Port of Melbourne – Container Capacity Review

Final Report

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BLACK QUAY CONSULTING

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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
NMPH	Net 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
UNCTAD	United Nations Conference on Trade and Development

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 Port of Melbourne (PoM). A number of modelling inputs were agreed with PoM. These are broadly summarised as follows:

- TEU:box ratio of 1.60
- 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 unexpected 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 TEU/crane/annum at the Swanson Dock terminals and 150,000TEU/crane/annum at WDE
- A net STS crane rate of 31nmph across crane working time, with crane working time assumed to be 87.5% of vessel productive time
- 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 to be 2.5 (straddle) and 5 (ASC). Reefer stack heights assumed to be 2 (straddle) and 5 (ASC)
- In the absence of current data, 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 (Base model assumes 2 days)
    - Export (Full): 4 - 6 days (Base model assumes 5 days)

  - Empties: 2 - 4 days (Base model 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.

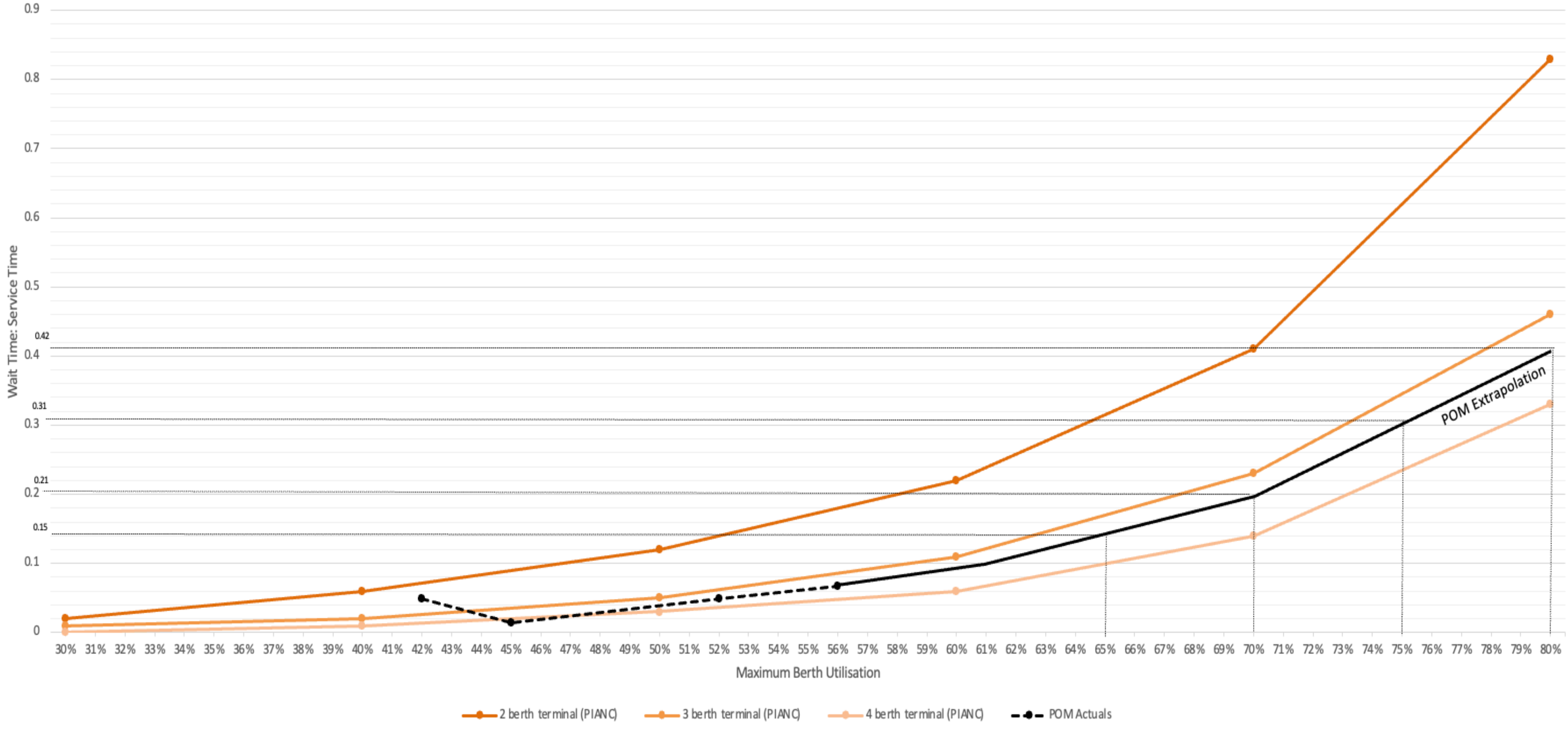
Black Quay identified three industry-recognised guidance documents (over and above PIANC WG158) which provided quantitative guidance. These are as follows:

- *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.

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%

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 not only undertaken on the Base Model (Scenario A), but also on a number of alternative scenarios which explored the sensitivity of key parameters within the model. These are as follows:

a) Base model based on the factors contained within Sections 3 to 7

b) Net crane working rate increased to 34nmph

c) Net crane working rate decreased to 28nmph

d) Dwell times increased by 0.5 days across each type

e) Dwell times decreased by 0.5 days across each type

f) Crane allocation modified to an average of two (2) cranes capable of working on vessels up to 5,000TEU, 3 cranes on vessels between 5,000-7,000 TEU, and 4 cranes on vessels over 7,000 TEU

g) Berth utilisation increased to 55% for a 2-berth and 65% for a 3-berth terminal (effective berth calculations remain unchanged.

The results of each of these scenarios is provided in the following figure.

Figure 3 **Model Findings Summary (TEU Optimum Annual Capacity in Year 2030) (Black Quay, 2022)**

Terminal		Scenario A	Scenario B	Scenario C	Scenario D	Scenario E	Scenario F	Scenario G
		Base	Crane working rate increased	Crane working rate decreased	Dwell times increased	Dwell times decreased	Increased cranes for larger vessels	Increased berth utilisation
Swanson Dock East	Berth[5]	1,260,000	1,260,000	1,257,000	1,260,000	1,260,000	1,260,000	1,260,000
	Yard	1,340,000	1,340,000	1,340,000	1,145,000	1,617,000	1,340,000	1,340,000
	Gate	1,785,000	1,785,000	1,785,000	1,785,000	1,785,000	1,785,000	1,785,000
	Constraint	Berth	Berth	Berth	Yard	Berth	Berth	Berth
	Max. Berth Utilisation[6]	61.6%	61.6%	61.6%	61.6%	61.6%	61.9%	65.0%
Swanson Dock West	Berth[5]	1,400,000	1,400,000	1,310,000	1,400,000	1,400,000	1,400,000	1,400,000
	Yard[1]	1,086,000	1,086,000	1,086,000	927,000	1,310,000	1,086,000	1,086,000
	Yard (with WSIT)	1,586,000	1,586,000	1,586,000	1,354,000	1,913,000	1,586,000	1,586,000
	Gate	3,570,000	3,570,000	3,570,000	3,570,000	3,570,000	3,570,000	3,570,000
	Constraint[3]	Berth	Berth	Berth	Yard	Berth	Berth	Berth
	Max. Berth Utilisation[6]	62.4%	62.4%	62.4%	62.4%	62.4%	62.7%	65.0%
Webb Dock East	Berth[5]	990,000	1,077,000	902,000	990,000	990,000	1,030,000	1,200,000
	Yard[2]	1,278,000	1,278,000	1,278,000	1,092,000	1,542,000	1,278,000	1,278,000
	Gate	6,545,000	6,545,000	6,545,000	6,545,000	6,545,000	6,545,000	6,545,000
	Constraint	Berth	Berth	Berth	Berth	Berth	Berth	Berth
	Max. Berth Utilisation[6]	53.0%	53.0%	53.0%	53.0%	53.0%	53.0%	65.0%
Total Indicative POM Capacity		3,650,000	3,737,000	3,469,000	3,489,000	3,650,000	3,690,000	3,860,000

Fig 3 Notes:

1. This is based on existing terminal only with assumed dwell times. Utilisation of the WSIT Area or just-in-time empty operations could increase this capacity as indicated.
2. Includes expansion to 13 ASC blocks as planned in 2023 and expansion to 15 ASC blocks by 2030 where required by scenario.
3. Constraint is based on considering the yard capacity including the use of WSIT.
4. Gate capacity at each terminal is based on an assumption of efficient gate operations with booking systems to alleviate peaking. Where this does not occur, achievable gate capacities will be reduced.
5. Berth capacity quoted is based upon limitations on crane minimum spacing and assumed annual productivity.
6. The maximum berth utilisation is based on assumed values for 1, 2 and 3 berth terminals reflecting maintenance of a certain level of service to the customer. Where the effective number of berths falls between whole numbers these values are interpolated. The value shown in the table is that calculated in 2030. Reference to Chapter 4.11 should be made for further context.
7. The capacities above are shown as modelled in year 2030. Please refer to figures contained within Appendix A for limiting capacity over the model timeframe.

Black Quay has undertaken terminal capacity modelling for each of the three international container terminals at Port of Melbourne.

The capacity modelling indicated that the combined capacity of the terminals is in the order of 3,860,000 TEU/annum. This is comprised of the following:

- SDE: 1,260,000
- SDW: 1,400,000
- WDE: 1,200,000

This capacity limitation represents an upper ceiling based on maximum practical STS crane deployment on the berthline. 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.

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 falls within the limits that would be reasonably expected of a regional port where these caps are in place
- As a result of the ultimate capacity being dictated by a cap on achievable crane spacings and annual productivities, scenarios that explore adjustment in crane productivity, berth utilisation and crane allocation (Scenarios B, C, F, G) do not typically alter the maximum capacity of the berthline. It does, however, change when this cap is expected to be reached. For example:
  - At SDW, the berth cap is expected to be reached in 2029 under Scenario A, 2027 under Scenario B, post-2050 under Scenario C, and 2027 under Scenario F and Scenario G
  - At SDE, the berth cap is expected to be reached as soon as the crane numbers at the berth reach 9 under all Scenarios
  - At WDE, the berth cap is expected to be reached in 2044 under Scenario A, 2041 under Scenario B, 2042 under Scenario F and 2028 under Scenario G. The berth cap is not reached within the model timeframes under Scenario C
- For the scenarios that explored changes in dwell times (Scenarios D and E), a decrease in the assumed dwell times across the terminals does not provide a capacity increase due to all terminals being ultimately berth constrained.
- 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.

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 taken 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

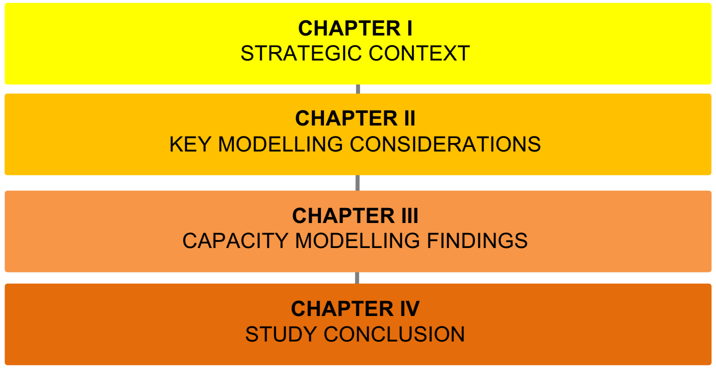
Black Quay Maritime Consulting Pty Ltd. (Black Quay) has been commissioned by Port of Melbourne (POM) to provide an independent assessment of container handling capacity at the Port of Melbourne (the Port).

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.

Various discussions were held with Port of Melbourne staff to assess the validity and suitability of the data and information provided by the Port.

1.2 Report Structure

The study chapters are illustrated below.



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 Supplied material
5. Other Publicly accessible documentation

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 4. 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.

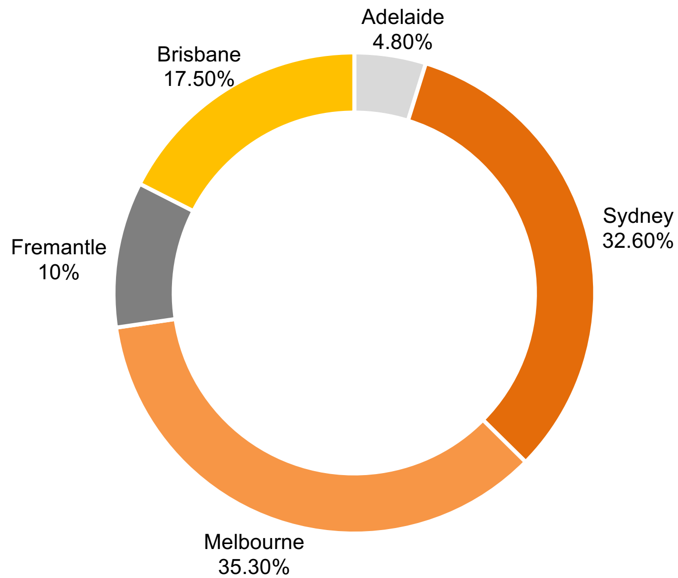
Port of Melbourne is currently the largest primary international container port in Australia, representing over 35% of the nation's task.

Figure 4 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 5. Melbourne's share has increased slightly since 2019.

Figure 5 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.

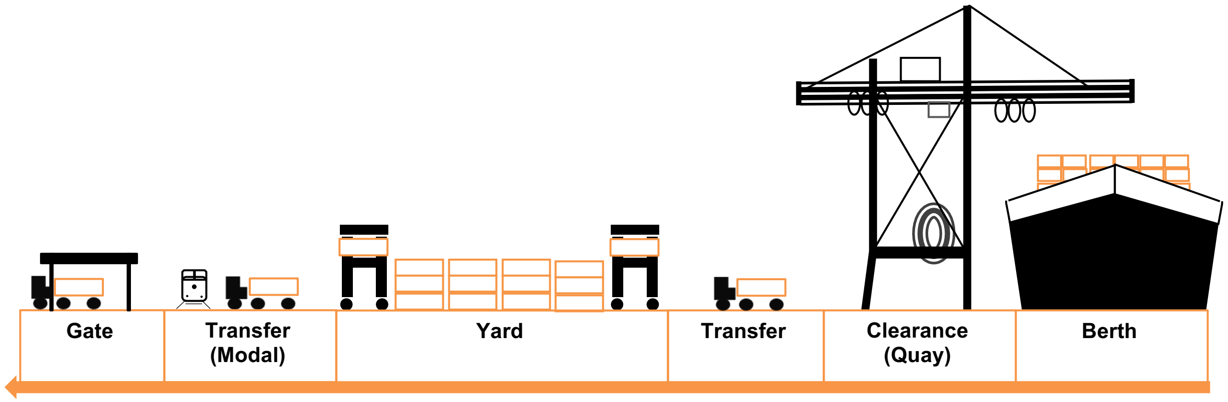
The regimes adopted in different terminals around the world differ significantly depending on the port type, port task and the subsequent infrastructure regime employed. Infrastructure and operational regime trends in the world's major transhipment ports for instance are significantly different from 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 6 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[1]

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[2]. 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)[1]

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), 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[3], operating as a three (3) berth terminal, with an alongside depth of 14.6m (facilitating a maximum draught of 14.0m)[2] 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.

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

[3] 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) [1]

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[2], 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 7 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[4]
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

In addition to the above, there are wider container capacity initiatives being explored outside of the existing terminals. However, the modelling of these projects is not within the scope of this project.

[4] 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. The forecasts were broken down across full, empty, import, export and transhipment volumes, including both international and Bass Strait trade.

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 8 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 67 highlights a TEU to box ratio of approximately 1.59 across the PoM container terminals (July to December 2020).

In the absence of any forecast changes to the TEU ratio contained within the trade forecasts, PoM has confirmed that a ratio of 1.60 should be utilised for modelling, with the provision to be sensitivity tested.

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 360 day/year. This allows for standard closures from Christmas Eve to 06:00 Boxing Day, New Year's Day, and some additional allowance for stoppages such as high winds and/or industrial action.

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

Information provided by PoM contained data on actual closure hours experienced by each terminal due to high winds or other events.

Based on a 5-year maximum value, the adopted berth operating days/year were 362 for SDE, 363 for SDW and 365 for WDE. It was noted that in FY21 the actual operating days were 362, 356 and 362 for each of SDE, SDW and VICT respectively.

Therefore, the values adopted in this report are considered realistic.

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 unexpected fluctuations such as terminal shutdowns[5] (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.

The optimum annual capacity is calculated as equal to:

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

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 overinvestment. For example, a greater factor could be adopted which assumes the occurrence of 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.
- 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.

[5] Beyond the allowance already considered within the assumed operating days per year, as outlined in Section 3.4.

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 9 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[6]
Webb Dock East	660m	2	330m

[6] 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.

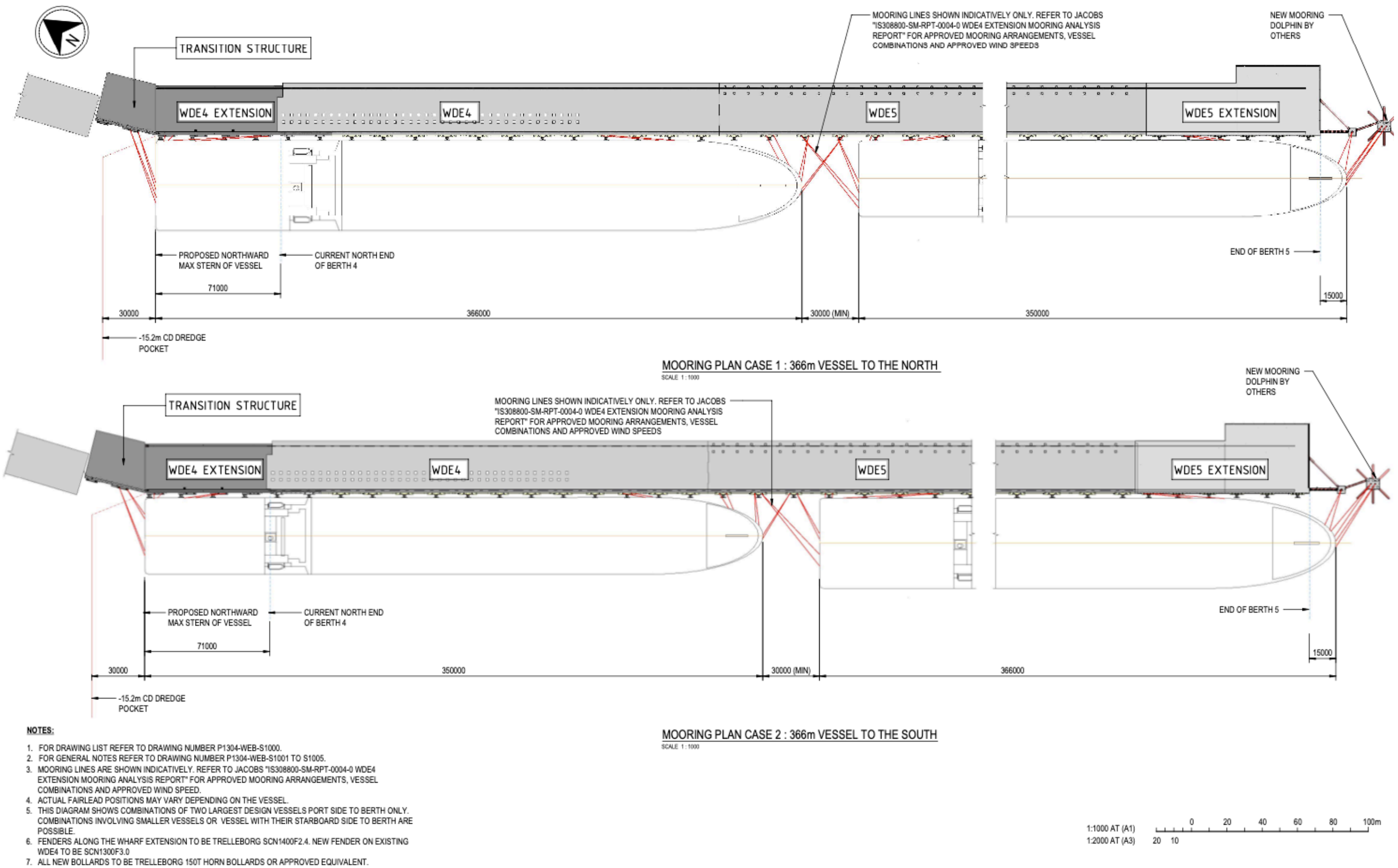
Other restrictions at Swanson Dock contained within the Harbourmaster’s directions are as follows:

- 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 10 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 reduce their berth availability for this period.

For the purposes of modelling, the following is assumed regarding these works:

- Works duration is 5 years commencing in 2022
- 700m of berth will be available at any point in time over this period. It is assumed that this will be provided in a manner that provides two (2) useable berths.

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:

$$n = \frac{Total\ berthline}{Average\ vessel\ length\ x\ \left(100\% + separation\ distance^{7}\right)}$$

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. 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.

[7] Refer to Mooring Gap Assumptions in Section 4.6

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
- The maximum practical STS crane productivity for a gateway terminal is 140,000-160,000TEU/annum/crane as per guidance contained within PIANC WG158. Black Quay note that this represents a highly efficient terminal and cranes. For the purposes of the modelling, it is assumed that the Swanson Dock terminals can achieve 140,000 TEU/crane/annum[8] and WDE can achieve 150,000TEU/crane/annum owing to enhanced reliability associated with its automation. It is noted that this is considered an optimum annual capacity and therefore an additional 15% factor (as discussed in Section 3.5) has not been applied to this figure.

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

- SDE – 9 STS cranes maximum
- SDW – 10 STS cranes maximum
- WDE – 8 STS cranes maximum

[8] It is noted that the existing PoM terminals have historically achieved figures above this at times and in the order of 190,000 TEU/crane/annum. However, into the future it is anticipated that additional cranes will be required at the PoM terminals due to increasing vessel sizes (up to a maximum number of cranes dictated by the berthline and minimum crane spacing). Where additional cranes are present on the berthline, it is expected that individual cranes will not be worked as hard and annual productivities would fall within PIANC guidance.

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.

In this instance, Gross Crane Rate is taken as being equal to the Net Crane Rate multiplied by the Crane Working Rate. These are defined in the following items.

4.8 Net Crane Rates

Information provided by BITRE suggests that crane rates achieved in 2020 (27.1 in the September Quarter and 28.0 in the December Quarter), were slightly down on those recorded over previous years, when 30-31.5mph was regularly achieved.

BITRE crane rate figures are considered to be similar to net crane rates once operational and non-operational delays have been taken into account (such as weather, hatch handling etc).

In the future and based on the published figures by BITRE, it is assumed that the net crane rate would be approximately 31mph.

4.9 Crane Working Rate

The average amount of time each crane at berth will work the vessel as a percentage of the vessel productive time has been assumed to be 87.5% of vessel productive time.

This is based upon advice from PoM which assumes a 1-hour shift handover for every 8-hour shift.

4.10 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.

This accounts for vessel mooring and de-mooring time etc and has been assumed to be 3 hours per vessel and the assumed vessel time at berth based on the crane deployment and productivity assumptions outlined in Sections 4.5, 4.8 and 4.9.

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4.11 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)[9].

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.

4.11.1 PIANC Guidance

PIANC[10] 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[11] 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[12] 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.

[9] 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'.

[10] 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.

[11] 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.

[12] 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 11 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

4.11.2 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[13] 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.

[13] 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.

Agershou 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 12 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 13 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

4.11.3 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.

Figure 14 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:

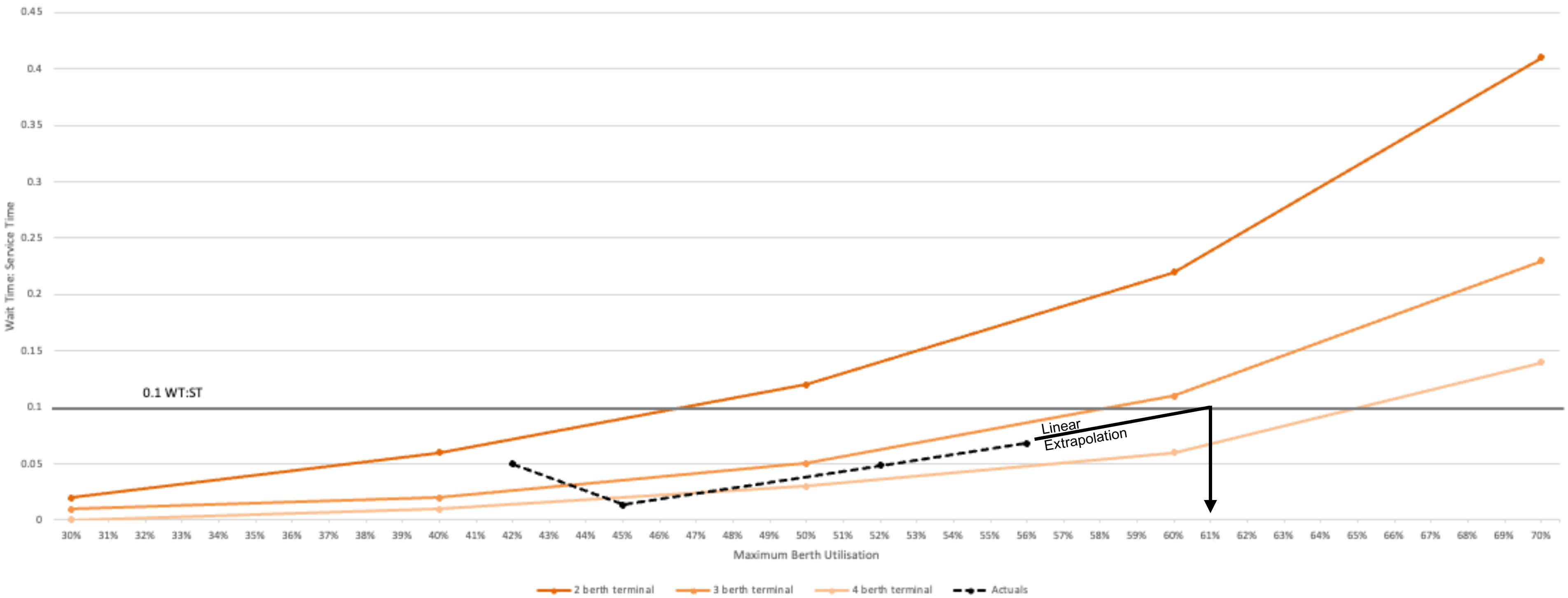
1. Information directly from BITRE Waterline 67

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 15 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.

4.11.4 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 PoM 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.

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.

Figure 16 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.

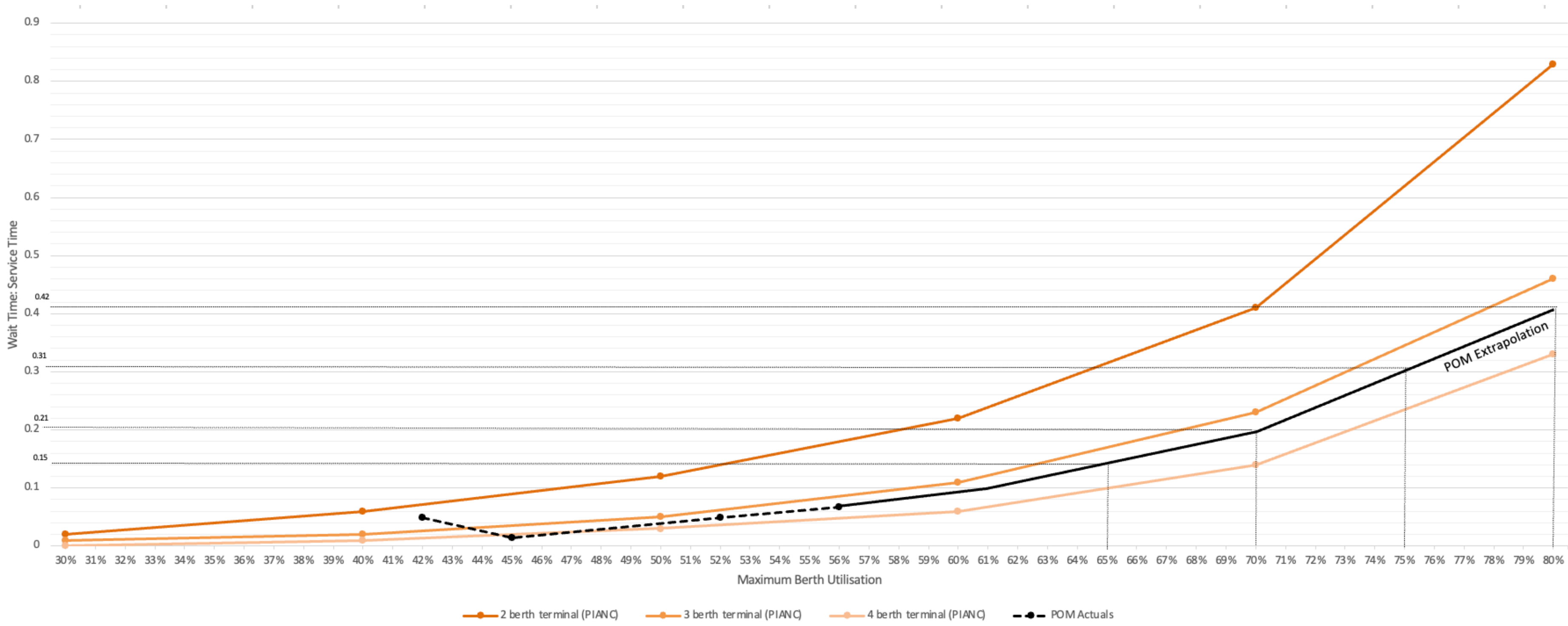
It is worth noting that this assumes that the terminal operators would wish to maintain a service level of ‘BB’ as defined by Monfort in Figure 12.

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 9).

To further highlight this point and with extrapolation of the PoM-wide profile contained within Figure 15, 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 17 Forecast Service impacts at Higher Berth Utilisations (Black Quay, 2022)



4.11.5 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.

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).

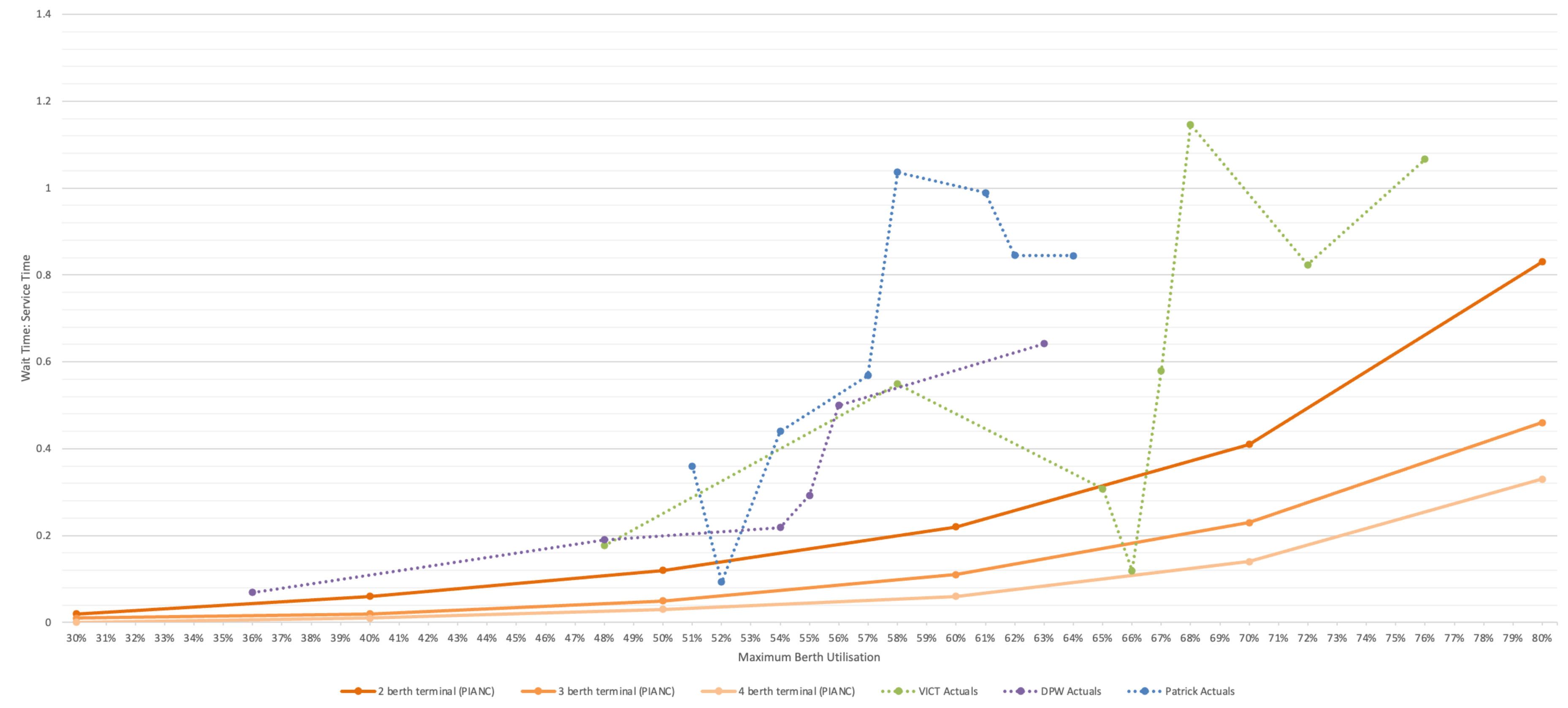
Whilst the supply chain, including the system serving Melbourne and wider Victoria will likely adapt to some extent as a result of these unsustainable and increasing pressures, the sensitivities associated with berth utilization at the port will continue to have both direct and consequential impacts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

4.11.6 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 extensive vessel queueing and wait times have been experienced (refer to Figure 18). These levels are beyond what would be expected by the PoM curve and associated recommendations contained within Figure 15.

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 18 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 19 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 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%[14]
- 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 20 Maximum Stacking Heights (# of containers)

Terminal	Dry slots	Reefer
Swanson Dock East	2.5[1]	2
Swanson Dock West	2.5[1]	2
Webb Dock East	5	5

Note:
1. Based on a maximum stacking height of 3 and 2 containers in alternating ground slots.

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.

Current information for dwell times has not been provided. In the absence of current data, the following values have been assumed which are considered reflective of an efficient gateway terminal.

- Import (Full): 1.5 - 2.5 days (Base model assumes 2 days)
- Export (Full): 4 - 6 days (Base model assumes 5 days)
- Empties: 2 - 4 days (Base model assumes 3 days)
- Transhipment: 2 days

The sensitivity of terminal capacity has been tested with the dwell times listed above. These figures can be updated in the model, if and when current figures are provided for each terminal.

[14] 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.

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 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.

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 a function of operating hours, number of berths, crane handling capacity, crane allocation, and berth utilisation.

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.

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

> The capacity of the yard (a function of yard slots, dwell times, achievable utilisation and stack heights)

> The capacity of the ASC's servicing it (a function of the operational hours, number of waterside ASC's, assumed ASC handling rate, ASC productivity and proportion of housekeeping moves).

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 function of operational hours, number of gates, processing time and achievable utilisation.

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.

8.1 Scenarios Assessed

In order to provide sensitivity testing on the key assumptions made within the model, modelling was undertaken of the following scenarios:

a) Base model based on the factors contained within Sections 3 to 7

b) Net crane working rate increased to 34nmph[15]

c) Net crane working rate decreased to 28nmph

d) Dwell times increased by 0.5 days across each type

e) Dwell times decreased by 0.5 days across each type

f) Crane allocation modified to average of two (2) cranes working on vessels up to 5,000TEU, 3 cranes on vessels between 5,000-7,000 TEU, and 4 cranes on vessels over 7,000 TEU

g) Berth utilisation increased to 65%, regardless of number of effective berths (effective berth calculations remain unchanged).

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.

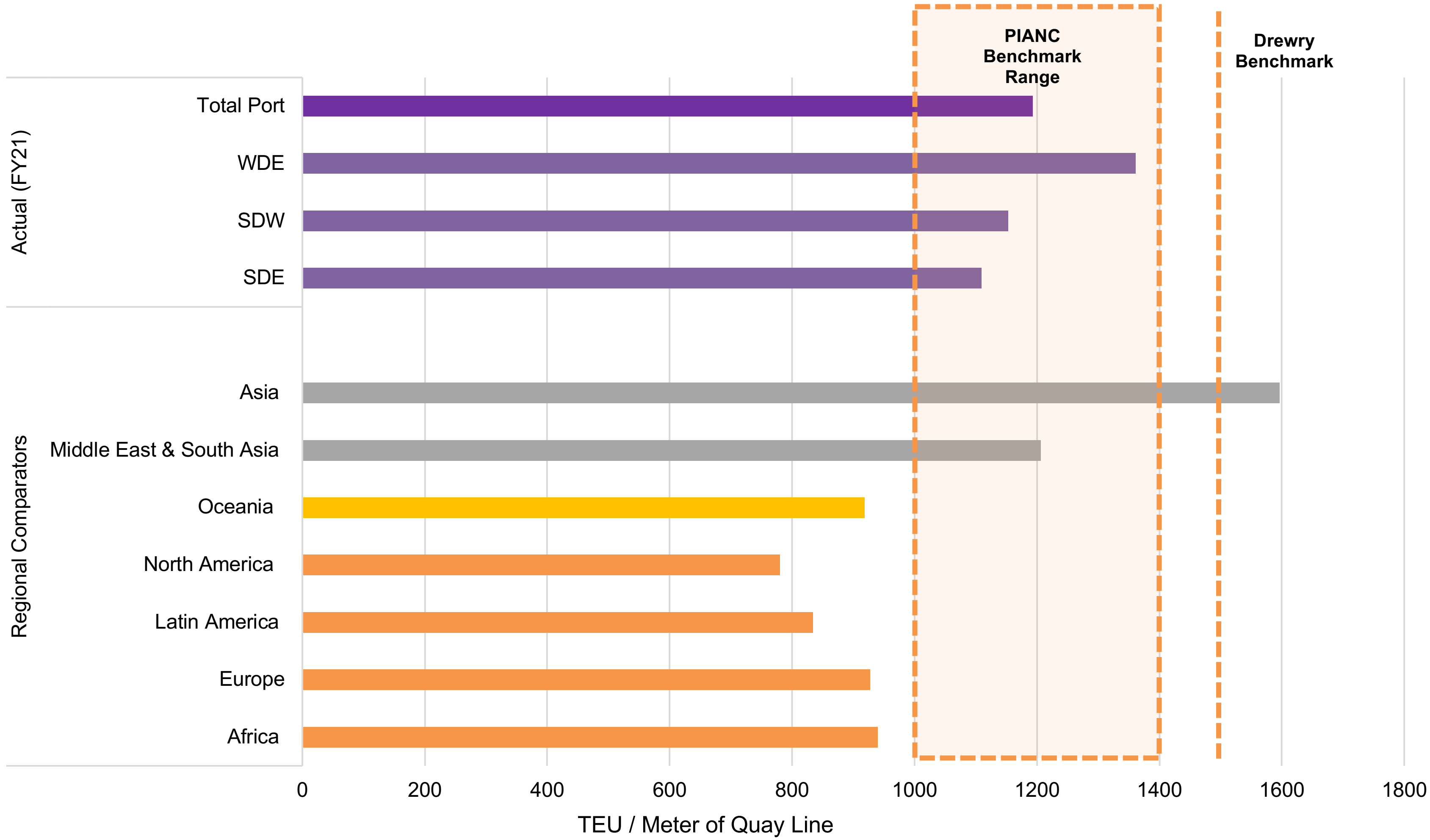
It is generally accepted that a quay line productivity of 1,100 to 1,500 TEU/m/annum is considered reasonable for regional ports. PIANC WG158 notes that this industry benchmark is appropriate for well-planned and well-equipped facilities handling large mainline container vessels. High-capacity transhipment ports can achieve over 2,000 TEU/m/annum.

Information provided by PoM provides quay line productivity comparisons. This is depicted in the figure below and supports that a quay line productivity of around 1,000 – 1,500 TEU/m/annum is reasonable.

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.

[15] To put this in context, this is not dissimilar to crane rates achieved at Flinders Adelaide Container Terminal in recent years, as per information contained within BITRE Waterline 67.

Figure 21 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 base scenario modelling for each of the terminals are depicted in Figure 22 to Figure 25.

Key inputs to the model as detailed within Section II, 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 parcel 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).

To demonstrate the effect of average cranes per vessel and effective berths on calculated berth capacity, these have been included in the graph outputs.

9.1 Swanson Dock East Capacity (Base Case)

The calculated Swanson Dock East capacity (under the base case) is depicted in Figure 22.

Under the base case 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[16] (as per the assumptions contained within Section 4.5) that limits the capacity.

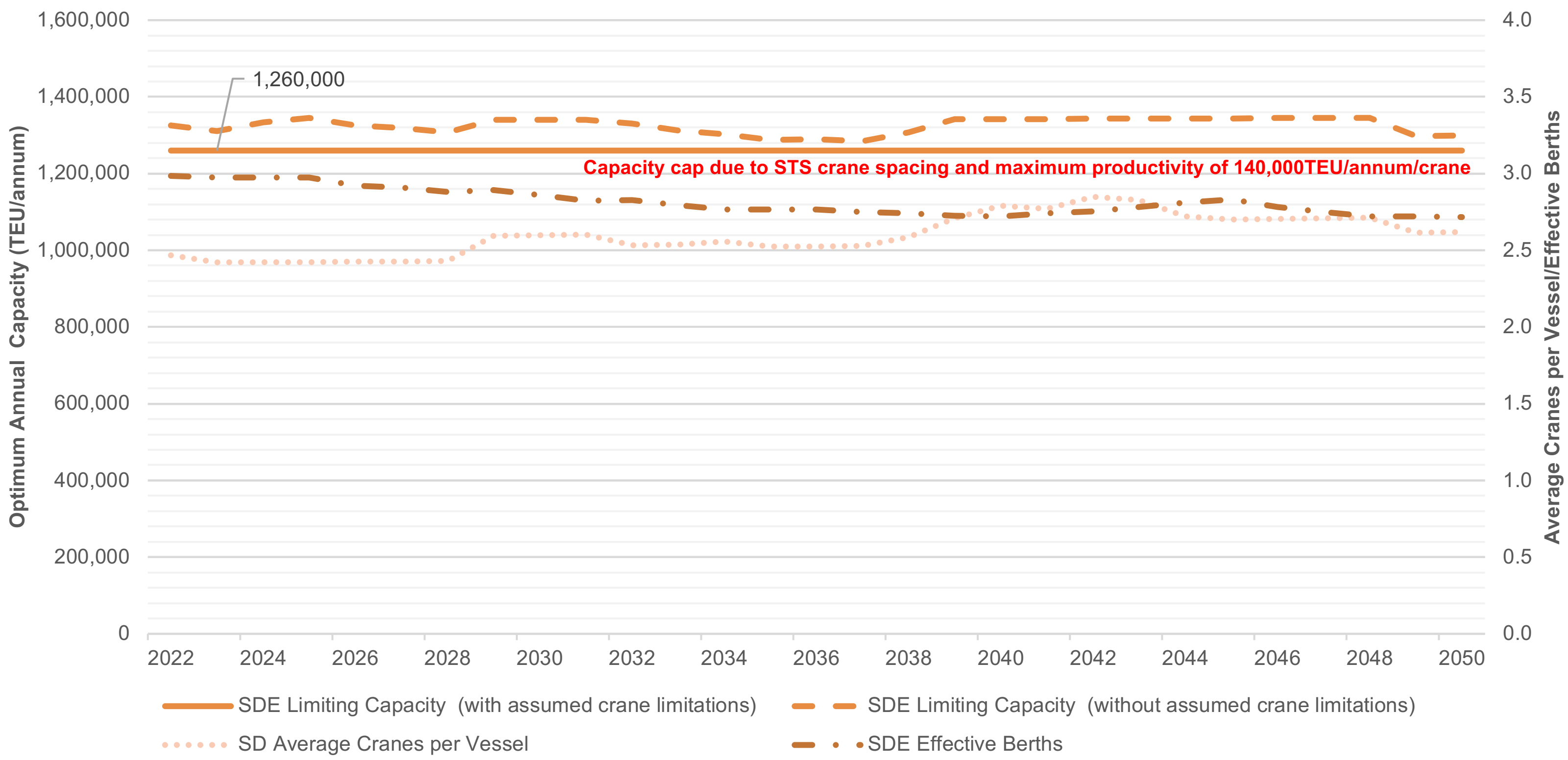
At this capacity of 1,260,000 TEU/annum, the overall quay line productivity is 1,425 TEU/annum, which is considered at the upper limit of what could be expected from a well-planned, efficient gateway terminal (as per the discussion in Section 8.2).

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 3.1 in response to the changing fleet profile. However, these changes do not impact the calculated berth capacity as it is still the cap of 9 cranes working at a maximum 140,000 TEU/annum that limits overall berth capacity.

It should be noted that the calculated yard capacity is only slightly above the limiting capacity at around 1,311,000 TEU/annum (this is the FY23 figure and varies with trade composition to a maximum of 1,359,000 in FY68). Therefore, SDE can be described as relatively yard/berth balanced. In the future, if measures were taken to increase berth capacity, measures would also be required to increase yard capacity.

[16] As noted previously within the report, it is understood that operators in Melbourne have historically achieved figures above this at times. However, into the future it is anticipated that additional cranes will be required at the PoM terminals due to increasing vessel sizes (up to a maximum number of cranes dictated by the berthline and minimum crane spacing). Where additional cranes are present on the berthline, it is expected that individual cranes will not be worked as hard and annual productivities would fall within PIANC guidance previously outlined.

Figure 22 Calculated Capacity (Base Scenario) – Swanson Dock East (Berth Constrained) [1]



Note:

1. SDE limiting capacity is driven by limiting berth capacity, however it is noted that yard capacity is only slightly higher and therefore the terminal could be considered largely berth/yard balanced.

Key Inputs (refer to Appendix B for full list of inputs):

Berthline	884m
TEU:Box Ratio	1.60
Net STS Rate	31nmph
Berth Util. factor	53% (2 berth), 63% (3 berth) – interpolated in between as required
Yard Dwell Times	2 days (import), 5 days (export), 3days (empties), 2 days (transhipment)
Crane Allocation	2 STS (< 5,000 TEU), 3 STS (5,000-9,000 TEU), 4 STS (>9,000 TEU)

9.2 Swanson Dock West Capacity (Base Case)

The calculated Swanson Dock West capacity (base case) is depicted in Figure 23.

In the short term (2022-2026), the capacity is limited by the berth due to the temporary reduction in berth length to 700m. With consideration to the forecast fleet at Swanson Dock, it is difficult to foresee an instance/vessel combination where this berthline could be utilised for 3 berths as that would imply berths of 233m each, which would be restricted to vessels of under 2,000TEU.

Therefore, the short-term capacity has been calculated on the basis that the 700m berthline acts as a 2-berth terminal. This results in a short-term limiting capacity of approximately 775,000-780,000TEU per annum.

Once the berth works are complete, the berth capacity is lifted to approximately 1,400,000 TEU/annum and it is the yard that limits overall capacity at SDW to approximately 1,090,000 TEU/annum.

It is noted that the above capacity calculation does not include for the utilisation of the West Swanson Intermodal Terminal area and assumes dwell times as provided in Section 5.5.

DPWA have historically handled volumes in excess of the quoted capacity 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.

In order to reflect these operations, a second capacity profile was established which considered the following scenarios:

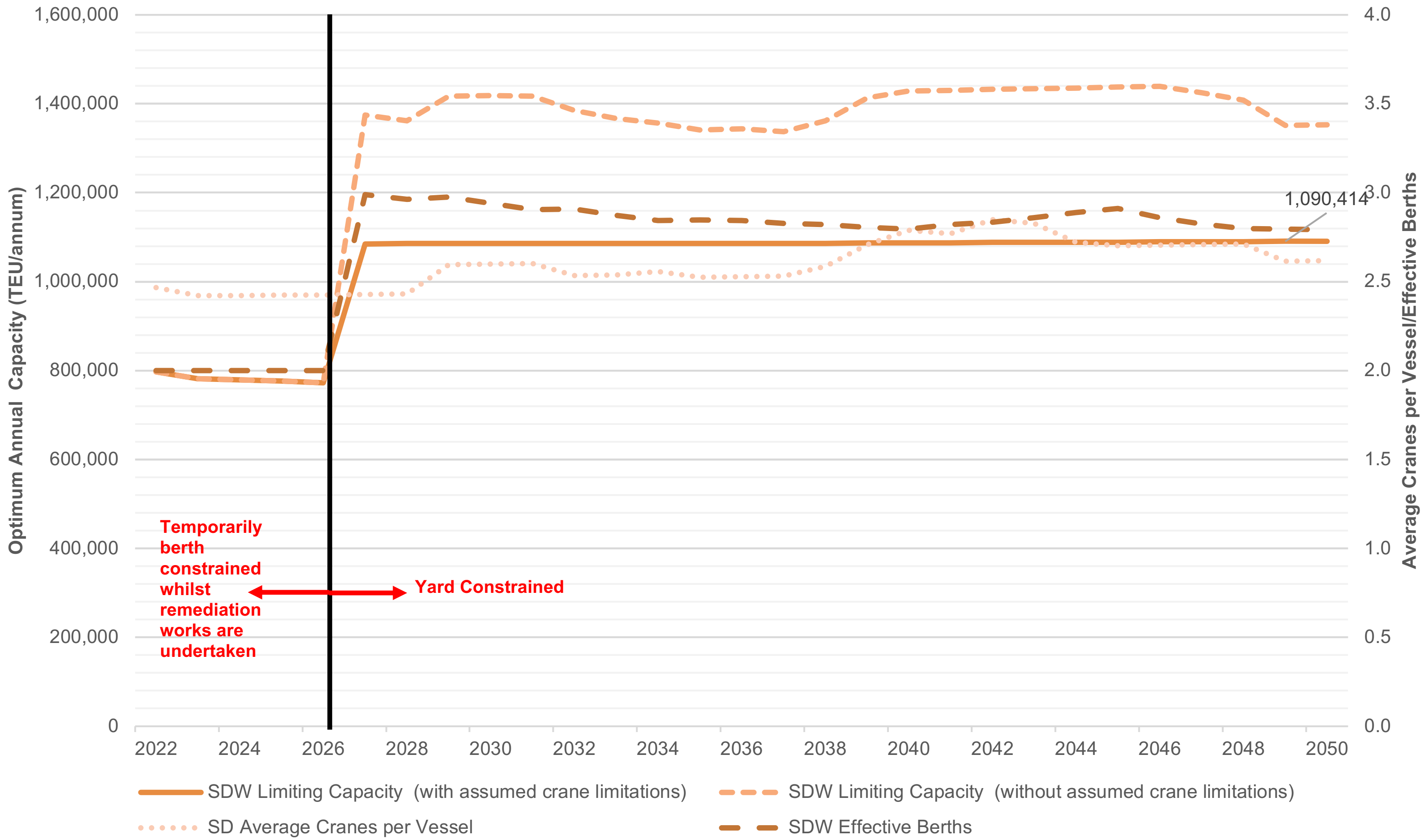
> Utilisation of West Swanson Intermodal Terminal (assumed to include 1,316 slots established from satellite imagery at a height of 5 containers for top pick operations and a utilisation of 70%)

> Reduction of empty container storage to 0.5 days dwell (without use of the West Swanson Intermodal Terminal).

The results of this analysis are depicted in Figure 24 and indicate that, with these yard measures, the terminal becomes berth constrained with the maximum capacity dictated by the limitation of crane spacing and crane productivity per annum, at approximately 1,400,000TEU/annum.

This yields a quay line productivity of 1,484 TEU/m/annum which is considered at the upper limitations of what could be expected from a well-planned, efficient gateway terminal (as per the discussion in Section 8.2).

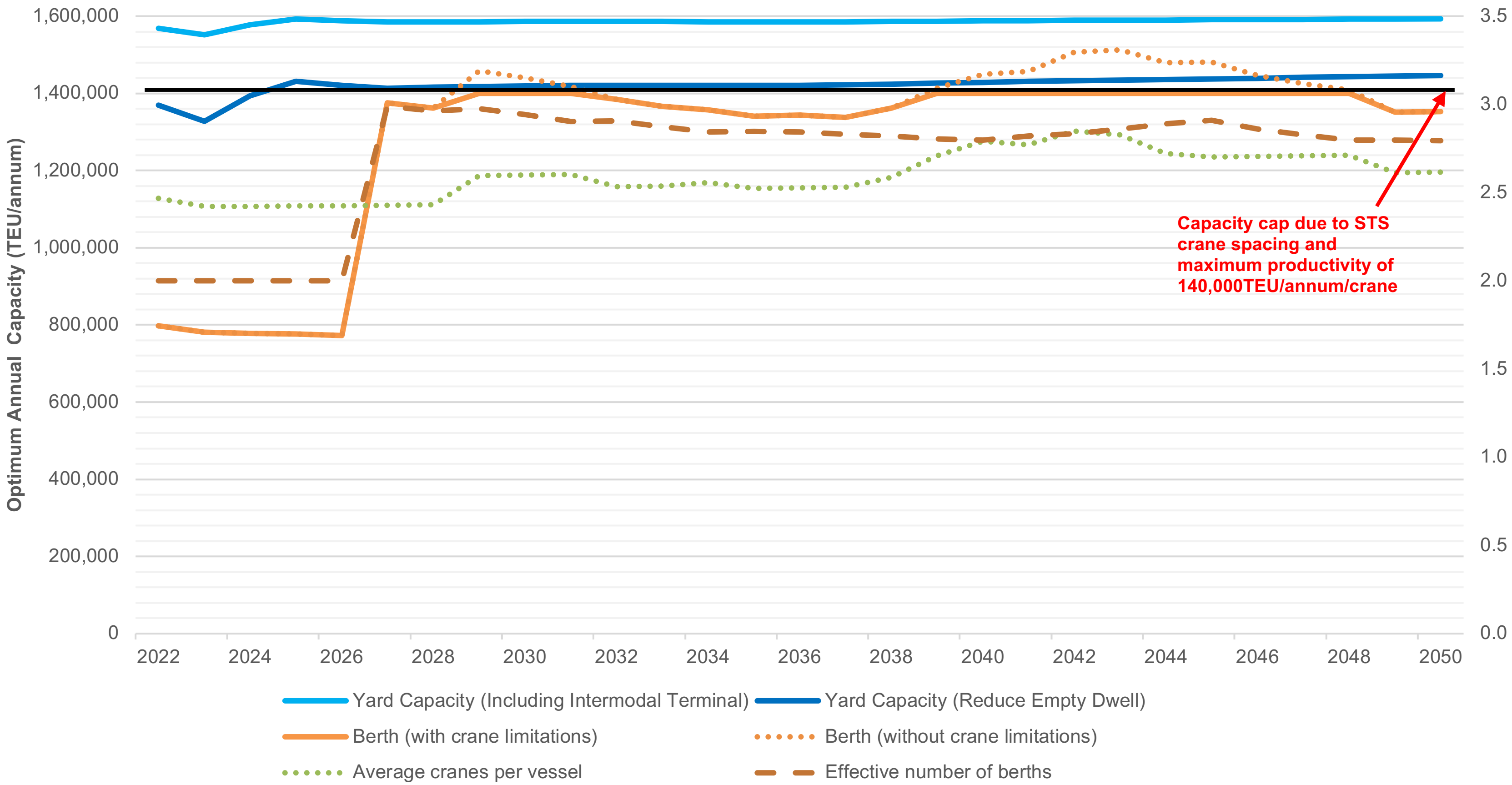
Figure 23 Calculated Capacity (Base Scenario) – Swanson Dock West (under base dwell assumptions and excluding depot area)



Key Inputs (refer to Appendix B for full list of inputs):

Berthline	944m
TEU:Box Ratio	1.60
Net STS Rate	31nmph
Berth Util. factor	53% (2 berth), 63% (3 berth) – interpolated in between as required
Yard Dwell Times	2 days (import), 5 days (export), 3days (empties), 2 days (transhipment)
Crane Allocation	2 STS (< 5,000 TEU), 3 STS (5,000-9,000 TEU), 4 STS (>9,000 TEU)

Figure 24 Calculated Capacity – Swanson Dock West (alternative assumptions)



Key Inputs (refer to Appendix B for full list of inputs):

	Yard (including intermodal terminal)	Yard (reduced empty dwell)
Berthline	944m	944m
TEU:Box Ratio	1.60	1.60
Net STS Rate	31nmph	31nmph
Berth Util. factor	53% (2 berth), 63% (3 berth) – interpolated in between as required	53% (2 berth), 63% (3 berth) – interpolated in between as required
Yard Dwell Times	2 days (import), 5 days (export), 3days (empties), 2 days (transhipment)	2 days (import), 5 days (export), 0.5days (empties), 2 days (transhipment)
Crane Allocation	2 STS (< 5,000 TEU), 3 STS (5,000-9,000 TEU), 4 STS (>9,000 TEU)	2 STS (< 5,000 TEU), 3 STS (5,000-9,000 TEU), 4 STS (>9,000 TEU)

9.3 Webb Dock East Capacity (Base Case)

The calculated Webb Dock East capacity is depicted in Figure 25.

Under the base case set of parameters, the berth was the limiting factor across the modelling horizon. Ultimately, the Webb Dock East limiting capacity was 1,200,000 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 1,642 TEU/m/annum. Whilst this falls above the benchmarks indicated in Section 8.2, it is expected that this may be achievable over time with enhanced productivities and with consideration to the technology at WDE.

It should be noted that, on the basis of the modelling assumptions, this capacity of 1,200,000 TEU/annum would not be reached until the mid 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 2044 that productivity rates reach the assumed STS crane annual productivity cap.

The following sections explore the impact of a change in modelling assumptions on this timing.

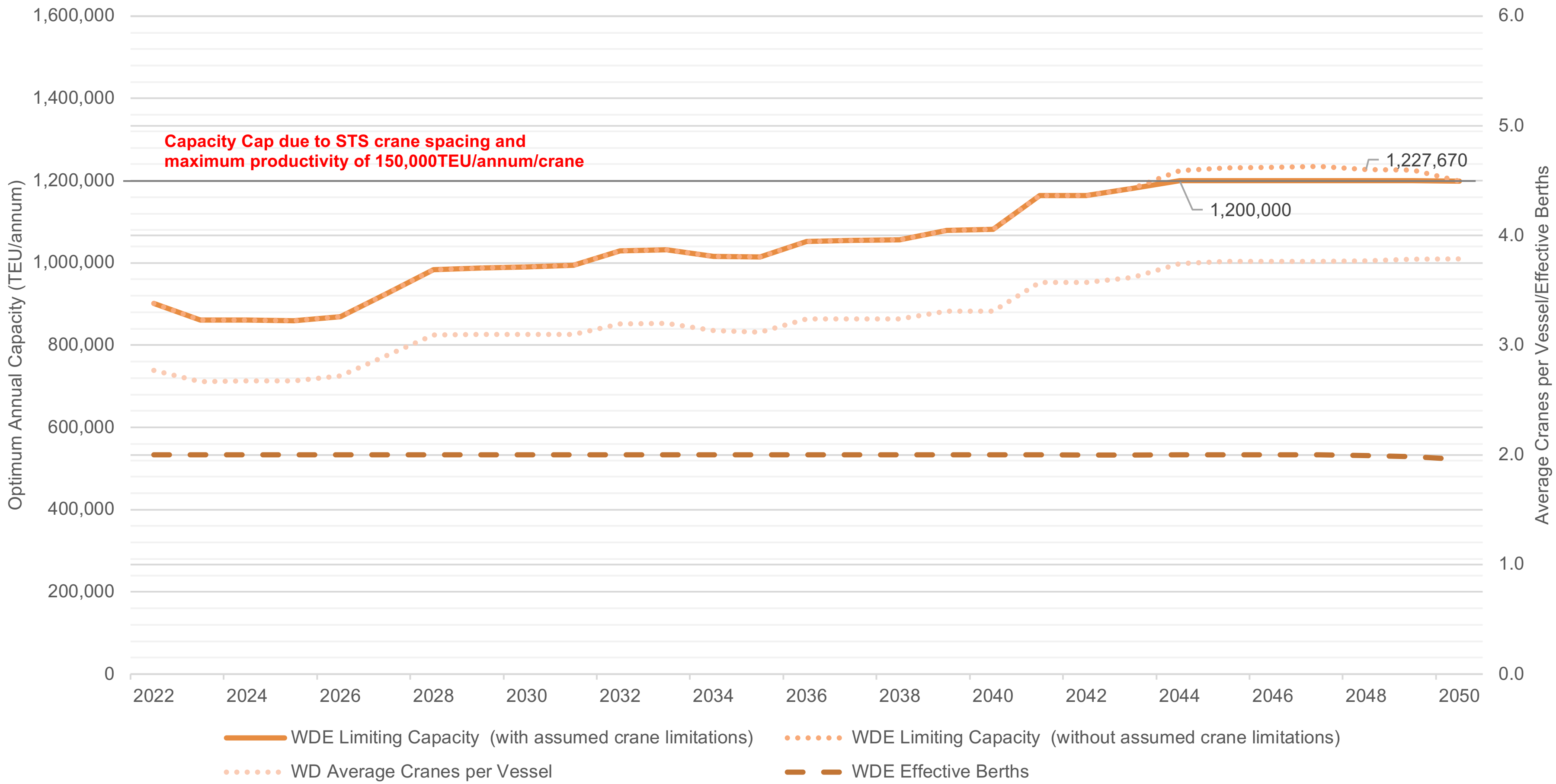
Yard capacity of the existing 10-block ASC yard was calculated at approximately 952,000 TEU/annum, which is driven by the limitations of the ASC's rather than the static yard capacity.

It is understood that expansion of the WDE yard is expected in the near term to include 13 blocks, and ultimately up to 15 blocks. The calculated capacity of the expanded yard (again driven by ASC limitations) was calculated at 1,238,000 TEU/annum (13 blocks) and 1,428,000 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 terminal operators will test stacking strategies in order to reduce moves as much as practicable. Should this be achieved, the yard capacity would increase accordingly.

Despite these calculated capacities, the timing/need for additional yard blocks was calculated on the basis of the ability to cater for peak waterside demand (rather than annualised trade figures). For this reason, it was determined that expansion from 13 to 15-yard blocks would be required by 2036 under the current set of assumptions.

Figure 25 Calculated Capacity (Base Scenario) – Webb Dock East (Berth Constrained)



Key Inputs (refer to Appendix B for full list of inputs):

Berthline	731m
TEU:Box Ratio	1.60
Net STS Rate	31nmph
Berth Util. factor	53% (2 berth), 63% (3 berth) – interpolated in between as required
Yard Dwell Times	2 days (import), 5 days (export), 3days (empties), 2 days (transhipment)
Crane Allocation	2 STS (< 5,000 TEU), 3 STS (5,000-9,000 TEU), 4 STS (>9,000 TEU)

9.4 Alternative Scenarios Capacity Summary

Beyond the base case modelling, each of the scenarios in Section 8.1 were also modelled. The results of each against the base case are presented in the figure below. Refer to Appendix A for graphing of each scenario across the study timeframe.

As demonstrated in the graphs above, the calculated capacities within the berths and yards fluctuate with trade and vessel mix. As such, capacities indicated are maximum capacities over the study period.

Figure 26 Model Findings Summary (TEU Capacity in Year 2030) (Black Quay, 2022)

		Scenario A	Scenario B	Scenario C	Scenario D	Scenario E	Scenario F	Scenario G
Terminal		Base	Crane working rate increased	Crane working rate decreased	Dwell times increased	Dwell times decreased	Increased cranes for larger vessels	Increased berth utilisation
Swanson Dock East	Berth[5]	1,260,000	1,260,000	1,257,000	1,260,000	1,260,000	1,260,000	1,260,000
	Yard	1,340,000	1,340,000	1,340,000	1,145,000	1,617,000	1,340,000	1,340,000
	Gate	1,785,000	1,785,000	1,785,000	1,785,000	1,785,000	1,785,000	1,785,000
	Constraint	Berth	Berth	Berth	Yard	Berth	Berth	Berth
	Max. Berth Utilisation[6]	61.6%	61.6%	61.6%	61.6%	61.6%	61.9%	65.0%
Swanson Dock West	Berth[5]	1,400,000	1,400,000	1,310,000	1,400,000	1,400,000	1,400,000	1,400,000
	Yard[1]	1,086,000	1,086,000	1,086,000	927,000	1,310,000	1,086,000	1,086,000
	Yard (with WSIT)	1,586,000	1,586,000	1,586,000	1,354,000	1,913,000	1,586,000	1,586,000
	Gate	3,570,000	3,570,000	3,570,000	3,570,000	3,570,000	3,570,000	3,570,000
	Constraint[3]	Berth	Berth	Berth	Yard	Berth	Berth	Berth
	Max. Berth Utilisation[6]	62.4%	62.4%	62.4%	62.4%	62.4%	62.7%	65.0%
Webb Dock East	Berth[5]	990,000	1,077,000	902,000	990,000	990,000	1,030,000	1,200,000
	Yard[2]	1,238,000	1,428,000	1,238,000	1,238,000	1,238,000	1,238,000	1,428,000
	Gate	6,545,000	6,545,000	6,545,000	6,545,000	6,545,000	6,545,000	6,545,000
	Constraint	Berth	Berth	Berth	Berth	Berth	Berth	Berth
	Max. Berth Utilisation[6]	53.0%	53.0%	53.0%	53.0%	53.0%	53.0%	65.0%
Total Indicative POM Capacity		3,650,000	3,737,000	3,469,000	3,489,000	3,650,000	3,690,000	3,860,000

Fig 27 Notes:

1. This is based on existing terminal only with assumed dwell times. Utilisation of the WSIT Area or just-in-time empty operations could increase this capacity as indicated.
2. Includes expansion to 13 ASC blocks as planned in 2023 and further expansion to 15 ASC blocks by 2030 where required by scenario.
3. Constraint is based upon considering the yard capacity with the use of WSIT.
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. Berth capacity quoted is based upon limitations on crane minimum spacing and assumed annual productivity
6. The maximum berth utilisation is based on assumed values for 1, 2 and 3 berth terminals and reflecting the maintenance of a certain level of service to the customer. Where the effective number of berths falls between whole numbers these values are interpolated. The value shown in the table is that calculated in 2030. Reference to Chapter 4.11 should be made for further context.
7. The capacities above are shown as modelled in year 2030. Please refer to figures contained within Appendix A for limiting capacity over the model timeframe.

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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 falls within the limits that would be reasonably expected of a regional port where these caps are in place

> Under the Base Scenario (A), the berth capacity cap is indicatively effective in the following years (subject to deployment of the maximum allowable cranes):

  - WDE - 2044
  - SDE - 2022
  - SDW – 2029

> The ability to operate at the capacity cap prior to these dates would require variation to the assumed parameters, particularly in relation to crane deployment

> As a result of the ultimate capacity being dictated by a cap on achievable crane spacings and annual productivities, scenarios that explore adjustment in crane productivity, berth utilisation and crane allocation (Scenarios B, C, F, G) do not typically alter the maximum capacity of the berthline. It does, however, change when this cap is expected to be reached. For example:

  - At SDW, the berth cap is expected to be reached in 2029 under Scenario A, 2027 under Scenario B, post-2050 under Scenario C, 2027 under Scenario F and Scenario G
  - At SDE, the berth cap is expected to be reached as soon as the crane numbers at the berth reach 9 under all Scenarios
  - At WDE, the berth cap is expected to be reached in 2044 under Scenario A, 2041 under Scenario B, 2042 under Scenario F and 2028 under Scenario G. The berth cap is not reached within the model timeframes under Scenario C.

> For the scenarios that explored changes in dwell times (Scenarios D and E), a decrease in the assumed dwell times across the terminals does not provide a capacity increase due to all terminals being ultimately berth constrained.

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 12). 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 such as SDE, 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.

The capacity modelling indicated that the combined capacity of the terminals is in the order of 3,860,000 TEU/annum. This is comprised of the following:

> SDE: 1,260,000
> SDW: 1,400,000
> WDE: 1,200,000

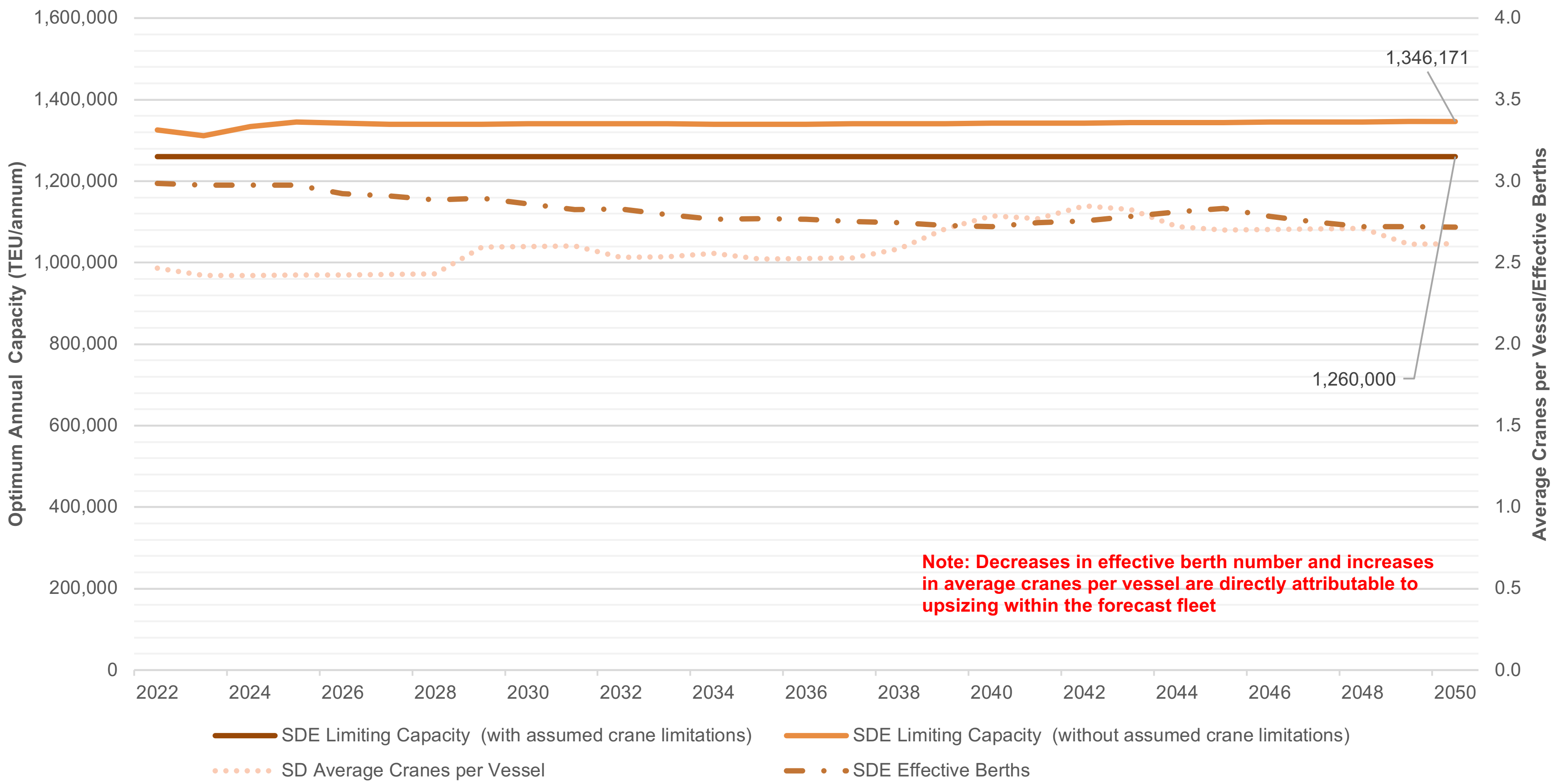
This capacity limitation represents an upper ceiling based on maximum practical STS crane deployment on the berthline. The actual capacity in any given year is heavily driven by the fleet profile, crane deployment and crane productivity, and the capacity cap may not be reached until a future point in 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.

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.

Appendix A – Alternative Scenario Graphs

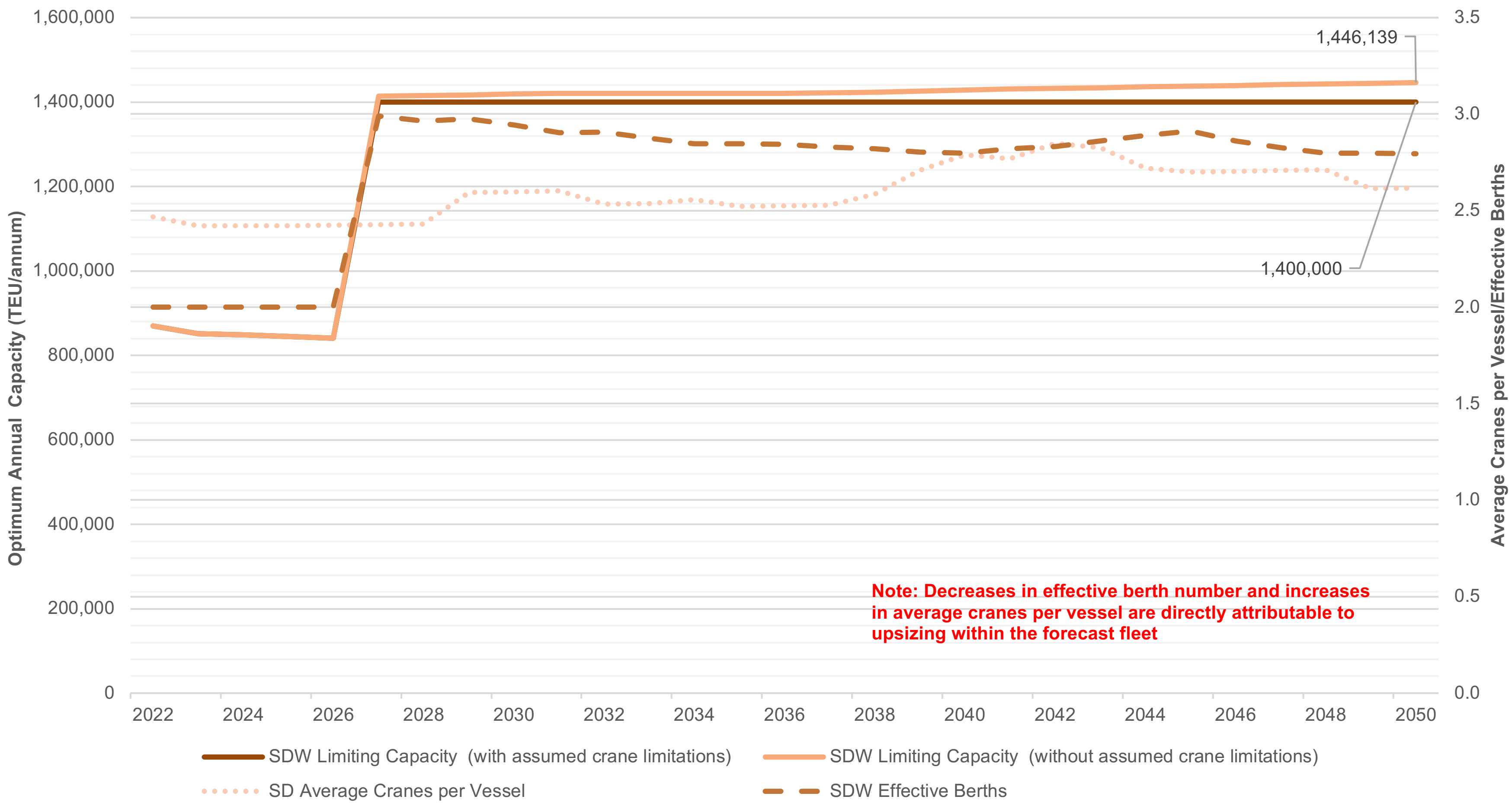
Figure 27 Calculated Capacity (Scenario B) – Swanson Dock East



Key Inputs (refer to Appendix B for full list of inputs):

Berthline	884m
TEU:Box Ratio	1.60
Net STS Rate	34nmph
Berth Util. factor	53% (2 berth), 63% (3 berth) – interpolated in between as required
Yard Dwell Times	2 days (import), 5 days (export), 3days (empties), 2 days (transhipment)
Crane Allocation	2 STS (< 5,000 TEU), 3 STS (5,000-9,000 TEU), 4 STS (>9,000 TEU)

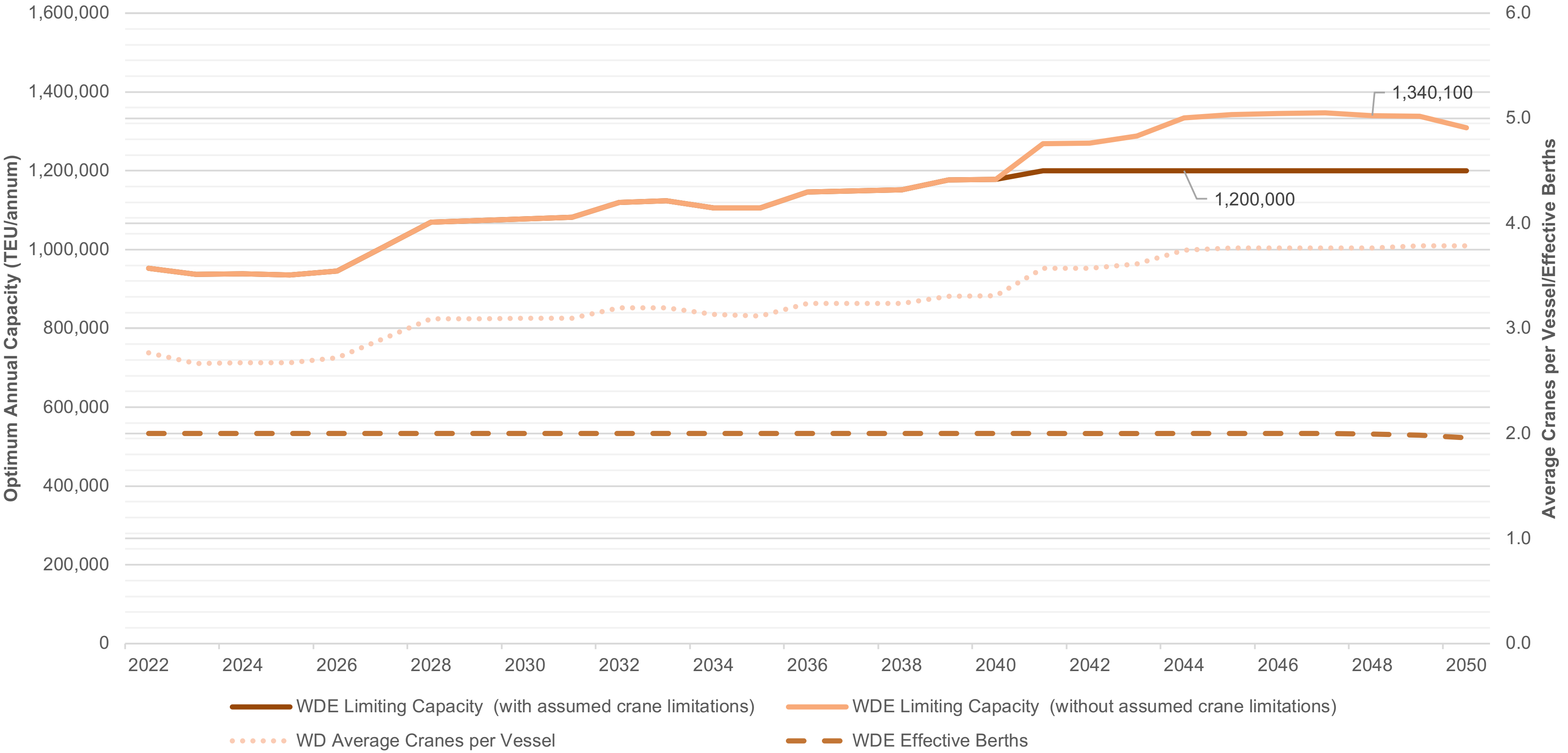
Figure 28 Calculated Capacity (Scenario B) – Swanson Dock West (with WSIT)



Key Inputs (refer to Appendix B for full list of inputs):

Berthline	944m
TEU:Box Ratio	1.60
Net STS Rate	34nmph
Berth Util. factor	53% (2 berth), 63% (3 berth) – interpolated in between as required
Yard Dwell Times	2 days (import), 5 days (export), 3days (empties), 2 days (transhipment)
Crane Allocation	2 STS (< 5,000 TEU), 3 STS (5,000-9,000 TEU), 4 STS (>9,000 TEU)

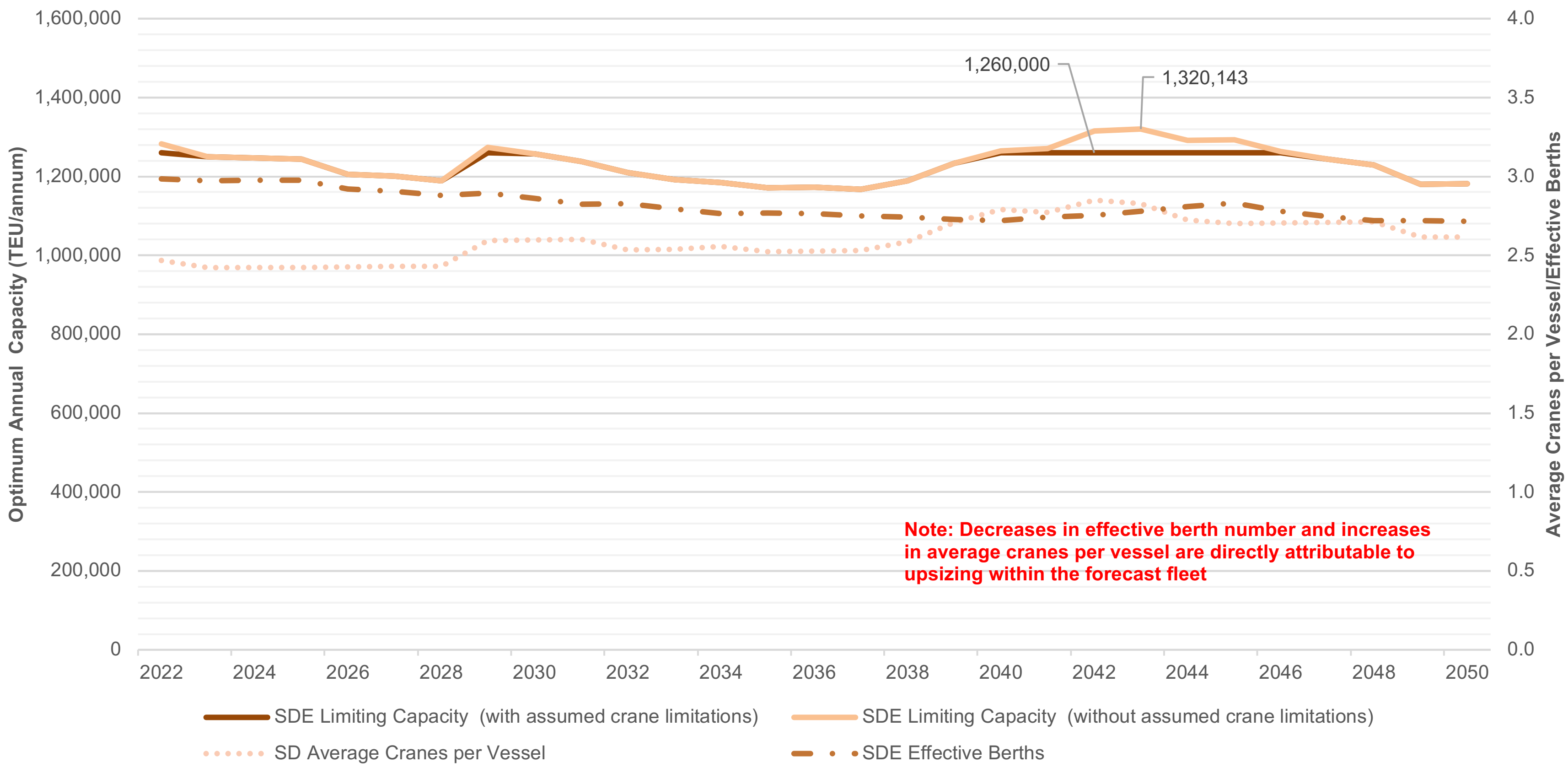
Figure 29 Calculated Capacity (Scenario B) – Webb Dock East



Key Inputs (refer to Appendix B for full list of inputs):

Berthline	731m
TEU:Box Ratio	1.60
Net STS Rate	34nmph
Berth Util. factor	53% (2 berth), 63% (3 berth) – interpolated in between as required
Yard Dwell Times	2 days (import), 5 days (export), 3days (empties), 2 days (transhipment)
Crane Allocation	2 STS (< 5,000 TEU), 3 STS (5,000-9,000 TEU), 4 STS (>9,000 TEU)

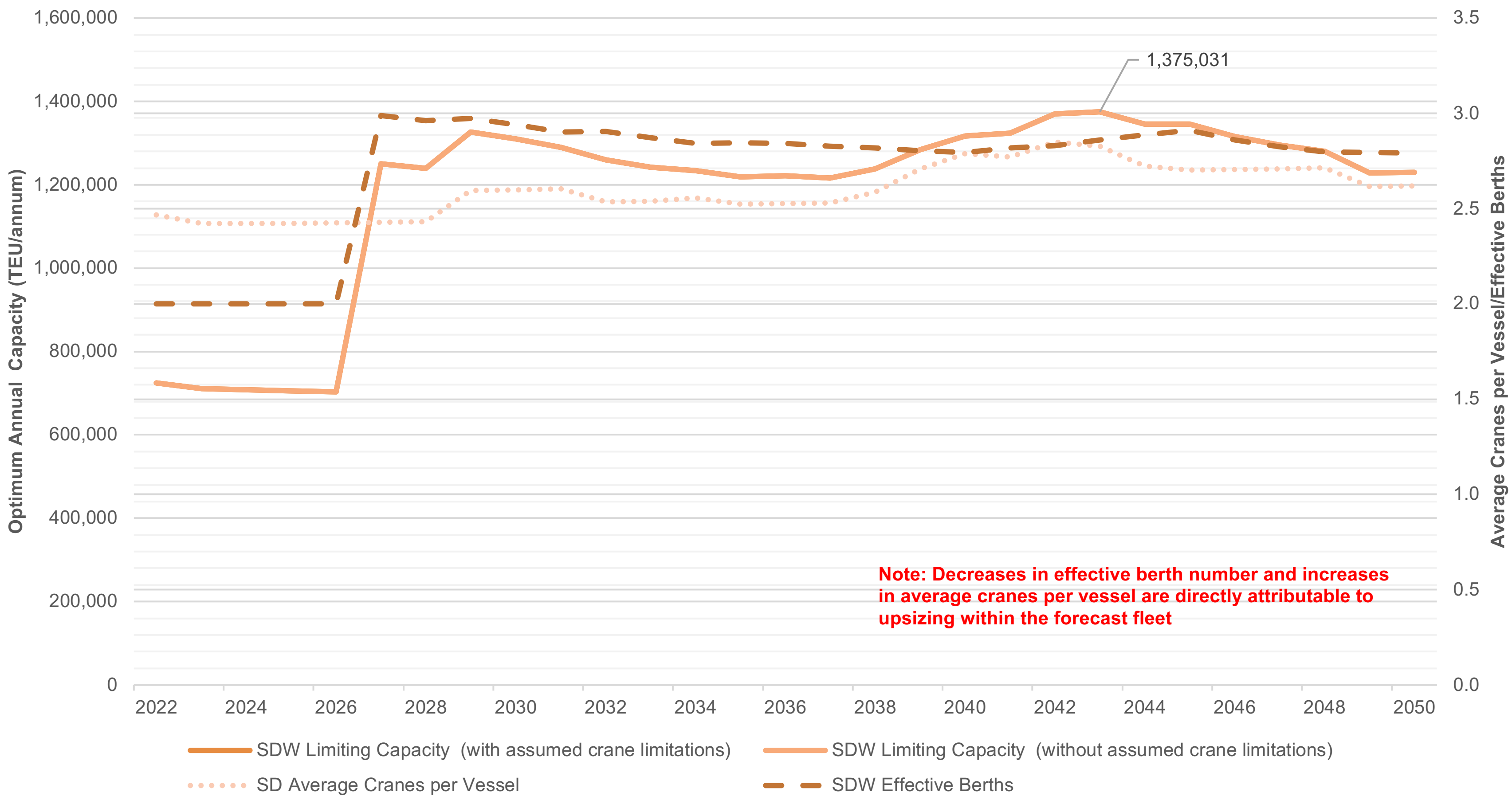
Figure 30 Calculated Capacity (Scenario C) – Swanson Dock East



Key Inputs (refer to Appendix B for full list of inputs):

Berthline	884m
TEU:Box Ratio	1.60
Net STS Rate	28nmph
Berth Util. factor	53% (2 berth), 63% (3 berth) – interpolated in between as required
Yard Dwell Times	2 days (import), 5 days (export), 3 days (empties), 2 days (transhipment)
Crane Allocation	2 STS (< 5,000 TEU), 3 STS (5,000-9,000 TEU), 4 STS (>9,000 TEU)

Figure 31 Calculated Capacity (Scenario C) – Swanson Dock West (with WSIT)



Key Inputs (refer to Appendix B for full list of inputs):

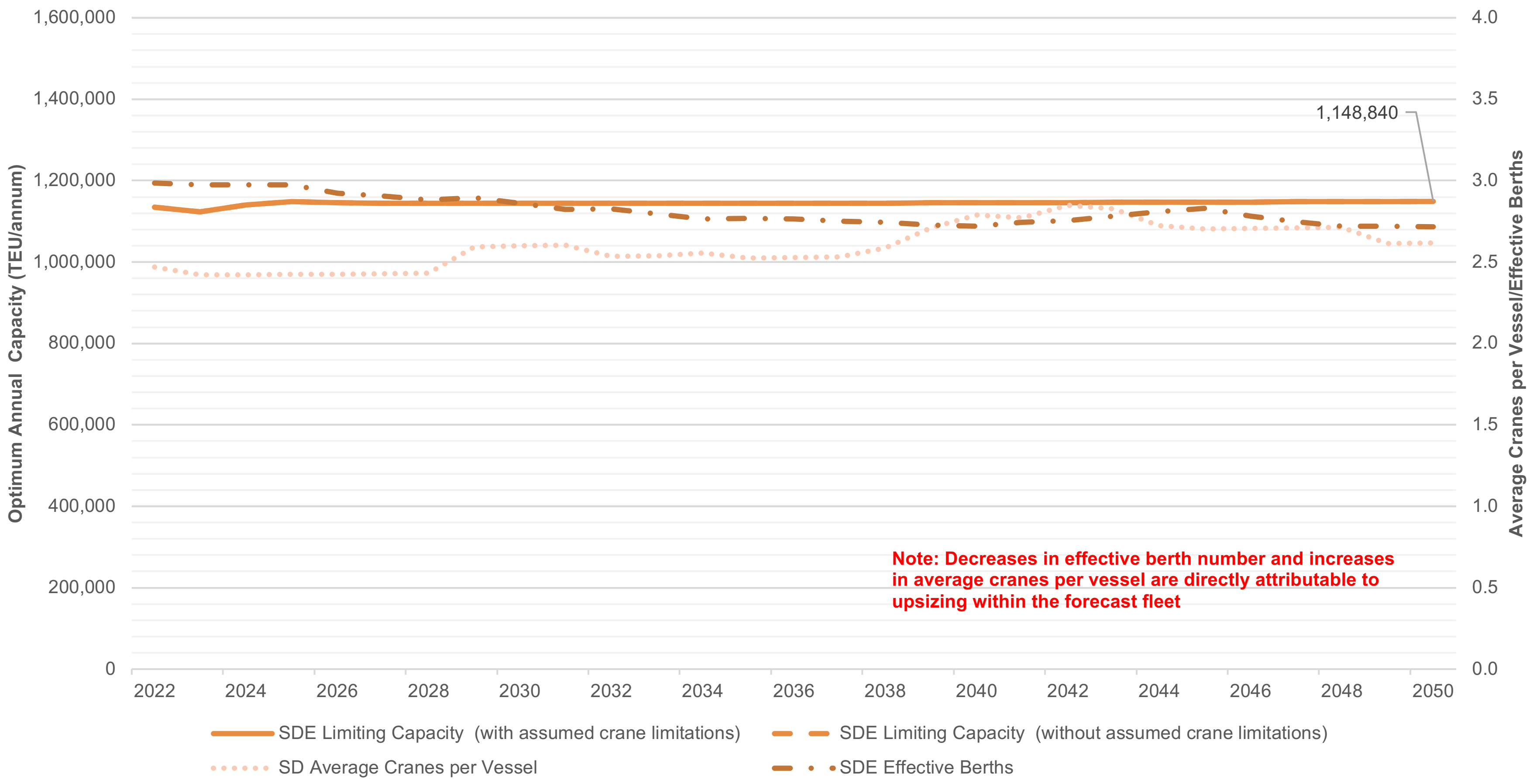
Berthline	944m
TEU:Box Ratio	1.60
Net STS Rate	28nmph
Berth Util. factor	53% (2 berth), 63% (3 berth) – interpolated in between as required
Yard Dwell Times	2 days (import), 5 days (export), 3days (empties), 2 days (transhipment)
Crane Allocation	2 STS (< 5,000 TEU), 3 STS (5,000-9,000 TEU), 4 STS (>9,000 TEU)

Figure 32 Calculated Capacity (Scenario C) – Webb Dock East

Key Inputs (refer to Appendix B for full list of inputs):

Berthline	731m
TEU:Box Ratio	1.60
Net STS Rate	28nmph
Berth Util. factor	53% (2 berth), 63% (3 berth) – interpolated in between as required
Yard Dwell Times	2 days (import), 5 days (export), 3days (empties), 2 days (transhipment)
Crane Allocation	2 STS (< 5,000 TEU), 3 STS (5,000-9,000 TEU), 4 STS (>9,000 TEU)

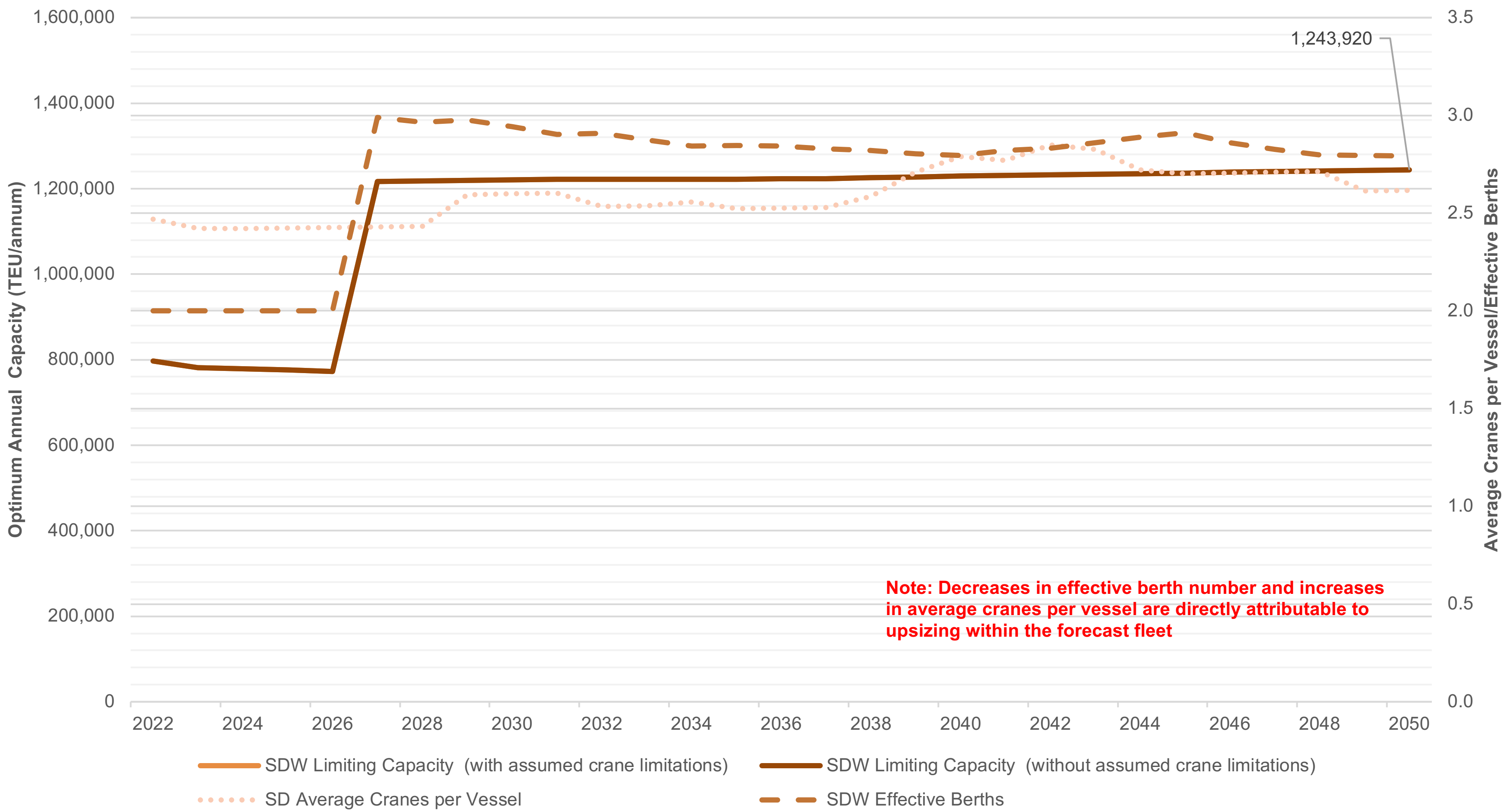
Figure 33 Calculated Capacity (Scenario D) – Swanson Dock East



Key Inputs (refer to Appendix B for full list of inputs):

Berthline	884m
TEU:Box Ratio	1.60
Net STS Rate	31nmph
Berth Util. factor	53% (2 berth), 63% (3 berth) – interpolated in between as required
Yard Dwell Times	2.5 days (import), 5.5 days (export), 3.5days (empties), 2.5 days (transhipment)
Crane Allocation	2 STS (< 5,000 TEU), 3 STS (5,000-9,000 TEU), 4 STS (>9,000 TEU)

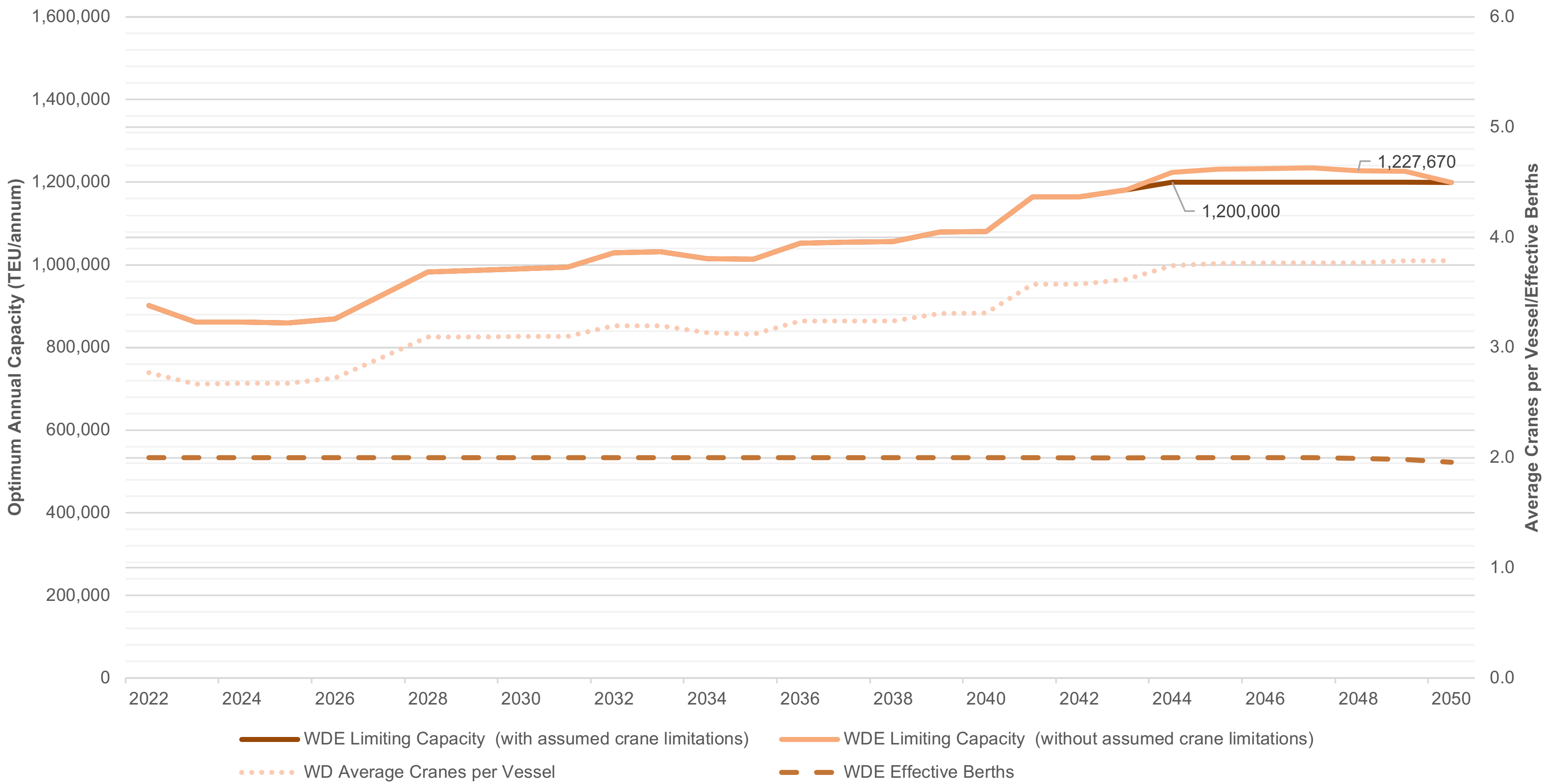
Figure 34 Calculated Capacity (Scenario D) – Swanson Dock West (with WSIT)



Key Inputs (refer to Appendix B for full list of inputs):

Berthline	944m
TEU:Box Ratio	1.60
Net STS Rate	31nmph
Berth Util. factor	53% (2 berth), 63% (3 berth) – interpolated in between as required
Yard Dwell Times	2.5 days (import), 5.5 days (export), 3.5days (empties), 2.5 days (transhipment)
Crane Allocation	2 STS (< 5,000 TEU), 3 STS (5,000-9,000 TEU), 4 STS (>9,000 TEU)

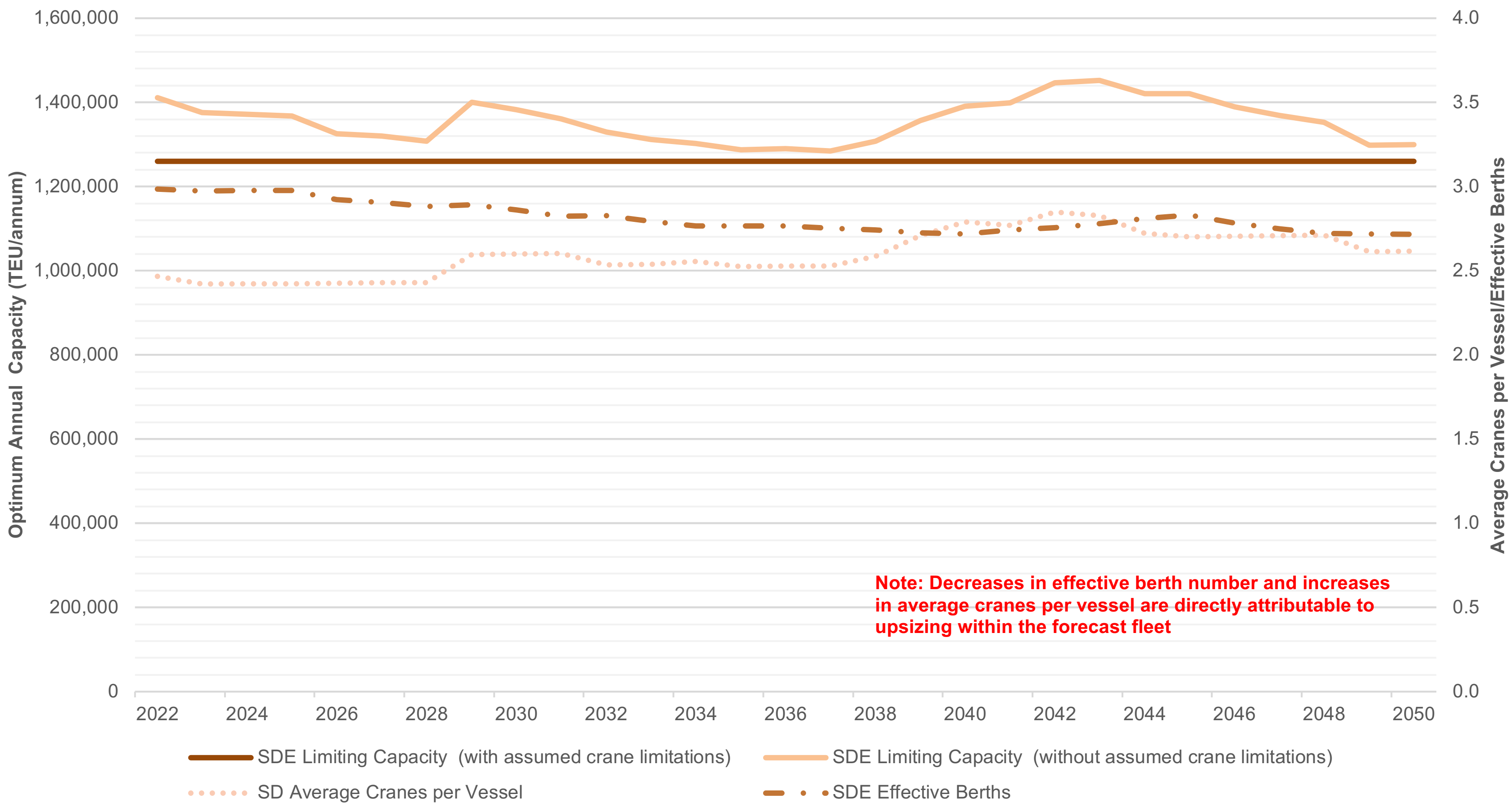
Figure 35 Calculated Capacity (Scenario D) – Webb Dock East



Key Inputs (refer to Appendix B for full list of inputs):

Berthline	731m
TEU:Box Ratio	1.60
Net STS Rate	31nmph
Berth Util. factor	53% (2 berth), 63% (3 berth) – interpolated in between as required
Yard Dwell Times	2.5days (import), 5.5days (export), 3.5days (empties), 2.5days (transhipment)
Crane Allocation	2 STS (< 5,000 TEU), 3 STS (5,000-9,000 TEU), 4 STS (>9,000 TEU)

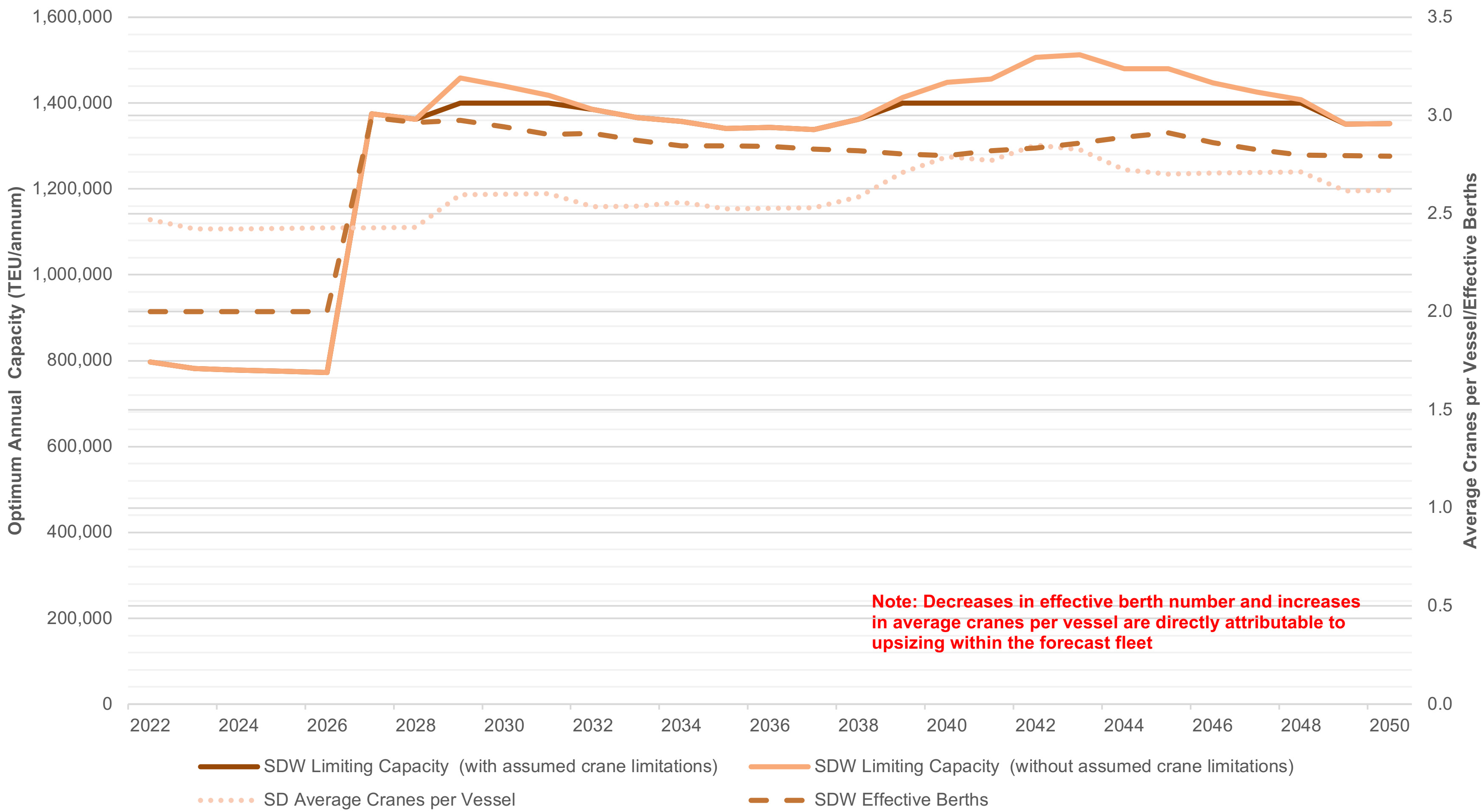
Figure 36 Calculated Capacity (Scenario E) – Swanson Dock East



Key Inputs (refer to Appendix B for full list of inputs):

Berthline	884m
TEU:Box Ratio	1.60
Net STS Rate	31nmph
Berth Util. factor	53% (2 berth), 63% (3 berth) – interpolated in between as required
Yard Dwell Times	1.5 days (import), 4.5 days (export), 2.5days (empties), 1.5 days (transhipment)
Crane Allocation	2 STS (< 5,000 TEU), 3 STS (5,000-9,000 TEU), 4 STS (>9,000 TEU)

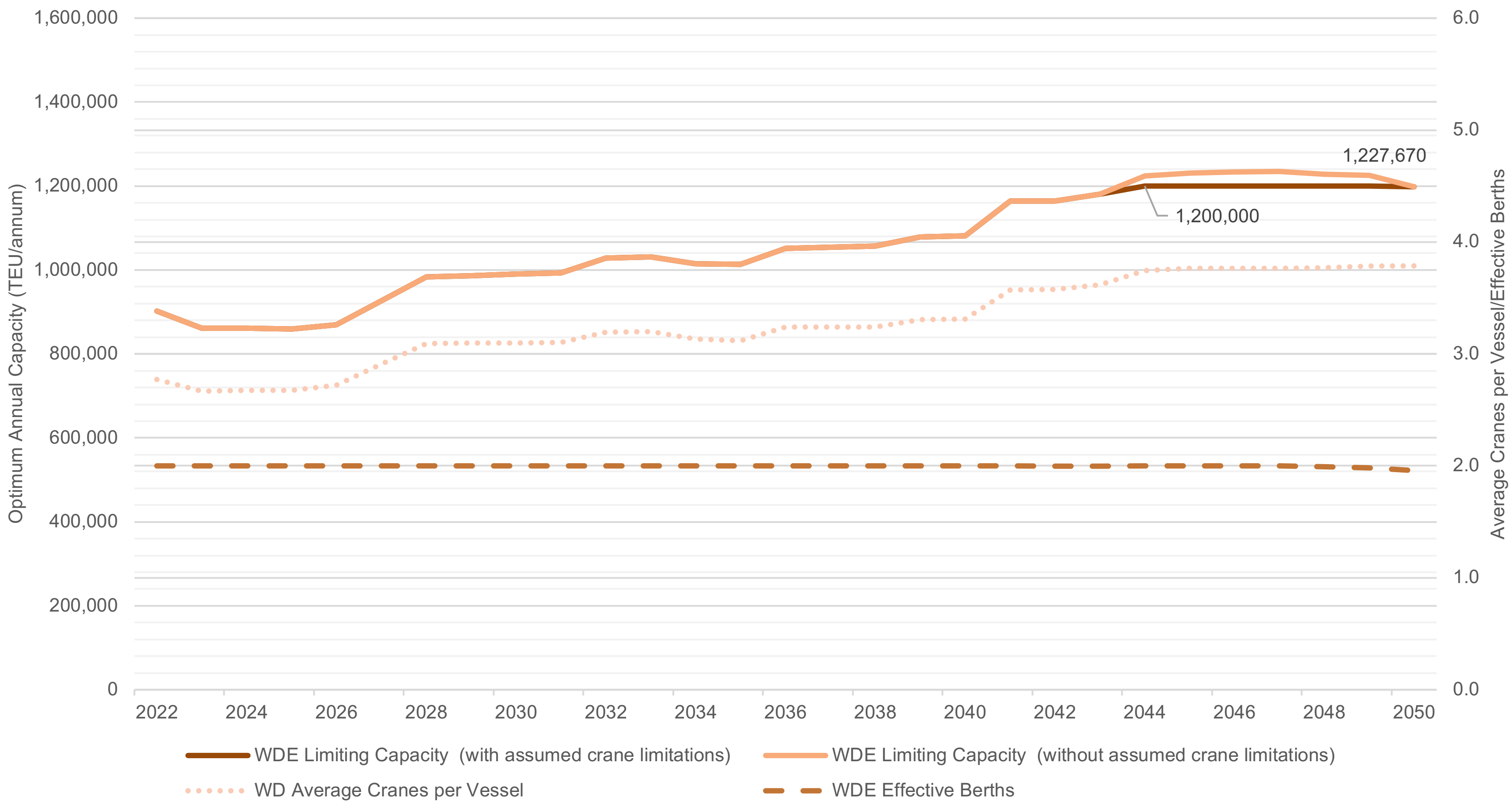
Figure 37 Calculated Capacity (Scenario E) – Swanson Dock West (with WSIT)



Key Inputs (refer to Appendix B for full list of inputs):

Berthline	944m
TEU:Box Ratio	1.60
Net STS Rate	31nmph
Berth Util. factor	53% (2 berth), 63% (3 berth) – interpolated in between as required
Yard Dwell Times	1.5 days (import), 4.5 days (export), 2.5days (empties), 1.5 days (transhipment)
Crane Allocation	2 STS (< 5,000 TEU), 3 STS (5,000-9,000 TEU), 4 STS (>9,000 TEU)

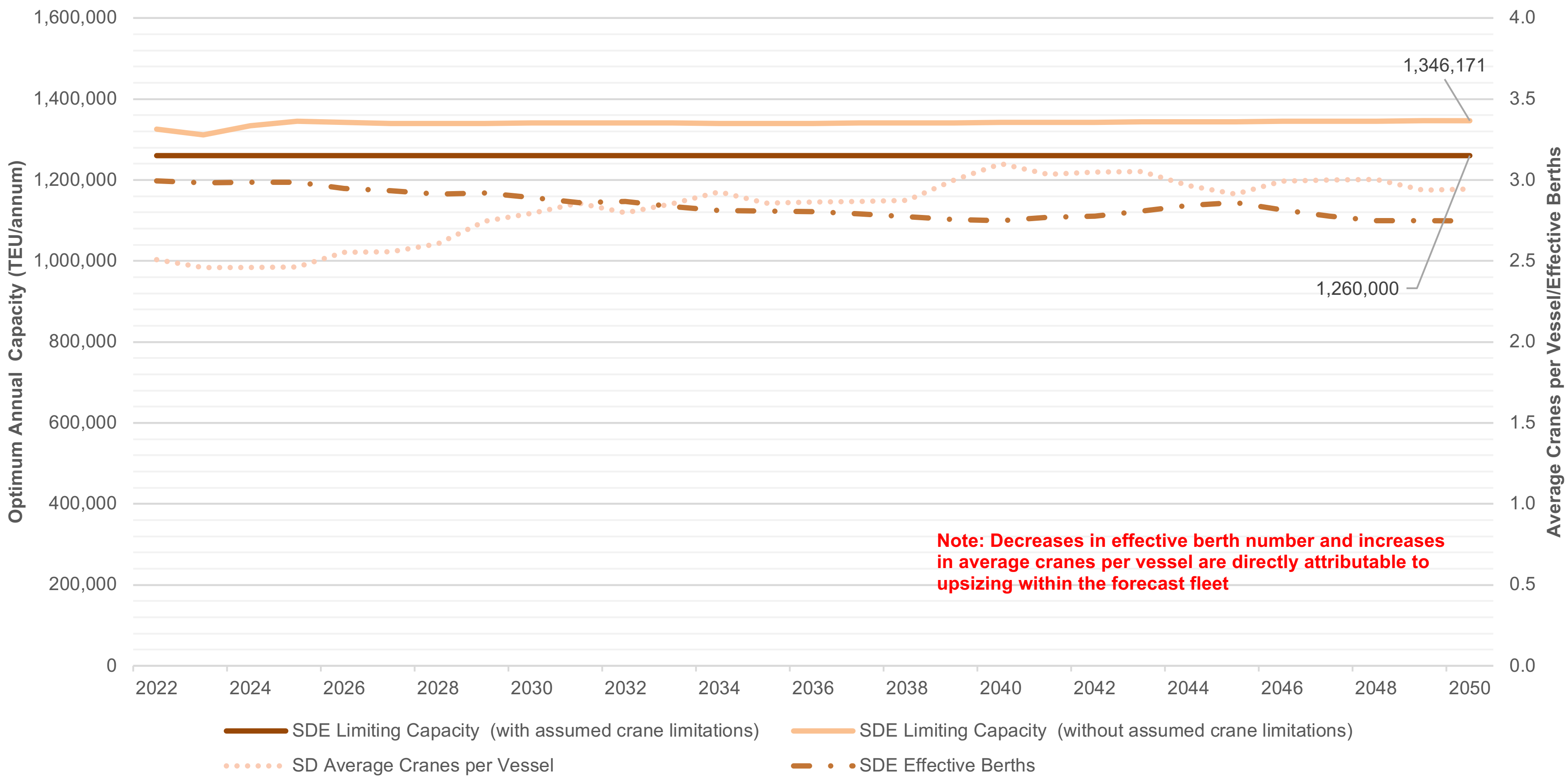
Figure 38 Calculated Capacity (Scenario E) – Webb Dock East



Key Inputs (refer to Appendix B for full list of inputs):

Berthline	731m
TEU:Box Ratio	1.60
Net STS Rate	31nmph
Berth Util. factor	53% (2 berth), 63% (3 berth) – interpolated in between as required
Yard Dwell Times	1.5 days (import), 4.5 days (export), 2.5days (empties), 1.5 days (transhipment)
Crane Allocation	2 STS (< 5,000 TEU), 3 STS (5,000-9,000 TEU), 4 STS (>9,000 TEU)

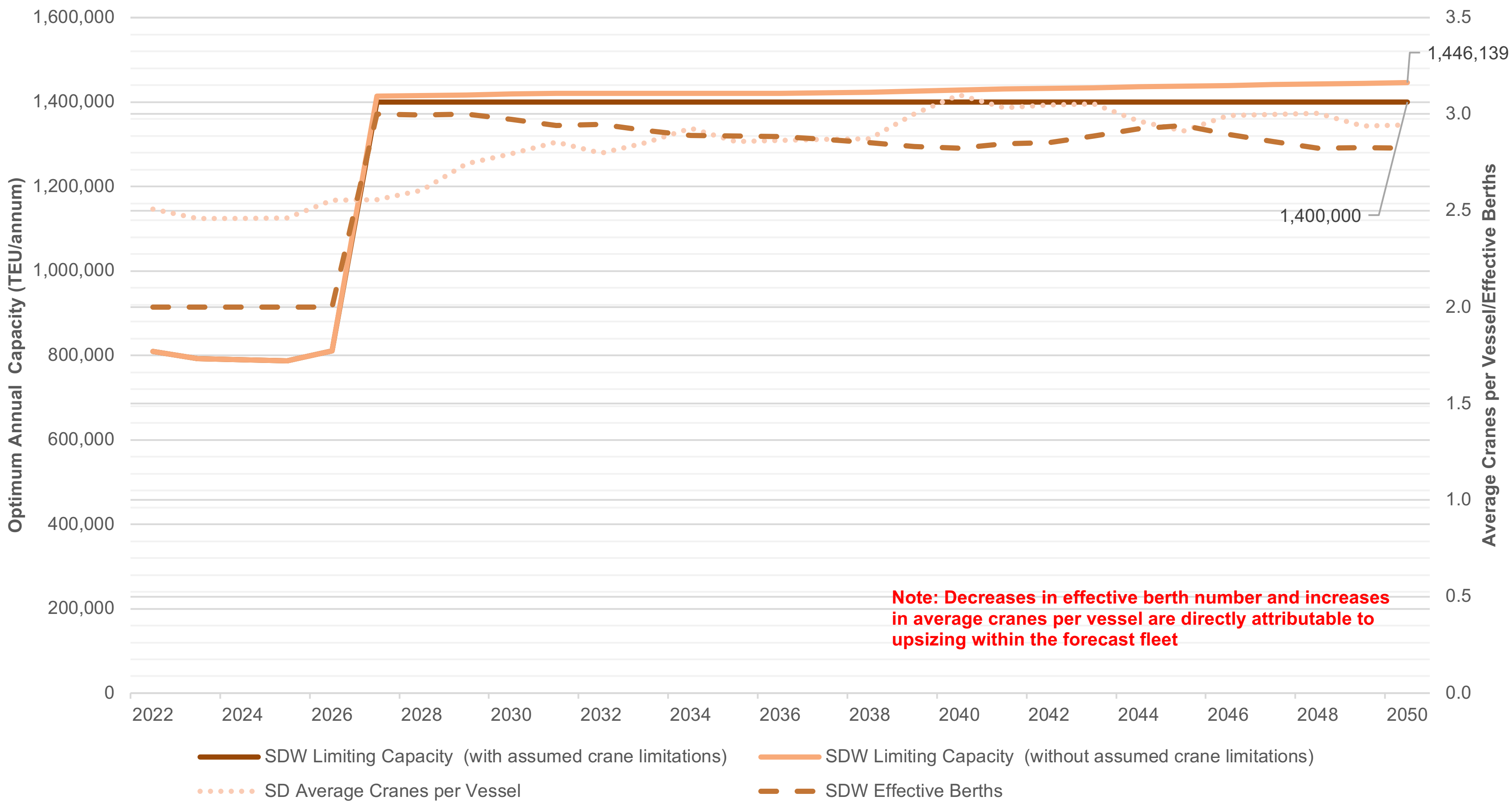
Figure 39 Calculated Capacity (Scenario F) – Swanson Dock East



Key Inputs (refer to Appendix B for full list of inputs):

Berthline	844m
TEU:Box Ratio	1.60
Net STS Rate	31nmph
Berth Util. factor	53% (2 berth), 63% (3 berth) – interpolated in between as required
Yard Dwell Times	2 days (import), 5 days (export), 3days (empties), 2 days (transhipment)
Crane Allocation	2 STS (< 5,000 TEU), 3 STS (5,000-7,000 TEU), 4 STS (>7,000 TEU)

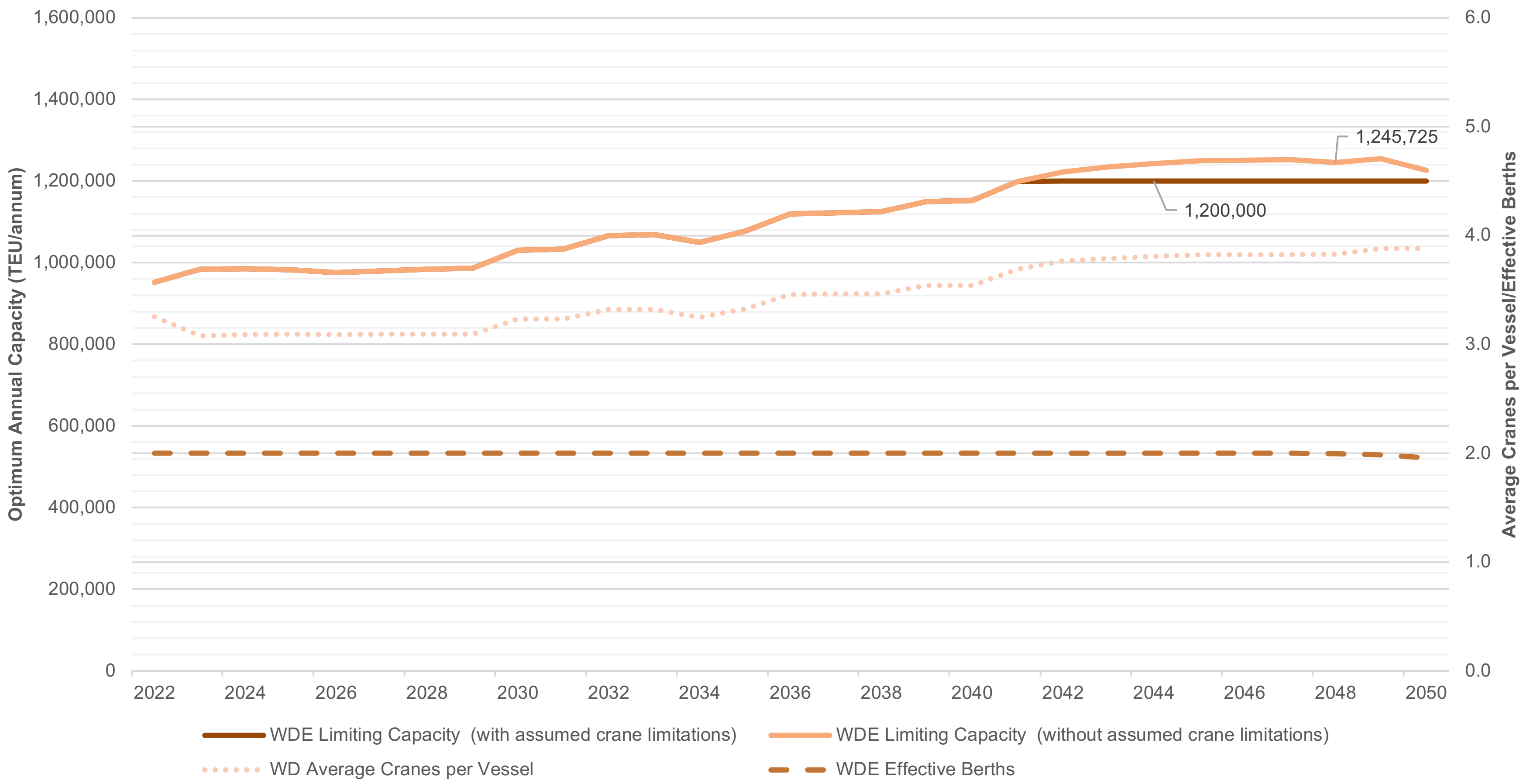
Figure 40 Calculated Capacity (Scenario F) – Swanson Dock West (with WSIT)



Key Inputs (refer to Appendix B for full list of inputs):

Berthline	944m
TEU:Box Ratio	1.60
Net STS Rate	31nmph
Berth Util. factor	53% (2 berth), 63% (3 berth) – interpolated in between as required
Yard Dwell Times	2 days (import), 5 days (export), 3days (empties), 2 days (transhipment)
Crane Allocation	2 STS (< 5,000 TEU), 3 STS (5,000-7,000 TEU), 4 STS (>7,000 TEU)

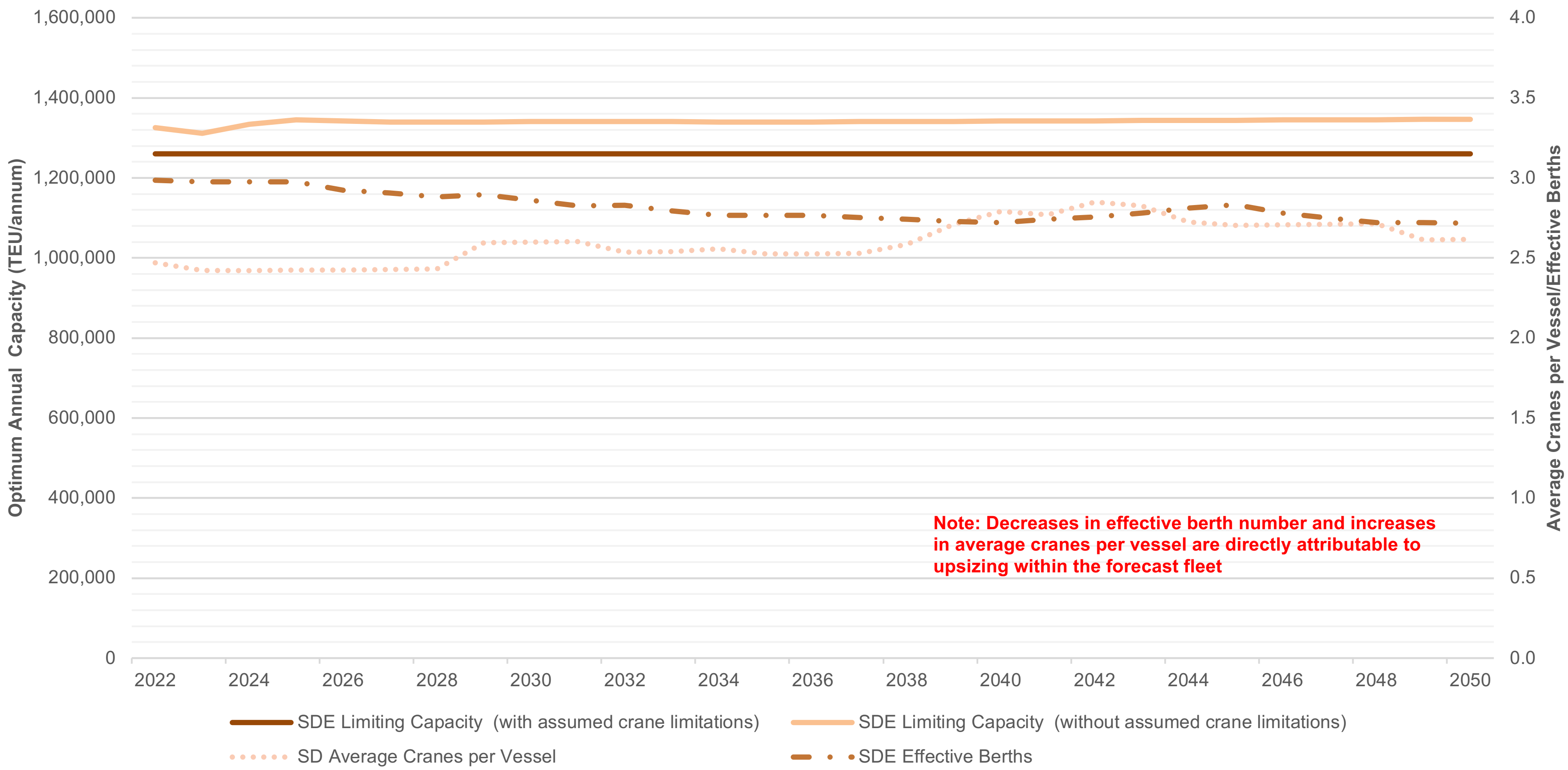
Figure 41 Calculated Capacity (Scenario F) – Webb Dock East



Key Inputs (refer to Appendix B for full list of inputs):

Berthline	731m
TEU:Box Ratio	1.60
Net STS Rate	31nmph
Berth Util. factor	53% (2 berth), 63% (3 berth) – interpolated in between as required
Yard Dwell Times	2 days (import), 5 days (export), 3days (empties), 2 days (transhipment)
Crane Allocation	2 STS (< 5,000 TEU), 3 STS (5,000-7,000 TEU), 4 STS (>7,000 TEU)

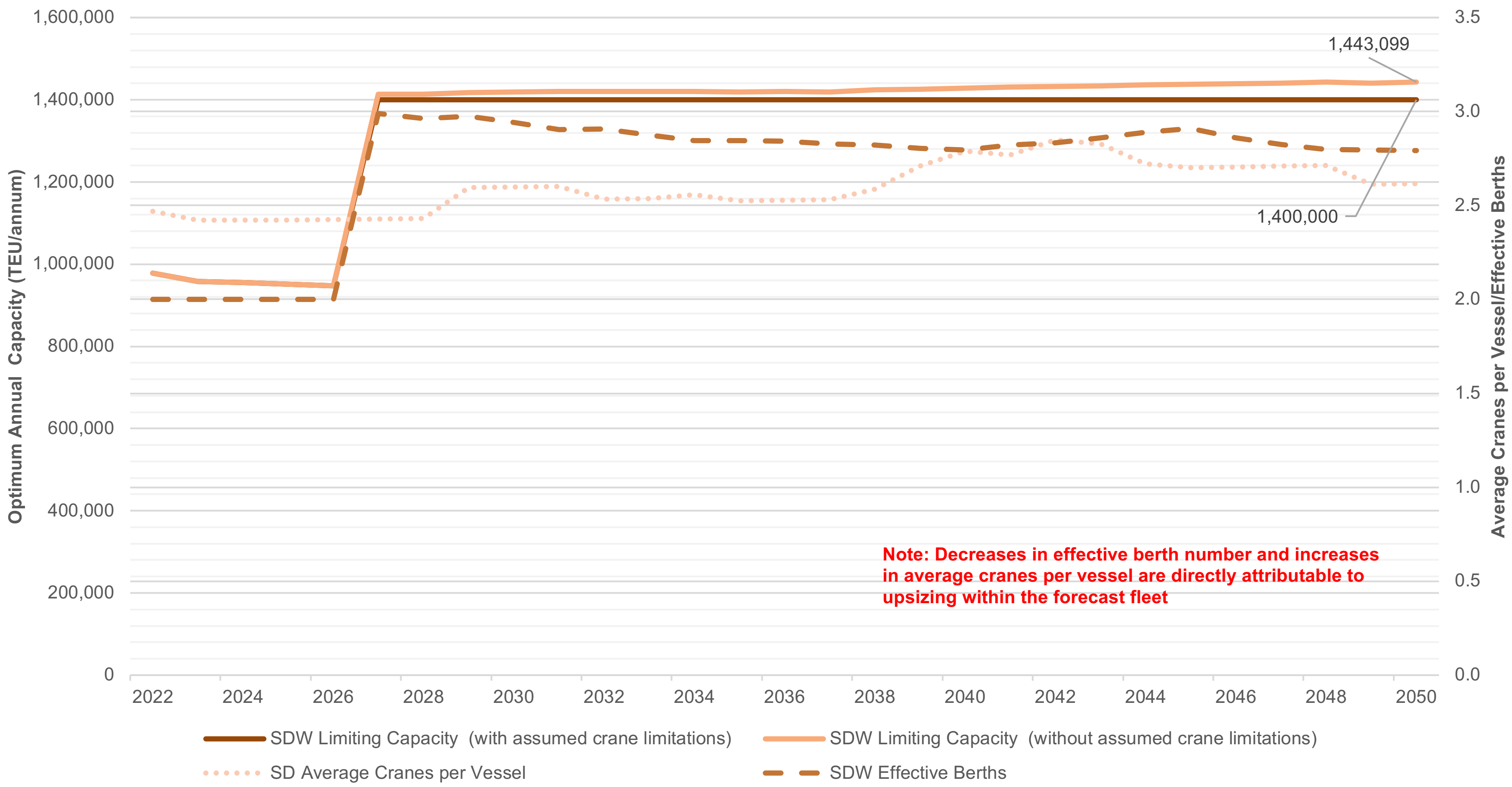
Figure 42 Calculated Capacity (Scenario G) – Swanson Dock East



Key Inputs (refer to Appendix B for full list of inputs):

Berthline	844m
TEU:Box Ratio	1.60
Net STS Rate	31nmph
Berth Util. factor	65%
Yard Dwell Times	2 days (import), 5 days (export), 3days (empties), 2 days (transhipment)
Crane Allocation	2 STS (< 5,000 TEU), 3 STS (5,000-9,000 TEU), 4 STS (>9,000 TEU)

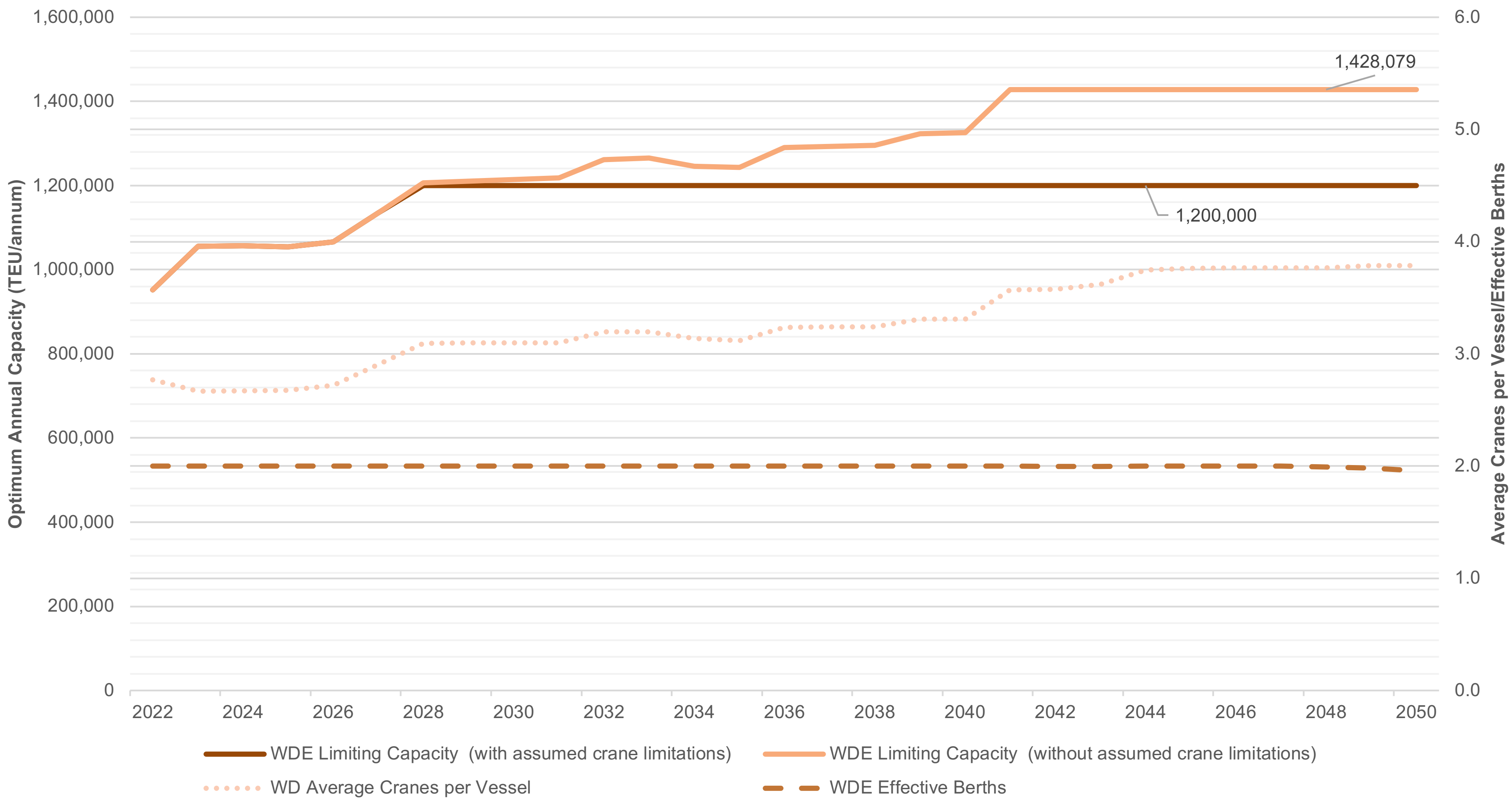
Figure 43 Calculated Capacity (Scenario G) – Swanson Dock West (with WSIT)



Key Inputs (refer to Appendix B for full list of inputs):

Berthline	944m
TEU:Box Ratio	1.60
Net STS Rate	31nmph
Berth Util. factor	65%
Yard Dwell Times	2 days (import), 5 days (export), 3days (empties), 2 days (transhipment)
Crane Allocation	2 STS (< 5,000 TEU), 3 STS (5,000-9,000 TEU), 4 STS (>9,000 TEU)

Figure 44 Calculated Capacity (Scenario G) – Webb Dock East



Key Inputs (refer to Appendix B for full list of inputs):

Berthline	731m
TEU:Box Ratio	1.60
Net STS Rate	31nmph
Berth Util. factor	65%
Yard Dwell Times	2 days (import), 5 days (export), 3days (empties), 2 days (transhipment)
Crane Allocation	2 STS (< 5,000 TEU), 3 STS (5,000-9,000 TEU), 4 STS (>9,000 TEU)

Appendix B – Key Model Inputs by Scenario

Description	SCENARIO A Base	SCENARIO B Crane working rate increased	SCENARIO C Crane working rate decreased	SCENARIO D Dwell times increased	SCENARIO E Dwell times decreased	SCENARIO F Increased cranes for larger vessels	SCENARIO G Increased allowable berth utilisation
TEU to Box Ratio							
Swanson Dock							
2022	1.6	1.6	1.6	1.6	1.6	1.6	1.6
2030	1.6	1.6	1.6	1.6	1.6	1.6	1.6
2040	1.6	1.6	1.6	1.6	1.6	1.6	1.6
2050	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Webb Dock							
2022	1.6	1.6	1.6	1.6	1.6	1.6	1.6
2030	1.6	1.6	1.6	1.6	1.6	1.6	1.6
2040	1.6	1.6	1.6	1.6	1.6	1.6	1.6
2050	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Dwell Times							
2022							
Imports - Full	2	2	2	2.5	1.5	2	2
Imports - Empty	3	3	3	3.5	2.5	3	3
Exports - Full	5	5	5	5.5	4.5	5	5
Exports - Empty	3	3	3	3.5	2.5	3	3
Transhipment - Inward	2	2	2	2.5	1.5	2	2
Transhipment - Outward	2	2	2	2.5	1.5	2	2
Transhipment - Empty	2	2	2	2.5	1.5	2	2
2030							

Imports - Full	2	2	2	2.5	1.5	2	2
Imports - Empty	3	3	3	3.5	2.5	3	3
Exports - Full	5	5	5	5.5	4.5	5	5
Exports - Empty	3	3	3	3.5	2.5	3	3
Transhipment - Inward	2	2	2	2.5	1.5	2	2
Transhipment - Outward	2	2	2	2.5	1.5	2	2
Transhipment - Empty	2	2	2	2.5	1.5	2	2
2040							
Imports - Full	2	2	2	2.5	1.5	2	2
Imports - Empty	3	3	3	3.5	2.5	3	3
Exports - Full	5	5	5	5.5	4.5	5	5
Exports - Empty	3	3	3	3.5	2.5	3	3
Transhipment - Inward	2	2	2	2.5	1.5	2	2
Transhipment - Outward	2	2	2	2.5	1.5	2	2
Transhipment - Empty	2	2	2	2.5	1.5	2	2
2050							
Imports - Full	2	2	2	2.5	1.5	2	2
Imports - Empty	3	3	3	3.5	2.5	3	3
Exports - Full	5	5	5	5.5	4.5	5	5
Exports - Empty	3	3	3	3.5	2.5	3	3
Transhipment - Inward	2	2	2	2.5	1.5	2	2
Transhipment - Outward	2	2	2	2.5	1.5	2	2
Transhipment - Empty	2	2	2	2.5	1.5	2	2
Net Crane Rate							
Swanson Dock							

2022	31	34	28	31	31	31	31
2030	31	34	28	31	31	31	31
2040	31	34	28	31	31	31	31
2050	31	34	28	31	31	31	31
Webb Dock							
2022	31	34	28	31	31	31	31
2030	31	34	28	31	31	31	31
2040	31	34	28	31	31	31	31
2050	31	34	28	31	31	31	31
Berth Utilisation Factor							
1 Berth (max. utilisation)	31.00%	31.00%	31.00%	31.00%	31.00%	31.00%	65.00%
2 Berth (max. utilisation)	53.00%	53.00%	53.00%	53.00%	53.00%	53.00%	65.00%
3 Berth (max. utilisation)	63.00%	63.00%	63.00%	63.00%	63.00%	63.00%	65.00%
4 Berth (max. utilisation)	70.00%	70.00%	70.00%	70.00%	70.00%	70.00%	65.00%
Assumed Mooring/Demooring Time per Visit							
All terminals (hours)	3	3	3	3	3	3	3
Quay Crane Allocation (Based upon vessel Size)							
Tier 1							
Minimum Vessel Size (TEU)	0	0	0	0	0	0	0
Maximum Vessel Size (TEU)	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Number of Cranes	2	2	2	2	2	2	2
Tier 2							
Minimum Vessel Size (TEU)	5,001	5,001	5,001	5,001	5,001	5,001	5,001
Maximum Vessel Size (TEU)	9,000	9,000	9,000	9,000	9,000	7,000	9,000
Number of Cranes	3	3	3	3	3	3	3

Tier 3							
Minimum Vessel Size (TEU)	9,001	9,001	9,001	9,001	9,001	7,001	9,001
Maximum Vessel Size (TEU)	14,000	14,000	14,000	14,000	14,000	14,000	14,000
Number of Cranes	4	4	4	4	4	4	4
Other							
STS Crane limitation – minimum spacing (m)	90	90	90	90	90	90	90
STS Maximum Productivity (TEU/annum/crane)							
SDE	140,000	140,000	140,000	140,000	140,000	140,000	140,000
SDW	140,000	140,000	140,000	140,000	140,000	140,000	140,000
WDE	150,000	150,000	150,000	150,000	150,000	150,000	150,000

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