capacity quoted (and in some instances, have historically done so on isolated occasions). However, this is at the detriment of the level of service provided to the customer, particularly leading to increased levels of congestion.

In monitoring terminal capacity at each of the terminals and any surplus capacity that exists, reference should be made back to the discussion contained within Section 4.10 which demonstrates the proposed linkages between customer wait time, berth productivity and overall level of services achieved.

Section 4.10.4 concluded that an overall WT:ST of 0.1 and a berth productivity of at least 50 containers/hour should be seen as the minimum level of service for the container terminal operators.

With this in mind, the following performance metrics are considered appropriate when monitoring terminal capacity (to be considered for each terminal):

> Actual WT:ST time ratios experienced by the fleet

> Berth utilisation figures

> Berth productivity in terms of containers/hour.

These figures should be taken over a suitable time period (recommend quarterly) to provide an accurate picture of terminal operations and not be distorted by short-term anomalies.

The monitoring of these factors will allow PoM to determine the level of service being provided to customers (in accordance with the framework provided in Figure 19). It will also allow for the assessment of the degree of surplus capacity within each terminal without detriment to service level.

It is noted that in some instances, the yard capacity is similar to berth capacity. Therefore, it is recommended that performance metrics in relation to yard operations are also monitored.

The following performance metrics would be appropriate when monitoring yard capacity:

> Actual dwell times in the yard

> Average yard utilisation figures

> Peak yard utilisation figures.

Finally, to monitor any congestion that is experienced as a downstream impact of blockages elsewhere, it is also recommended that the following performance metrics at the gate are monitored:

> Average truck turnaround times (taken from truck arrival/scheduled window time)

Chapter IV: Conclusion

Port of Melbourne – Container Capacity Review

Black Quay has undertaken terminal capacity modelling for each of the three international container terminals at Port of Melbourne and this is summarised in the following figure.

The modelling considers five (5) scenarios, four (4) of which consider future improvements in operating parameters that Black Quay consider to be possible future outcomes.

The capacity modelling indicated that the future combined capacity of the terminals is between 3,780,000 ‐ 4,766,000 TEU/annum, dependent on the five (5) different scenarios. All, but one scenario falls between 3,780,000 to 4,455,000 TEU/annum. The outlying scenario (4,766,000 TEU/annum) relies on multiple parameters improving, including an uncapped crane productivity.

The modelling considers practical operational and spatial limitations of STS handling equipment operating at maximum crane numbers along the berth (referred to as a 'crane cap). Upon stakeholder feedback, Black Quay also included the 'unconstrained' capacity under each of the five (5) scenarios. This would rely on increased crane deployment over and above what has been assumed in Section 4.5 and/or a higher proportion of berth productive hours than the Port of Melbourne terminals or any other Australian port are currently achieving. Black Quay consider this to be an unlikely scenario.

It should be noted that the actual capacity in any given year is heavily driven by the fleet profile, crane deployment and crane productivity, and the capacity cap may not be reached until a future point in time.

Essentially, the point at which the capacity cap is reached is dependent on fleet deployment, crane working rates and crane allocation.

Regardless of which scenario, the review of capacity development over time against base trade forecasts indicated that by 2034, additional capacity would be required at the Port Melbourne. This would be brought forward should crane rates, TEU ratio and berth utilisation not increase as forecast in Scenario C or if the high trade case eventuated.

Whilst there may be points in time that a terminal can achieve a throughput above its optimum capacity (and closer to its maximum capacity), this is not considered to be a sustainable level of operation. In instances where optimum capacity is exceeded, it would be expected that productivity, efficiency, reliability and safety may all be negatively impacted.

Figure 42 PoM Optimum Capacity (Peak Figures Presented)

	Scenario A		Scenario B1		Scenario B2		Scenario B3		Scenario C	
	Crane Cap	Unconstrained	Crane Cap	Unconstrained	Crane Cap	Unconstrained	Crane Cap	Unconstrained	Crane Cap	Unconstrained
Swanson Dock East	1,260,000	1,456,808	1,350,000	1,547,859	1,395,000	1,606,895	1,260,000	1,530,963	1,485,000	1,682,475
Swanson Dock West	1,400,000	1,517,382	1,500,000	1,612,218	1,550,000	1,673,714	1,400,000	1,583,947	1,650,000	1,809,009
Webb Dock East	1,120,000	1,238,556	1,200,000	1,315,966	1,195,110	1,195,110	1,120,000	1,402,139	1,320,000	1,437,514
PoM Total	3,780,000	4,158,545*	4,050,000	4,418,454*	4,140,110	4,423,287*	3,780,000	4,455,534*	4,455,000	4,916,089*
Dependent on	SD Terminal operators invest in 1 over 3 strads as required to increase yard capacity		SD Terminal operators invest in 1 over 3 strads as required to increase yard capacity TEU factor continues to increase to 1.70		SD Terminal operators invest in 1 over 3 strads as required to increase yard capacity Improvements in DPW productivity to 30gmph noting that this would likely require improvements in DP World's industrial framework as per DPW submission to the Productivity Commission		SD Terminal operators invest in 1 over 3 strads as required to increase yard capacity Increased berth utilisation through vessel schedule reliability increases and/or increased wait time tolerance by shipping lines		TEU factor continues to increase to 1.70 Increased berth utilisation through vessel schedule reliability increases and/or increased wait time tolerance by shipping lines SD Terminal operators invest in 1 over 3 strads as required to increase yard capacity Improvements in DPW productivity to 30gmph noting this would likely require improvements in DPW's industrial framework as per DPW submission to the Productivity Commission	

Note: *Timing of SDE, SDW and WDE peak capacities is not coincident and therefore the peak optimum capacity of PoM as a whole is slightly lower than the sum of the individual terminal capacities.

Appendix A – Key Model Inputs by Scenario

	Scenario A As per current	Scenario B1 Increased TEU Ratio	Scenario B2 Increased Crane Rate at SDW	Scenario B3 Increased Berth Productivity	Scenario C All Productivity Increases
TEU to Box Ratio					
Swanson Dock					
2022	1.60	1.60	1.60	1.60	1.60
2030	1.60	1.70	1.60	1.60	1.70
2040	1.60	1.70	1.60	1.60	1.70
2050	1.60	1.70	1.60	1.60	1.70
Webb Dock					
2022	1.60	1.60	1.60	1.60	1.60
2030	1.60	1.70	1.60	1.60	1.70
2040	1.60	1.70	1.60	1.60	1.70
2050	1.60	1.70	1.60	1.60	1.70
Dwell Times					
2022					
Imports - Full	2	2	2	2	2
Imports - Empty	3	3	3	3	3
Exports - Full	5	5	5	5	5
Exports - Empty	3	3	3	3	3
Transhipment - Inward	2	2	2	2	2
Transhipment - Outward	2	2	2	2	2
Transhipment - Empty	2	2	2	2	2
2030					
Imports - Full	2	2	2	2	2
Imports - Empty	3	3	3	3	3
Exports - Full	5	5	5	5	5

Exports - Empty	3	3	3	3	3
Transhipment - Inward	2	2	2	2	2
Transhipment - Outward	2	2	2	2	2
Transhipment - Empty	2	2	2	2	2
2040					
Imports - Full	2	2	2	2	2
Imports - Empty	3	3	3	3	3
Exports - Full	5	5	5	5	5
Exports - Empty	3	3	3	3	3
Transhipment - Inward	2	2	2	2	2
Transhipment - Outward	2	2	2	2	2
Transhipment - Empty	2	2	2	2	2
2050					
Imports - Full	2	2	2	2	2
Imports - Empty	3	3	3	3	3
Exports - Full	5	5	5	5	5
Exports - Empty	3	3	3	3	3
Transhipment - Inward	2	2	2	2	2
Transhipment - Outward	2	2	2	2	2
Transhipment - Empty	2	2	2	2	2
Gross Crane Rate					
Swanson Dock					
2022	27.0	27.0	30.0	27.0	30.0
2030	27.0	27.0	30.0	27.0	30.0
2040	27.0	27.0	30.0	27.0	30.0
2050	27.0	27.0	30.0	27.0	30.0
Webb Dock					
2022	27.0	27.0	26.0	27.0	26.0

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2030	27.0	27.0	26.0	27.0	26.0
2040	27.0	27.0	26.0	27.0	26.0
2050	27.0	27.0	26.0	27.0	26.0
Berth Utilisation Factor					
Berth Numbers					
1 Berth (maximum utilisation)	31.0%	31.0%	31.0%	31.0%	31.0%
2 Berth (maximum utilisation)	53.0%	53.0%	53.0%	60.0%	60.0%
3 Berth (maximum utilisation)	63.0%	63.0%	63.0%	65.0%	65.0%
4 Berth (maximum utilisation)	70.0%	70.0%	70.0%	70.0%	70.0%
Assumed Mooring/Demooring Time per Visit					
All terminals (hours)	3	3	3	3	3
Quay Crane Allocation (Based upon vessel Size)					
Tier 1					
Minimum Vessel Size (TEU)	0	0	0	0	0
Maximum Vessel Size (TEU)	5,000	5,000	5,000	5,000	5,000
Number of Cranes	2	2	2	2	2
Tier 2					
Minimum Vessel Size (TEU)	5,001	5,001	5,001	5,001	5,001
Maximum Vessel Size (TEU)	9,000	9,000	9,000	9,000	9,000
Number of Cranes	3	3	3	3	3
Tier 3					
Minimum Vessel Size (TEU)	9,001	9,001	9,001	9,001	9,001
Maximum Vessel Size (TEU)	14,000	14,000	14,000	14,000	14,000
Number of Cranes	4	4	4	4	4
Other					

STS Crane limitation (absolute minimum spacing = berthline/#cranes)	90	90	90	90	90
STS Maximum Productivity (TEU/annum/crane)					
SDE	140,000	150,000	155,000	140,000	165,000
SDW	140,000	150,000	155,000	140,000	165,000
WDE	140,000	150,000	155,000	140,000	165,000
Straddles					
Convert to 1 over 3 at SDE?	Yes				
Convert to 1 over 3 at SDW?	Yes				

Appendix B – Key Model Inputs by Year - SDE

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	Trade Year	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
General Parameters																														
Operating Hours/Day - Berth	**hours/day**	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Operating Hours/Day - Yard	**hours/day**	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Operating Hours/Day - Road Gate	**hours/day**	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
Operating Days per Year - Berth	**days/year**	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7
Operating Days per Year - Yard	**days/year**	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7
Operating Days per Year - Gate	**days/year**	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7
TEU Factor (Scenario A, B2, B3)	**TEU/container**	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
TEU Factor (Scenario B1, C)	**TEU/container**	1.60	1.61	1.63	1.64	1.65	1.66	1.68	1.69	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70
Assumed Trade Characteristics (from trade forecasts)																														
Imports - Full	**%**	46.4%	45.9%	46.2%	46.2%	46.2%	46.2%	46.1%	46.1%	46.1%	46.1%	46.1%	46.1%	46.1%	46.1%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%
Imports - Empty	**%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Exports - Full	**%**	22.8%	24.1%	23.1%	21.4%	21.5%	21.7%	22.0%	21.9%	21.9%	21.8%	21.9%	21.9%	22.0%	22.1%	22.1%	22.2%	22.2%	22.2%	22.2%	22.2%	22.2%	22.3%	22.3%	22.3%	22.4%	22.4%	22.4%	22.5%	22.5%
Exports - Empty	**%**	25.5%	24.2%	25.5%	27.2%	27.2%	27.0%	26.8%	26.9%	27.0%	27.0%	27.0%	26.9%	26.9%	26.8%	26.8%	26.7%	26.8%	26.8%	26.8%	26.8%	26.8%	26.7%	26.7%	26.7%	26.7%	26.6%	26.6%	26.6%	26.5%
Transhipment - Inward	**%**	2.3%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%
Transhipment - Outward	**%**	2.8%	3.2%	2.6%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
Transhipment - Empty	**%**	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%
Berth Capacity																														
Average Vessel Length (from Fleet Forecasts)	**m LOA**	274	275	275	275	280	282	285	284	287	291	291	294	298	297	298	299	300	302	303	300	299	296	293	290	296	300	303	303	303
Effective Number of berths	**no.**	3.0	3.0	3.0	3.0	2.9	2.9	2.9	2.9	2.9	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.7	2.7	2.7	2.7	2.8	2.8	2.8	2.8	2.8	2.7	2.7	2.7	2.7
Berth Occupancy Factor (Scenario A, B1, B2)	**%**	62.8%	62.7%	62.8%	62.8%	62.2%	62.1%	61.8%	61.9%	61.6%	61.2%	61.3%	60.9%	60.7%	60.7%	60.6%	60.5%	60.4%	60.3%	60.2%	60.4%	60.5%	60.8%	61.1%	61.3%	60.8%	60.5%	60.2%	60.2%	60.2%
Berth Occupancy Factor (Scenario B3, C)	**%**	64.9%	64.9%	64.9%	64.9%	64.6%	64.5%	64.4%	64.5%	64.3%	64.1%	64.1%	64.0%	63.8%	63.8%	63.8%	63.8%	63.7%	63.6%	63.6%	63.7%	63.8%	63.9%	64.1%	64.2%	63.9%	63.7%	63.6%	63.6%	63.6%
Average cranes per vessel	**cranes/vessel**	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.6	2.6	2.6	2.5	2.5	2.6	2.5	2.5	2.5	2.6	2.7	2.8	2.8	2.8	2.8	2.7	2.7	2.7	2.7	2.7	2.6	2.6
Gross Crane Rate (Scenario A, B1, B3)	**moves/hour**	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27
Gross Crane Rate (Scenario B2, C)	**moves/hour**	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Vessel Productive Time (Scenario A, B3)	**%**	90.0%	89.8%	89.3%	88.8%	88.0%	88.4%	88.7%	88.3%	88.6%	89.0%	89.1%	89.4%	89.6%	89.6%	89.9%	90.1%	90.2%	90.0%	90.0%	89.9%	89.9%	89.6%	89.6%	89.3%	89.5%	89.6%	89.8%	89.3%	89.5%
Vessel Productive Time (Scenario B1)	**%**	90.0%	89.7%	89.2%	88.6%	87.7%	88.0%	88.2%	87.8%	88.0%	88.3%	88.5%	88.8%	89.0%	89.0%	89.3%	89.6%	89.6%	89.4%	89.4%	89.4%	89.3%	89.0%	89.0%	88.7%	88.9%	89.1%	89.3%	88.7%	88.9%
Vessel Productive Time (Scenario B2)	**%**	89.0%	88.8%	88.3%	87.7%	86.9%	87.2%	87.6%	87.2%	87.5%	87.9%	88.1%	88.4%	88.5%	88.6%	88.9%	89.1%	89.2%	89.0%	89.0%	88.9%	88.9%	88.5%	88.6%	88.2%	88.4%	88.6%	88.8%	88.3%	88.5%
Vessel Productive Time (Scenario C)	**%**	89.0%	88.7%	88.1%	87.4%	86.5%	86.8%	87.1%	86.6%	86.9%	87.2%	87.4%	87.7%	87.9%	88.0%	88.3%	88.5%	88.6%	88.4%	88.4%	88.3%	88.3%	87.9%	87.9%	87.6%	87.8%	88.0%	88.2%	87.6%	87.8%
Yard Capacity																														
Number of ground slots- Dry	**no. TGS**	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642
Dry Stack height	**no.**	2.5	2.5	2.5	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Number of Ground Slots - Reefer	**no. TGS**	664	664	664	664	664	664	664	664	664	664	664	664	664	664	664	664	664	664	664	664	664	664	664	664	664	664	664	664	664
Reefer Stack Height	**no.**	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Total Static Capacity	**no.**	15,433	15,433	15,433	19,382	19,382	19,382	19,382	19,382	19,382	19,382	19,382	19,382	19,382	19,382	19,382	19,382	19,382	19,382	19,382	19,382	19,382	19,382	19,382	19,382	19,382	19,382	19,382	19,382	19,382
Dwell times																														
Imports - Full	**days/container**	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Imports - Empty	**days/container**	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Exports - Full	**days/container**	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Exports - Empty	**days/container**	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Transhipment - Inward	**days/container**	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Transhipment - Outward	**days/container**	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Transhipment - Empty	**days/container**	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Average Dwell Time	**days/container**	2.9	3.0	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Storage area utilisation	**%**	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%
GATE (Road) Capacity																														
In-Gate Number - Main	**no**	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Out-Gate Number	**no**	ASSUMED NO CONSTRAINT																												
In-Gate - Main Processing Times per Lane	**secs/truck**	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
Maximum in gate productivity	**%**	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
Average parcel size/vehicle	**TEU/truck**	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7

Appendix C – Key Model Inputs by Year - SDW

BLACK QUAY CONSULTING

	Trade Year	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
General Parameters																														
Operating Hours/Day - Berth	**hours/day**	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Operating Hours/Day - Yard	**hours/day**	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Operating Hours/Day - Road Gate	**hours/day**	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
Operating Days per Year - Berth	**days/year**	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7
Operating Days per Year - Yard	**days/year**	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7
Operating Days per Year - Gate	**days/year**	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7
TEU Factor (Scenario A, B2, B3)	**TEU/container**	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
TEU Factor (Scenario B1, C)	**TEU/container**	1.60	1.61	1.63	1.64	1.65	1.66	1.68	1.69	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70
Assumed Trade Characteristics (from trade forecasts)																														
Imports - Full	**%**	46.4%	45.9%	46.2%	46.2%	46.2%	46.2%	46.1%	46.1%	46.1%	46.1%	46.1%	46.1%	46.1%	46.1%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%
Imports - Empty	**%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Exports - Full	**%**	22.8%	24.1%	23.1%	21.4%	21.5%	21.7%	22.0%	21.9%	21.9%	21.8%	21.9%	21.9%	22.0%	22.1%	22.1%	22.2%	22.2%	22.2%	22.2%	22.2%	22.2%	22.3%	22.3%	22.3%	22.4%	22.4%	22.4%	22.5%	22.5%
Exports - Empty	**%**	25.5%	24.2%	25.5%	27.2%	27.2%	27.0%	26.8%	26.9%	27.0%	27.0%	27.0%	26.9%	26.9%	26.8%	26.8%	26.7%	26.8%	26.8%	26.8%	26.8%	26.8%	26.7%	26.7%	26.7%	26.7%	26.6%	26.6%	26.6%	26.5%
Transhipment - Inward	**%**	2.3%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%
Transhipment - Outward	**%**	2.8%	3.2%	2.6%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
Transhipment - Empty	**%**	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%
Berth Capacity																														
Average Vessel Length (from Fleet Forecasts)	**m LOA**	274	275	275	275	280	282	285	284	287	291	291	294	298	297	298	299	300	302	303	300	299	296	293	290	296	300	303	303	303
Effective Number of berths	**no.**	2.0	2.0	2.0	2.0	2.0	3.0	3.0	3.0	2.9	2.9	2.9	2.9	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.9	2.9	2.9	2.9	2.8	2.8	2.8	2.8
Berth Occupancy Factor (Scenario A, B1, B2)	**%**	53.0%	53.0%	53.0%	53.0%	53.0%	62.9%	62.6%	62.8%	62.4%	62.0%	62.1%	61.7%	61.4%	61.5%	61.4%	61.3%	61.2%	61.0%	61.0%	61.2%	61.3%	61.6%	61.9%	62.1%	61.6%	61.3%	61.0%	61.0%	60.9%
Berth Occupancy Factor (Scenario B3, C)	**%**	60.0%	60.0%	60.0%	60.0%	60.0%	65.0%	64.8%	64.9%	64.7%	64.5%	64.5%	64.4%	64.2%	64.2%	64.2%	64.1%	64.1%	64.0%	64.0%	64.1%	64.2%	64.3%	64.5%	64.6%	64.3%	64.1%	64.0%	64.0%	64.0%
Average cranes per vessel	**cranes/vessel**	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.6	2.6	2.6	2.5	2.5	2.6	2.5	2.5	2.5	2.6	2.7	2.8	2.8	2.8	2.8	2.7	2.7	2.7	2.7	2.7	2.6	2.6
Gross Crane Rate (Scenario A, B1, B3)	**moves/hour**	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27
Gross Crane Rate (Scenario B2, C)	**moves/hour**	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Vessel Productive Time (Scenario A, B3)	**%**	90.0%	89.8%	89.3%	88.8%	88.0%	88.4%	88.7%	88.3%	88.6%	89.0%	89.1%	89.4%	89.6%	89.6%	89.9%	90.1%	90.2%	90.0%	90.0%	89.9%	89.9%	89.6%	89.6%	89.3%	89.5%	89.6%	89.8%	89.3%	89.5%
Vessel Productive Time (Scenario B1)	**%**	90.0%	89.7%	89.2%	88.6%	87.7%	88.0%	88.2%	87.8%	88.0%	88.3%	88.5%	88.8%	89.0%	89.0%	89.3%	89.6%	89.6%	89.4%	89.4%	89.4%	89.3%	89.0%	89.0%	88.7%	88.9%	89.1%	89.3%	88.7%	88.9%
Vessel Productive Time (Scenario B2)	**%**	89.0%	88.8%	88.3%	87.7%	86.9%	87.2%	87.6%	87.2%	87.5%	87.9%	88.1%	88.4%	88.5%	88.6%	88.9%	89.1%	89.2%	89.0%	89.0%	88.9%	88.9%	88.5%	88.6%	88.2%	88.4%	88.6%	88.8%	88.3%	88.5%
Vessel Productive Time (Scenario C)	**%**	89.0%	88.7%	88.1%	87.4%	86.5%	86.8%	87.1%	86.6%	86.9%	87.2%	87.4%	87.7%	87.9%	88.0%	88.3%	88.5%	88.6%	88.4%	88.4%	88.3%	88.3%	87.9%	87.9%	87.6%	87.8%	88.0%	88.2%	87.6%	87.8%
Yard Capacity																														
Number of ground slots- Dry	**no. TGS**	4,482	4,482	4,482	4,482	4,482	4,482	4,482	4,482	4,482	4,482	4,482	4,482	4,482	4,482	4,482	4,482	4,482	4,482	4,482	4,482	4,482	4,482	4,482	4,482	4,482	4,482	4,482	4,482	4,482
Dry Stack height	**no.**	2.5	2.5	2.5	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Number of Ground Slots - Reefer	**no. TGS**	650	650	650	650	650	650	650	650	650	650	650	650	650	650	650	650	650	650	650	650	650	650	650	650	650	650	650	650	650
Reefer Stack Height	**no.**	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Total Static Capacity	**no.**	12,505	12,505	12,505	15,642	15,642	15,642	15,642	15,642	15,642	15,642	15,642	15,642	15,642	15,642	15,642	15,642	15,642	15,642	15,642	15,642	15,642	15,642	15,642	15,642	15,642	15,642	15,642	15,642	15,642
Dwell times																														
Imports - Full	**days/container**	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Imports - Empty	**days/container**	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Exports - Full	**days/container**	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Exports - Empty	**days/container**	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Transhipment - Inward	**days/container**	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Transhipment - Outward	**days/container**	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Transhipment - Empty	**days/container**	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Average Dwell Time	**days/container**	2.9	3.0	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Storage area utilisation	**%**	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%
GATE (Road) Capacity																														
In-Gate Number - Main	**no**	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Out-Gate Number	**no**	ASSUMED NO CONSTRAINT																												
In-Gate - Main Processing Times per Lane	**secs/truck**	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
Maximum in gate productivity	**%**	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
Average parcel size/vehicle	**TEU/truck**	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7

Appendix D – Key Model Inputs by Year - WDE

BLACK QUAY
CONSULTING

	Trade Year	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
General Parameters																														
Operating Hours/Day - Berth	**hours/day**	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Operating Hours/Day - Yard	**hours/day**	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Operating Hours/Day - Road Gate	**hours/day**	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
Operating Days per Year - Berth	**days/year**	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7
Operating Days per Year - Yard	**days/year**	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7
Operating Days per Year - Gate	**days/year**	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7	362.7
TEU Factor (Scenario A, B2, B3)	**TEU/container**	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
TEU Factor (Scenario B1, C)	**TEU/container**	1.60	1.61	1.63	1.64	1.65	1.66	1.68	1.69	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70
Assumed Trade Characteristics (from trade forecasts)																														
Imports - Full	**%**	46.4%	45.9%	46.2%	46.2%	46.2%	46.2%	46.1%	46.1%	46.1%	46.1%	46.1%	46.1%	46.1%	46.1%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%	46.0%
Imports - Empty	**%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Exports - Full	**%**	22.8%	24.1%	23.1%	21.4%	21.5%	21.7%	22.0%	21.9%	21.9%	21.8%	21.9%	21.9%	22.0%	22.1%	22.1%	22.2%	22.2%	22.2%	22.2%	22.2%	22.2%	22.3%	22.3%	22.3%	22.4%	22.4%	22.4%	22.5%	22.5%
Exports - Empty	**%**	25.5%	24.2%	25.5%	27.2%	27.2%	27.0%	26.8%	26.9%	27.0%	27.0%	27.0%	26.9%	26.9%	26.8%	26.8%	26.7%	26.8%	26.8%	26.8%	26.8%	26.8%	26.7%	26.7%	26.7%	26.7%	26.6%	26.6%	26.6%	26.5%
Transhipment - Inward	**%**	2.3%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%
Transhipment - Outward	**%**	2.8%	3.2%	2.6%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
Transhipment - Empty	**%**	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%
Berth Capacity																														
Average Vessel Length (from Fleet Forecasts)	**m LOA**	310	302	303	303	303	301	302	292	301	304	304	310	319	321	326	329	330	332	331	331	336	336	333	328	331	334	337	338	343
Effective Number of berths	**no.**	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Berth Occupancy Factor (Scenario A, B1, B2)	**%**	53.0%	53.0%	53.0%	53.0%	53.0%	53.0%	53.0%	53.0%	53.0%	53.0%	53.0%	53.0%	53.0%	53.0%	53.0%	53.0%	53.0%	53.0%	53.0%	53.0%	53.0%	53.0%	53.0%	53.0%	53.0%	53.0%	52.9%	52.7%	52.1%
Berth Occupancy Factor (Scenario B3, C)	**%**	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	59.9%	59.6%	58.9%
Average cranes per vessel	**cranes/vessel**	2.8	2.7	2.7	2.7	2.7	2.9	3.1	3.1	3.1	3.1	3.2	3.2	3.1	3.1	3.2	3.2	3.2	3.3	3.3	3.6	3.6	3.6	3.7	3.8	3.8	3.8	3.8	3.8	3.8
Gross Crane Rate (Scenario A, B1, B3)	**moves/hour**	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27
Gross Crane Rate (Scenario B2, C)	**moves/hour**	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Vessel Productive Time (Scenario A, B3)	**%**	91.1%	89.9%	89.7%	89.2%	88.4%	88.0%	87.8%	88.2%	88.5%	88.9%	89.5%	89.8%	90.3%	90.8%	90.8%	91.0%	91.2%	91.3%	91.5%	91.2%	91.4%	91.6%	91.6%	91.7%	91.9%	92.0%	92.2%	92.4%	92.5%
Vessel Productive Time (Scenario B1)	**%**	91.1%	89.8%	89.5%	89.0%	88.0%	87.6%	87.3%	87.6%	87.9%	88.3%	88.9%	89.2%	89.8%	90.3%	90.2%	90.5%	90.7%	90.8%	91.0%	90.7%	90.9%	91.2%	91.1%	91.3%	91.4%	91.6%	91.7%	92.0%	92.1%
Vessel Productive Time (Scenario B2)	**%**	91.4%	90.2%	90.0%	89.6%	88.7%	88.4%	88.2%	88.6%	88.9%	89.3%	89.8%	90.1%	90.6%	91.1%	91.1%	91.3%	91.5%	91.6%	91.8%	91.5%	91.7%	91.9%	91.9%	92.0%	92.2%	92.3%	92.5%	92.7%	92.8%
Vessel Productive Time (Scenario C)	**%**	91.4%	90.1%	89.9%	89.3%	88.4%	88.0%	87.7%	88.0%	88.3%	88.7%	89.3%	89.6%	90.1%	90.6%	90.6%	90.8%	91.1%	91.1%	91.3%	91.0%	91.2%	91.5%	91.4%	91.6%	91.7%	91.9%	92.0%	92.2%	92.4%
Yard Capacity																														
Number of ground slots- Dry	**no. TGS**	2780	3614	3892	3892	3892	3892	4170	4170	4170	4170	4170	4170	4170	4170	4170	4170	4170	4170	4170	4170	4170	4170	4170	4170	4170	4170	4170	4170	4170
Dry Stack height	**no.**	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Number of Ground Slots - Reefer	**no. TGS**	164	213	230	230	230	230	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246
Reefer Stack Height	**no.**	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Total Static Capacity	**no.**	14,720	19,136	20,608	20,608	20,608	20,608	22,080	22,080	22,080	22,080	22,080	22,080	22,080	22,080	22,080	22,080	22,080	22,080	22,080	22,080	22,080	22,080	22,080	22,080	22,080	22,080	22,080	22,080	22,080
Dwell times																														
Imports - Full	**days/container**	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Imports - Empty	**days/container**	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Exports - Full	**days/container**	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Exports - Empty	**days/container**	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Transhipment - Inward	**days/container**	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Transhipment - Outward	**days/container**	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Transhipment - Empty	**days/container**	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Average Dwell Time	**days/container**	2.9	3.0	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Storage area utilisation	**%**	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%
ASC Capacity																														
Waterside ASC's	**no.**	10	13	14	14	14	14	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
ASC Gross moves per hour	**moves/hour**	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
Gross Working Time	**%**	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
% Housekeeping Moves	**%**	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%
GATE (Road) Capacity																														
In-Gate Number - OCR	**no**	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
In-Gate Number - Main	**no**	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Out-Gate Number	**no**	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
In-Gate - OCR Processing Times per Lane	**secs/truck**	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
In-Gate - Main Processing Times per Lane	**secs/truck**	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
Out-Gate Processing Times per Lane	**secs/truck**	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Maximum in gate productivity	**%**	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
Maximum out gate productivity	**%**	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
Average parcel size/vehicle	**TEU/truck**	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7

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