Economic Reviews

Summary report

March 2018

PORT OF
HAY POINT

ECONOMIC REVIEWS

SYNOPSIS

Port of Hay Point Sustainable Sediment Management assessment for maintaining navigational infrastructure

Economic reviews

As part of the Sustainable Sediment Management (SSM) Assessment, Dalrymple Bay Coal Terminal (DBCT) Pty Ltd undertook a study looking at the likely loss of capacity and potential economic flow on effects if maintenance dredging was not undertaken in their berth pockets.

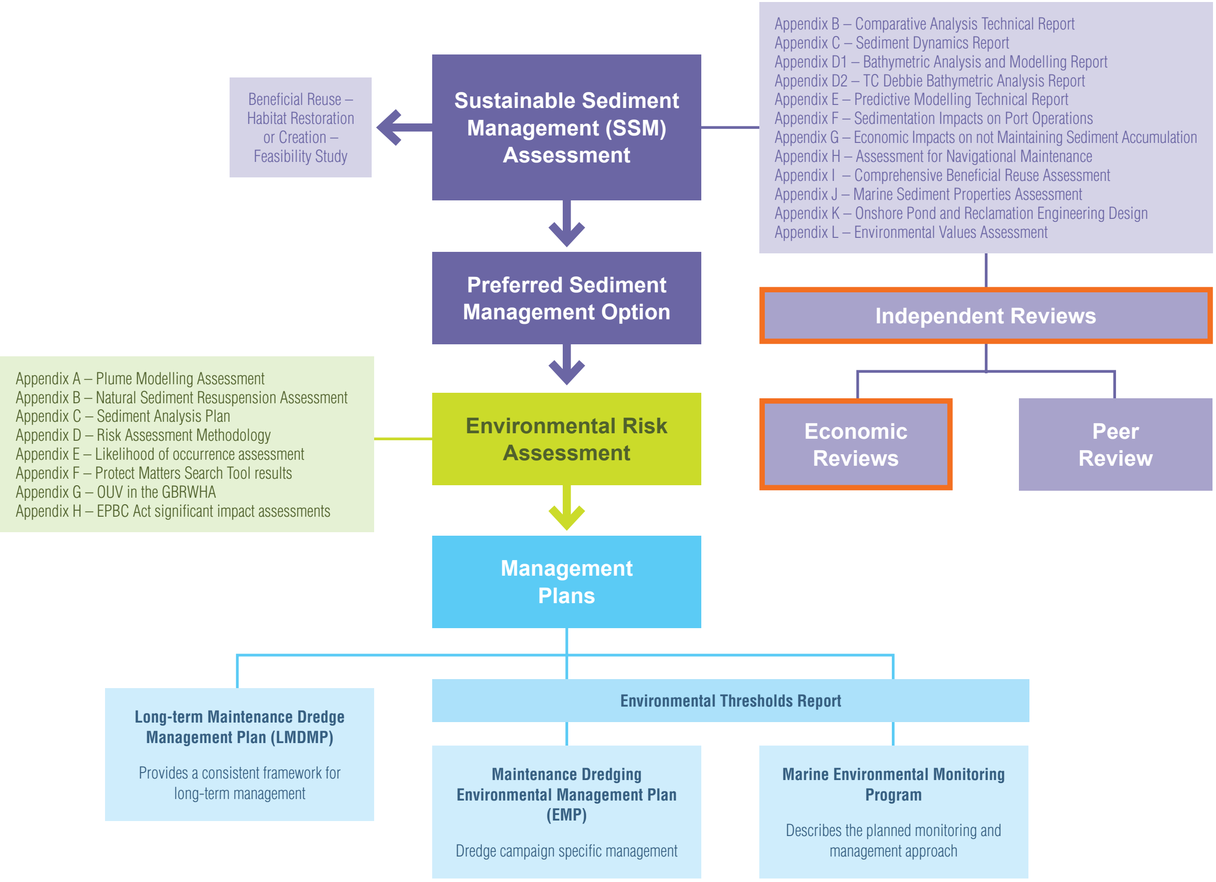
The study identified significant economic impacts to the terminal as siltation increased and working berth pocket depth decreased (Appendix G of the SSM assessment report).

NQBP has sought two additional independent reviews on the impacts to shipping and economics associated with a loss of depth within the Port of Hay Point, if maintenance dredging was not undertaken to remove accumulated sediments.

These reviews were undertaken by:

1. **GHD Advisory** – assessing the impacts on shipping and terminal operations,
2. **ACIL Allen** – assessing the broader economic impacts

A number of supporting studies have been undertaken to inform this assessment



Appendix B – Comparative Analysis Technical Report
Appendix C – Sediment Dynamics Report
Appendix D1 – Bathymetric Analysis and Modelling Report
Appendix D2 – TC Debbie Bathymetric Analysis Report
Appendix E – Predictive Modelling Technical Report
Appendix F – Sedimentation Impacts on Port Operations
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Sustainable Sediment Management (SSM) Assessment

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Appendix D – Risk Assessment Methodology
Appendix E – Likelihood of occurrence assessment
Appendix F – Protect Matters Search Tool results
Appendix G – OUV in the GBRWHA
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Environmental Risk Assessment

Management Plans

Long-term Maintenance Dredge Management Plan (LMDMP)

Provides a consistent framework for long-term management

Environmental Thresholds Report

Maintenance Dredging Environmental Management Plan (EMP)

Dredge campaign specific management

Marine Environmental Monitoring Program

Describes the planned monitoring and management approach

Key Findings

1. GHD Advisory (Independent Assessment of Hay Point capacity and shipping impacts from depth loss)

The need to undertake maintenance dredging to provide a competitive and sustainable industry are consistent with the Maintenance Dredging Strategy for Great Barrier Reef World Heritage Area Ports, noting that:

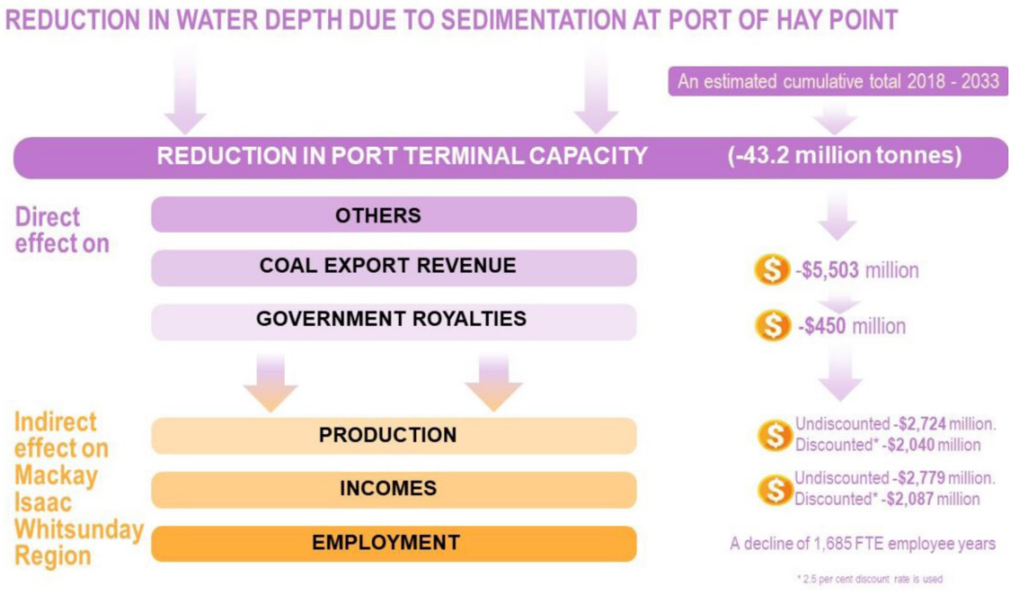
  - *Maintenance dredging is required to maintain designated channel and berth depths to ensure the continued efficient passage of vessels utilising the port*
  - *Most ports cannot sustainably function without maintenance dredging, and maintenance dredging has occurred in Queensland since ports were first established*
  - *Dredging to maintain navigation depths is critical to the effective operation of ports to facilitate export of Queensland's agricultural, pastoral and mineral commodities*

- Siltation effects are more prevalent in berth pockets than in other areas of the port.
- Increased siltation, results in a reduced declared operating depth which effects shipping and operations in three main ways:
  - The period for which vessels must stop loading, due to tidal delays, increases.
  - The number of vessels effected by tidal delays increases
  - The wait time to depart declines and may result in short loading and an increase in dead freight claims
- For the combined terminals, significant lost capacity was observed from a 1.6m berth pocket depth loss from 2016 levels increasing at approximately 2mtpa per 0.4 metres loss.
- The potential for lost throughput has a number of key impacts for terminal operators which include; increased operational cost per tonne, and a reduction in supply chain velocity and efficiency which reduces capacity.
- Cyclone Debbie in early 2017 highlighted a significant risk due to the sudden and shock impact from high volume sediment deposits.

2. ACIL Allen (Economic impact of no maintenance dredging at the Port of Hay Point)

This report developed a scenario based on the data and information contained in the SSM Assessment and the data provided by GHD Advisory. This scenario was analysed using the ACIL Allen's economy wide computable general equilibrium model – *Tasman Global Model*. The model captures the dynamic, intra-industry and inter-industry linkages in the Mackay Isaac Whitsunday Region of Queensland, rest of Queensland, rest of Australia and rest of the World.

The key findings of this report, illustrated in the figure below, outline the potential economic impacts if no regular maintenance dredging was to occur at the Port of Hay Point from 2018 to 2033. This highlights the economic impacts would extend outside of the terminals and has the ability to materially impact regional economics and employment.



Independent Review:

Independent Assessment of Hay Point and Shipping Impacts from Depth Loss

Summary report

March 2018

PORT OF
HAY POINT

Independent Assessment of Hay Point and Shipping Impacts from Depth Loss

March 2018

Disclaimer

This report: has been prepared by GHD for North Queensland Bulk Ports (NQBP) and may only be used and relied on by NQBP as set out in Section 1.2 and Section 1.3 of this report and in relation to an application for maintenance dredging at the Port of Hay Point. This report is not to be relied on by any other person(s) or party for any other purpose.

GHD otherwise disclaims responsibility to any person other than NQBP arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out below.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section(s) 1.4 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by NQBP, DBCT, BMA, MSQ, and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

Limitations

In preparing this report, the following assumptions have been made with respect to the material received (from stakeholders and other parties), unless otherwise specifically stated:

- *Officers who provided advice throughout this engagement were qualified to answer the questions that they were asked.*
- *All documents and records examined were genuine, complete and up to date.*
- *The basis of information provided by stakeholders, and from other sources, has not been independently verified or checked beyond the agreed scope of work. No liability is accepted in connection with unverified information, including any errors and omissions that were caused by errors or omissions in that information.*
- *No environmental fieldwork, regulatory approval or related permitting work has been performed as a part of this study.*
- *This study may be used by NQBP for evidence-based analysis only.*

Glossary of terms

Term/Abbreviation	
Accretion	The process of growth by a gradual build-up
Apron	The area immediately near to a terminal on which cargo is lifted
Berth	The wharf space at which a vessel docks
Berth Pocket	An area of deeper water in front of the loading wharf used to minimise tidal impact on the loading process
BMA	BHP Mitsubishi Alliance
Capesize	Large dry bulk vessel class designated above 150,000 DWT
DBCT	Dalrymple Bay Coal Terminal
Dead Weight Tonnage (DWT)	Maximum weight of a vessel including cargo and ballast
Deballast	Removing ballast water from a vessel to decrease displacement and draught
Demurrage	A penalty fee assessed when cargo isn’t loaded before the free time allowance ends
Drag Barring	A process that levels rather than removes sediment
Draught	Depth from the waterline to lowest point of the vessels keel
Dredge	The process of removing sediment
DUKC	Dynamic Under Keel Clearance
Free on Board (FOB)	Terms of trade where the point of sale is in the vessel hold at the port of origin
GBRWHA	Great Barrier Reef World Heritage Area
Highest Astronomical Tide (HAT)	Highest possible theoretical tide
HPCT	Hay Point Coal Terminal
HPS	Hay Point Services
Layby Berth	An additional berth used to prepare a vessel prior to loading
Lowest Astronomical Tide (LAT)	Lowest possible theoretical tide
MHWN	Mean High Water Neap
MHWS	Mean High Water Spring
Mixed Semi-Diurnal Tides	Tidal patterns containing two highs and lows of differing heights per day
MLWN	Mean Low Water Neap
MLWS	Mean Low Water Spring
MOF	Marine Operating Facility
Neap Tide	The smallest tidal variation occurring on the first and third quarter moons
NQBP	North Queensland Bulk Ports Corporation
Panamax	Medium vessel class able to pass through the Panama Canal, average 65,000 DWT
Pilot Boarding Area/Ground	The zone in which a pilot will board an incoming vessel
Spring Tide	The largest tidal variation occurring on the new or full moon
Stochastic Events	Involving a random variable or probability distribution
Swing Basins	A wider body of water that allows a vessel to turn and/or reverse direction
UKC	Under Keel Clearance
Vessel Parcel	An individual consignment on a vessel
VTS	Vessel Traffic Services

Executive summary

Introduction

North Queensland Bulk Ports Corporation (NQBP) retained the services of Grant Denholm, Executive Advisor – Logistics and Infrastructure Policy at GHD to develop a technical paper (this report) to assess the operational implications of not undertaking maintenance dredging and its impact on terminals at the Port of Hay Point. This report focuses on assessing the shipping and terminal operational impacts which would result from the inability to undertake maintenance dredging at the Port of Hay Point. The tasks undertaken as part of the assessment process included examination of previous technical work, vessel call analysis, review of operations, quantification of shipping impacts, potential shipping responses and potential impact on terminals.

Background

NQBP is the port authority of four ports operating in Queensland, which collectively account for more than half of Queensland's trade by tonnage. Three of the ports NQBP manages, including the Port of Hay Point, are in the Great Barrier Reef World Heritage Area (GBRWHA). NQBP recognises that for the continued long-term operation and prosperity of the Port of Hay Point, it is critical to effectively maintain navigational areas into the future and to do this within the setting of GBRWHA.

The Port of Hay Point supports the mines in the central Bowen Basin region of Queensland and comprises two separate coal export terminals at Dalrymple Bay Coal Terminal (DBCT) and Hay Point Coal Terminal (HPCT), which predominantly handle metallurgical coal. Coal terminals at the Port of Hay Point have seven operational berths, with a variety of physical characteristics, specialised handling infrastructure and associated limitations, as shown in Table E1. There has been no major maintenance dredging programme in the Port of Hay Point since 2010, apart from drag bar operations which levels, rather than removes, the deposited sediment in the bottom of the berth pockets. Without the ability to perform regular and, at times, emergency maintenance dredging, the inflow of silt deposits has resulted in a loss of the water depth of the berth pockets at the Port of Hay Point (refer Table E1). If the situation continues there will inevitably be a further reduction in berth pocket depth, and possibly areas of the departure channel, which will further impact shipping and terminal operations.

Table E1 Port of Hay Point berth facilities

Berth	Design Depth (m)	Depth – June 2017 (m)	Loss from Design (m)	Berth length (m)	Berth pocket (L x W)	Max DWT (t)	Shiploaders
HPCT 1	16.6	16.1	-0.5	203.6	342.9 x 60.96	180,000	1. 6,000 tph 2. 6,000 tph 3. 8,400 tph
HPCT 2	16.7	16.7	0.0	188.7	365.7 x 60.9	200,000	
HPCT 3	19.0	18.4	-0.6	252.0	460.0 x 70.0	220,000	
DBCT 1	19.6	17.5	-2.1	662	838.0 x 65.0	220,000	1. 7,200 tph 2. 7,600 tph 3. 8650 tph
DBCT 2	19.6	17.4	-2.2			220,000	
DBCT 3	19.0	17.3	-1.7	676	890.0 x 65.0	220,000	
DBCT 4	19.0	17.1	-1.9			220,000	

Source: Notice to Mariners 375 (T) of 2017, Department of Transport and Main Roads – Maritime Safety Queensland; (2) Port Procedures and Information for Shipping – Port of Hay Point, June 2017; (3) NQBP 2015, Port of Hay Point - Port Handbook and http://www.dbct.com.au/shipping; accessed 2 August 2016; (4) Port of Hay Point Operations Manual Revised 2016

Previous technical work

There have been previous studies carried out for NQBP on the operational impacts of maintenance dredging. As part of this study a review was undertaken on the report by Adaptive Strategies, Open Lines Consulting and RMC (hereafter referred to as the Consultants) who collaborated to prepare a single report, entitled ‘Port of Hay Point – Sustainable Sediment Management Assessment – Assessment for Navigational Maintenance’ for NQBP.

The Consultants’ report analysed the effect of sedimentation on navigational depths at the Port of Hay Point reaching a general conclusion that not performing maintenance dredging at the facilities (DBCT and HPCT) would lead to reduced navigational depths within the berths and channels.

The Consultant’s report went on to identify that if the depth in the channel is reduced, there is also less opportunity to manage the timeframes around which ships can arrive at, or depart berth pockets, and is further limited by UKC requirements. Similarly, it was reported that reduced navigational depths in berth pockets have an effect in reducing available operating windows.

The Consultants’ report stated that reduced navigational depths would result in:

- Reduced maximum cargo exported per ship
- Tidal delays in the vessel’s loading, possibly resulting in loading not being finished in time for the vessel to sail on necessary high tide. This delay has a flow-on effect on other ships in the queue

Given these findings, the Consultants’ report concluded that the operational impact of not undertaking maintenance dredging would result in diminished capacity and throughput at the Port of Hay Point. The Consultant’s report also noted that that lower throughput levels, would culminate in reductions of free-on-board coal revenue and associated State-government royalties.

Historical analysis

Historical berth pocket data, despite some fluctuations resulting from accretion and drag-bar intervention has shown an incremental loss across DBCT berth pockets between 2005 and 2014 to approximately 1.5 metres less than design depth. Some berth pocket depth recovery was achieved (with the exclusion of Berth 4) in 2016 from drag barring resulting in a 0.25m gain[1]. While depth loss from accretion has been observed at DBCT, there has been limited loss at HPCT – which in 2016 was approximately 0.13m less than design. However, this does not necessarily mean that HPCT is not subject to accretion or exposed to a risk of a significant deposit.

In identifying the relationship, based on potential symptoms discussed in this report, the following four hypotheses were identified.

- *The loss of payload per vessel results in a change from larger tidal vessels to smaller vessels*
- *There is a reduction in load rates resulting from stop loading delays for tidally affected vessels*
- *There is a decrease in the wait to depart times for tidal vessels*
- *There is a reduction in tidal vessel capacity utilisation*

Due to the berth pocket depth loss (and variation) particularly at DBCT, identification of the related operational impacts were explored for the purposes of this analysis for DBCT only. Analysis of historical DBCT data for berth pocket depth change and operations (with respect to the above hypotheses) over the last five years identified:

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[1] Berth 1 and Berth 3 received the greatest benefit. Little gain was achieved at Berth 2, while depth loss occurred at Berth 4

- There is little evidence of a move from larger vessels to smaller vessels and a limited desire for vessels to be significantly larger. However, a change to smaller vessels may be held back by low Capesize charter rates over recent years, and the commercial decision of exporters/consumers to achieve the lowest delivered cost per tonne rather than seeking terminal operational efficiency and capacity. Nonetheless, with terminal design for the efficient and full loading of vessels above 200,000dwt, and persisting market demand for vessels of this size, it is desirable that infrastructure capability for larger vessels be maintained for full port and terminal operational capacity, particularly if there is a change in the fleet mix towards larger vessels in the future.
- There is little evidence, on average, that there is a reduction in load rates resulting from stop loading delays for tidal vessels. This outcome, in the average, is not unexpected, due to the many external factors that influence the load rates (such as process improvement initiatives, better performing fleet, and more complicated loading process of multiple cargo vessels), the variable impact of the stop loading delays (which are confirmed to be occurring) on a per vessel basis, and the ability to reliably confirm the exact number of vessels affected by low water delays in the data. However, if the period of stop loading delays increases, which is contrary to the design function of a berth pocket, and the proportion of the fleet affected increases, the effect of lost depth on vessel load rates will become more pronounced in the average.
- There is an observed decrease in the wait to depart times for tidal vessels and a correlation with berth pocket depth for tidal vessels. This is an outcome of the impact of low water stop loading delays, and the need to load closer to the scheduled departure on the high tide. With continued depth loss, the wait time to depart will continue to decline to the point that will trigger short loading and tonnage loss for tidal vessels, and an increase in the number of dead freight claims.
- There is little evidence that there is a reduction in tidal vessel capacity utilisation in the average from loss of berth pocket depth to date, and that the tidal vessel fleet are currently able to meet required tonnage largely due to the operators loading with the tide to achieve the required tonnes, which is captured in the reduced wait to depart time outcomes. However, a reduction in vessel capacity utilisation will become significant when the proportion of vessels that are unable to meet the tonnes required before the departing high tide increase, and the duration of stop loading delays during the low tide becomes longer (also reflected in the loss of buffer in the wait to departure time).

Due to the many external factors that influence operations, the variable impact of low water stop loading delays, and the ability to reliably confirm the exact number of vessels affected by low water delays in the data, it is difficult to isolate all discrete operational impacts unless a significant proportion of the fleet is affected. Despite these data limitations, a correlation for berth pocket depth change and wait time to depart was identified, where a reduction in berth pocket depth resulted in a reduced wait to depart time (or a reduced buffer between the completion of loading and the departure window of the vessel).

Capacity effects from reduced pocket depth

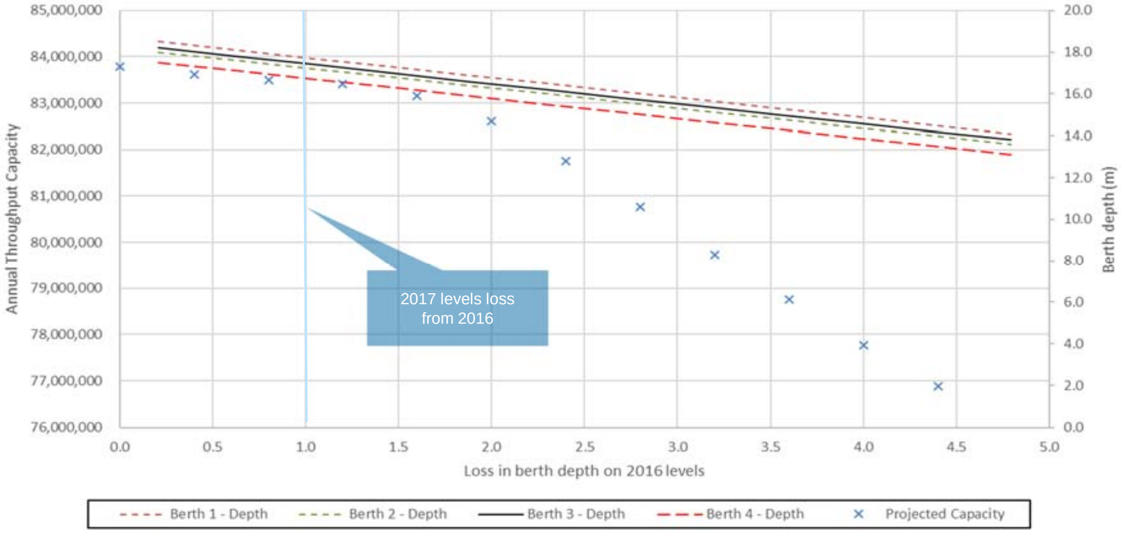
The derivation of capacity is highly complex, due largely to the inter-dependent relationship of infrastructure with many external dynamic factors. These include, but are not limited to; market forces, environmental conditions, operational requirements and stochastic events.

A capacity model was developed for HPCT and DBCT based on operational considerations only, with the impact of external factors excluded. The modelling of the change in operational impacts and capacity from an incremental loss in berth pocket depth identified:

- For DBCT (Figure E1), significant lost capacity was observed from around 1.6m loss from 2016 levels (available berth depth of 16.9m), increasing at approximately 1mtpa per 0.4 metres loss (which would be greater with an increase of large vessels in the fleet profile),, with a capacity tonnage loss in the order of 8mtpa at 4.4m loss beyond 2016 levels (around channel depth). This volume represents the need for approximately 65 additional vessels to recover lost capacity.

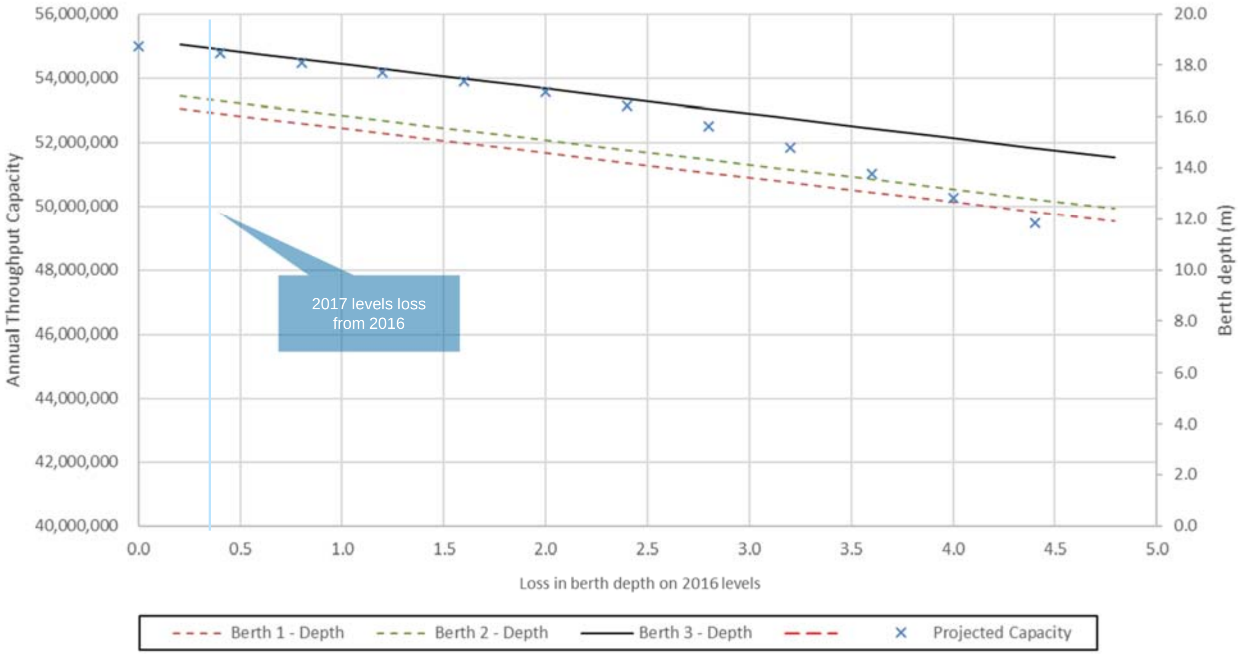
- For HPCT (Figure E2), significant lost capacity was observed from around 2m loss from 2016 levels (available berth depth of 16.8m), increasing at approximately 1mtpa per 0.4 metres loss (which would be greater with an increase of large vessels in the fleet profile),, with an actual capacity loss in the order of 5.5mtpa at 4.4m loss beyond 2016 levels. This volume represents the need for approximately 55 additional vessels to recover lost capacity.
- For the combined terminals, significant lost capacity was observed from a 1.6m berth pocket loss from 2016 levels (available berth depth of 16.9m), increasing at approximately 2mtpa per 0.4 metres loss (which would be greater with an increase of large vessels in the fleet profile),. This translates to an actual capacity loss in the order of 13mtpa at 4.4m loss beyond 2016 levels (a calculated capacity of 126mtpa from the current 140mtpa nameplate capacity, or 2016 calculated 139mtpa); however, the combined terminal impact calculation masks the true effect due to loss asymmetry, and will likely understate the impact.

Figure E1: Terminal throughput capacity versus loss in berth pocket depth – DBCT



Source: GHD calculations

Figure E2: Terminal throughput capacity versus loss in berth pocket depth - HPCT



Source: GHD calculations

Terminal and exporter responses to reduced pocket depth

The potential for lost throughput has a number of key impacts for terminal operators which include; increased operational cost per tonne, and a reduction in supply chain velocity and efficiency which reduces capacity. Terminal operators have implemented operational practices (loading with the tide, utilisation of layby berths, reducing vessel changeover time and the like), and process improvement initiatives to maximise capacity, maintain efficiency and keep costs as low as possible in order to maintain competitiveness against reducing infrastructure capability.

For exporters, impacts from the loss of infrastructure capability, largely relate to shipping cost impacts resulting from longer port stays, potential for demurrage and dead freight claims, and ultimately a decrease in vessel size (which increases the number of vessels required and further lowers terminal capacity due to lower load rate performance). With the potential loss of vessel capacity and the need to meet contracted volumes, which have the potential to increase with a recent improvement in market confidence, exporters would need to order additional vessels, however, the number of additional vessels is limited by the level of berth occupancy, as well as landside operation constraints for stockyard management, product availability, and rail scheduling. As such the recovery potential is limited.

Reduction in economies of scale per vessel from continued loss of payload (which is contrary to the nature of market demand) resulting from berth pocket depth is estimated to increase by approximately USD2 per tonne at 4.4m loss beyond 2016 levels for every tonne on Capesize (tidal) vessels from Hay Point, with a tipping point (at around USD1 per tonne above current Capesize rates) for tidally unaffected smaller Panamax vessels at 3.2-3.6m loss.

Sudden significant depth loss

Despite the depth recovery achieved in 2016 (from drag barring), gains in berth pocket depth were offset by the impact of Cyclone Debbie in early 2017. The initial impact saw a reduction in Declared Depth in the order of 1.5 to 2.5 metres at each of the DBCT berths. This resulted in the majority of berths operating at 3 to 3.5 metres less than design. Recovery of some depth to around 2 metres less than design was achieved, however, with the inability to remove silt deposits from berth pockets an additional 0.5m to 1m loss was observed (to around 2m less than design).

Depth loss from cyclones, as a result, is a significant risk due to the sudden and shock impact from high volume sediment deposits, particularly when this is combined with accretion and the inability to remove material from the berth pockets. With the historical use of drag-barring, no further depth recovery will be achievable without the removal of sediment from the berth pockets. Additional berth pocket loss, as a result, will have an increased incidence and impact on operations, and therefore terminal capacity, especially with the overarching risk of sudden depth loss potential from cyclones.

Government policy and strategy

There has been no major maintenance dredging programme in the Port of Hay Point since 2010, apart from drag bar operations. As demonstrated in the analysis undertaken as part of this report, further berth pocket loss will result in the loss of throughput and terminal capacity, which even if recovered through additional vessels (achievable only to a point) will be transported at higher cost (which will reduce the competitiveness and/or viability of the industry)

The findings of the analysis in this report, and the need to undertake maintenance dredging to provide a competitive and sustainable industry are consistent and confirmed by the State of Queensland Maintenance Dredging strategy, noting that:

- *Maintenance dredging is required to maintain designated channel and berth depths to ensure the continued efficient passage of vessels utilising the port*
- *Most ports cannot sustainably function without maintenance dredging, and maintenance dredging has occurred in Queensland since ports were first established*
- *Dredging to maintain navigation depths is critical to the effective operation of ports to facilitate export of Queensland's agricultural, pastoral and mineral commodities*

Contents

Appendices

1. Introduction

1.1 Background

North Queensland Bulk Ports Corporation (NQBP) is the port authority for four ports operating in Queensland (refer Figure 1), which collectively account for more than half of Queensland's trade by tonnage[2]. Three of the ports NQBP manages, including the Port of Hay Point, are in the Great Barrier Reef World Heritage Area (GBRWHA). NQBP recognises that for the continued long-term operation and prosperity of the Port of Hay Point, it is critical to effectively maintain navigational areas into the future and to do this within the setting of GBRWHA.

Figure 1 NQBP Port Locations

Source: GHD

There has been no major maintenance dredging programme in the Port of Hay Point since 2010, apart from drag bar operations which levels, rather than removes, the deposited sediment in the bottom of the berth pockets. Without the ability to perform regular and, at times, emergency maintenance dredging, the inflow of silt deposits has resulted in a loss of the water depth of the berth pockets at the Port of Hay Point. If the situation continues there will inevitably be a further reduction in berth pocket depth, and possibly areas of the departure channel, which will further impact shipping and terminal operations.

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[2] https://nqbp.com.au/port-of-mackay-keeping-trade-afloat/

This potential outcome has been previously identified, and is a key driver for development of the State of Queensland Maintenance Dredging strategy, which states:

> *Channels, berths and swing basins naturally shallow over time due to siltation and sediment transport processes. Maintenance dredging is required to maintain designated channel and berth depths to ensure the continued efficient passage of vessels utilising the port*. [3]

Furthermore, the consequential impacts of not undertaking maintenance dredging were identified:

> *Most ports cannot sustainably function without maintenance dredging, and maintenance dredging has occurred in Queensland since ports were first established. Dredging to maintain navigation depths is critical to the effective operation of ports to facilitate export of Queensland's agricultural, pastoral and mineral commodities, and import of a range of goods on which communities rely including household goods, manufactured products, vehicles, machinery and fuel.* [4]

1.2 Purpose of this report

NQBP, has retained the services of Grant Denholm, Executive Advisor – Logistics and Infrastructure Policy at GHD to develop a technical paper (this report) to assess the operational implications of not undertaking maintenance dredging and its impact on terminals at the Port of Hay Point.

1.3 Scope and report structure

1.3.1 Scope of works and exclusions

This report focuses on assessing the shipping and terminal operational impacts which would result from the inability to undertake maintenance dredging at the Port of Hay Point. The tasks undertaken (scope of work) in the preparation of this report include:

- Examination of previous technical work
- Vessel call analysis
- Review of operations
- Quantification of shipping impacts
- Potential shipping responses
- Potential impact on terminals

This report, and the analysis undertaken excludes the following:

- Forecasting of the level of accretion in the berth pockets and/or shipping channel
- Financial and economic analysis of the impacts on the port, terminals and vessel operators
- Forecasting of coal demand, contracted tonnage, and/or estimation of terminal throughput

1.3.2 Structure of the report

This report is structured in five main sections. In addressing the scope of works, the report provides an overview of the port of Hay Point and its coal terminals (Section 2), this includes a summary of the terminal infrastructure, key coal trade statistics, port operating environment, and identification of the maintenance

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[3] Maintenance Dredging Strategy for Great Barrier Reef World Heritage Area Ports, State of Queensland (Department of Transport and Main Roads), 2019, p. 12

[4] Maintenance Dredging Strategy for Great Barrier Reef World Heritage Area Ports, State of Queensland (Department of Transport and Main Roads), 2019, pp. 12-13

dredging areas. The report then identifies key aspects from previous consultant engagements (Section 3) related to maintenance dredging and the assessment process for estimating operational impacts, as well as considerations that more detailed analysis (in this report), could apply.

In order to establish the basis for the assessment for terminals and shipping at the Port of Hay Point, the report includes an assessment of operational impacts (Section 4). Section 4 includes discussion on the key aspects of capacity and key influencers for delivery of capacity. The report then goes on to identify potential impacts on those key capacity influencers from berth pocket depth loss, and discusses the resulting symptoms and response by industry. A number of hypotheses are then identified and tested against historical ship call data to identify relationships between berth pocket depth variation and key performance metrics that influence capacity delivery. Section 4 concludes with a quantification of throughput and capacity loss resulting from berth pocket loss based on historical performance data and those identified relationships with key capacity influencers.

The report goes on to discuss terminal and exporter responses (Section 5) in terms of operations and commercial behaviour from changing infrastructure capability as a result of berth pocket depth loss. The report concludes (Section 6) with a summary of key findings from the analysis.

2. Port and terminal overview

2.1 Port of Hay Point

The Port of Hay Point is situated on the Central Queensland coast to the south of Mackay and is one of the largest coal export ports in the world. The port has expanded considerably over the past 20 years and now primarily exports metallurgical coal, a key input to the steel-making process[5].

The port supports the mines in the central Bowen Basin region of Queensland and comprises two separate coal export terminals at Dalrymple Bay Coal Terminal (DBCT) and Hay Point Coal Terminal (HPCT).

DBCT is leased from the State Government by DBCT Management Pty Ltd and operated by DBCT P/L, and HPCT is owned by the BHP Billiton Mitsubishi Alliance (BMA) and operated by Hay Point Services (HPS).

DBCT and HPCT have stated terminal capacities of 85 million tonnes per annum (mtpa) and 55 mtpa respectively.[6] Total coal exports in 2015/16 were approximately 65 million tonnes at DBCT and 51 million tonnes at HPCT.[7]

Infrastructure at the Port of Hay Point includes purpose-built rail dump facilities, stockyards, conveyors and offshore jetties leading to wharves and shiploaders for the purpose of coal exports, as shown in Figure 2.

Figure 2 Aerial of Port of Hay Point

Source: Imagery ©2016 CNES/Astrium, TerraMetrics, Data SIO, NOAA, U.S. Navy, NGA & GEBCO, and Map data ©2016 GBRMPA & Google

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[5] https://nqbp.com.au/our-ports/hay-point

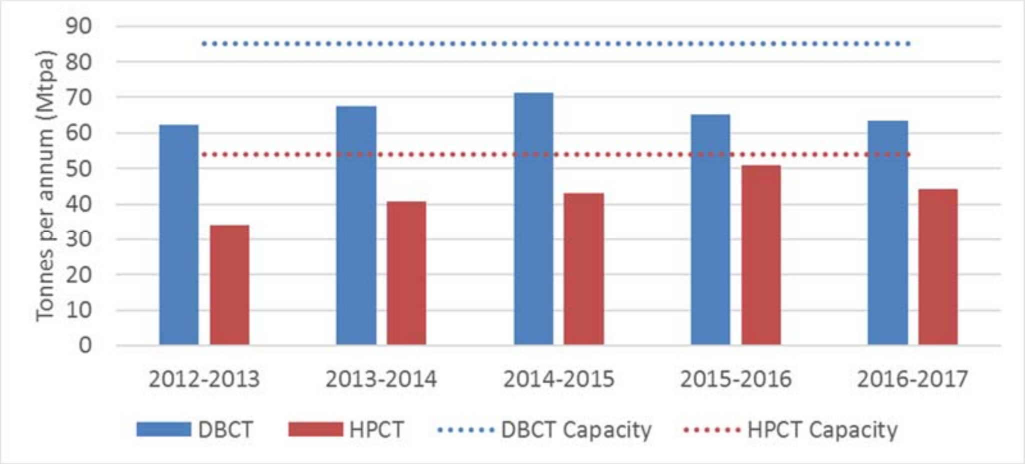
[6] Port-of-Hay-Point-Operations-Manual-February-2017

[7] Coal industry review tables 2016-17, Table 16 - Queensland exports by port (tonnes), Interim - 24 October 2017 v1.0

2.1.1 Port statistics

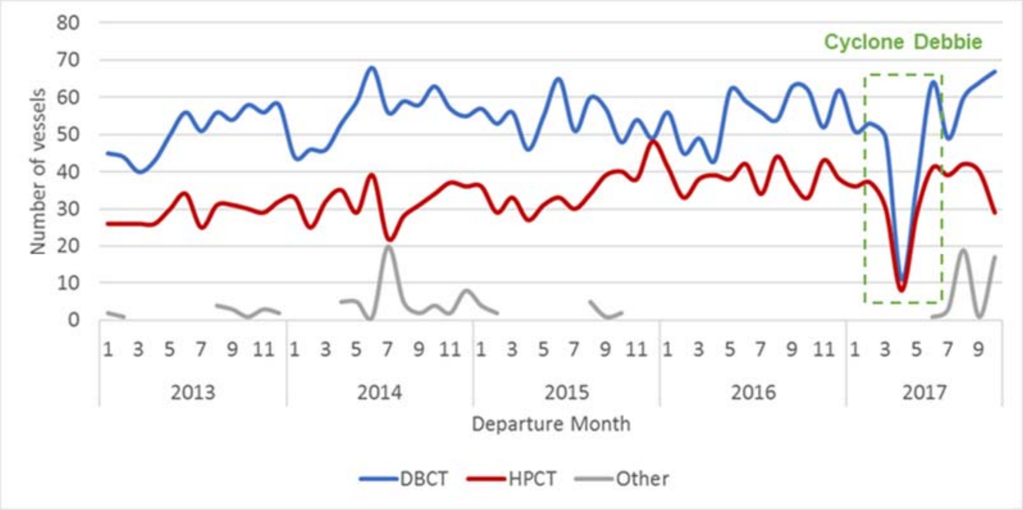
Between 2012/13 to 2016/17 exports from DBCT and HPCT terminals have fluctuated between 61 to 71.5 million tonnes per annum and 34 to 51 million tonnes per annum respectively. Between 2013 and October 2017, the number of vessel calls at DBCT and HPCT was on average approximately 1,000 vessel calls per annum, with 60% of calls to DBCT and 40% of calls to HPCT, indicating an average of 50 vessel calls per month for DBCT and 33 calls per month for HPCT. In addition to coal vessels, a number of calls occurred across the period to the Marine Operating Facility (MOF) and other non-coal related infrastructure within the port.[8] Figure 3 and Figure 4 below detail the annual throughput at the Port of Hay Point from FY2012/13 to FY2016/17 and the number of ship calls by month between 2013 and October 2017.

Figure 3 Hay Point historical annual throughput (2012/13 to 2016/17)



Source: Coal industry review tables 2016-17, Table 16 - Queensland exports by port (tonnes), Interim - 24 October 2017 v1.0

Figure 4 Hay Point monthly shipping calls (Jan 2013- Oct 2017)



Source: GHD, based on MSQ QShips Data

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[8] NQBP operates the Half Tide Tug Harbour Marine Operating Facility (HTTH MOF), a safe location for the short, medium and long-term basing of barges and other marine support equipment. There are three loading facilities at the port's MOF. Source: https://nqbp.com.au/our-ports/hay-point

2.1.2 Major operational functions

The coal terminal operations are 24 hours, 365 days per annum and include the following key components:

- Specialised coal receival from dedicated rail services
- Stockpiling of coal products
- Yard machinery to stack and reclaim coal to and from stockpiles
- Shiploading facilities (coal)

In addition to the coal terminals, the following facilities are provided by NQBP:

- Shipping channel and navigational aids
- Tug Harbour

The Port of Hay Point is a compulsory pilotage area and calling vessels are allotted a designated anchorage position by Vessel Traffic Services (VTS)[9] prior to receiving berthing instructions. Ship movements require a minimum of two tugs, with a third tug required for vessels longer than 270m in high wind warnings and particular wave conditions[10].

The Port of Hay Point also operates a Dynamic Underkeel Clearance (DUKC) system that determines the safe and efficient sailing drafts for vessels based on tidal and other environmental conditions. Ships are given approval to access the channels/berths by the Harbour Master when the stipulated DUKC requirements are met. In addition to the calculation of maximum depth in the channel using the DUKC system, a minimum static Under Keel Clearance of 1.5m is required for all vessels at berth to maintain safe operations[11].

2.1.3 Berth facilities

Coal terminals at the Port of Hay Point have seven operational berths, with a variety of physical characteristics, specialised handling infrastructure and associated limitations, as shown in Table 1.

Table 1 Port of Hay Point berth facilities

Berth	Design Depth (m)	Depth – June 17 (m)	Loss from Design (m)	Berth length (m)	Berth pocket (L x W)	Max DWT (t)	Shiploaders
HPCT 1	16.6	16.1	-0.5	203.6	342.9 x 60.96	180,000	1. 6,000 tph 2. 6,000 tph 3. 8,400 tph
HPCT 2	16.7	16.7	0.0	188.7	365.7 x 60.9	200,000	
HPCT 3	19.0	18.4	-0.6	252.0	460.0 x 70.0	220,000	
DBCT 1	19.6	17.5	-2.1	662	838.0 x 65.0	220,000	1. 7,200 tph 2. 7,600 tph 3. 8650 tph
DBCT 2	19.6	17.4	-2.2			220,000	
DBCT 3	19.0	17.3	-1.7	676	890.0 x 65.0	220,000	
DBCT 4	19.0	17.1	-1.9			220,000	

Source: Notice to Mariners 375 (T) of 2017, Department of Transport and Main Roads – Maritime Safety Queensland; (2) Port Procedures and Information for Shipping – Port of Hay Point, June 2017; (3) NQBP 2015, Port of Hay Point - Port Handbook and http://www.dbct.com.au/shipping; accessed 2 August 2016; (4) Port of Hay Point Operations Manual Revised 2016

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[9] Provided by Maritime Safety Queensland

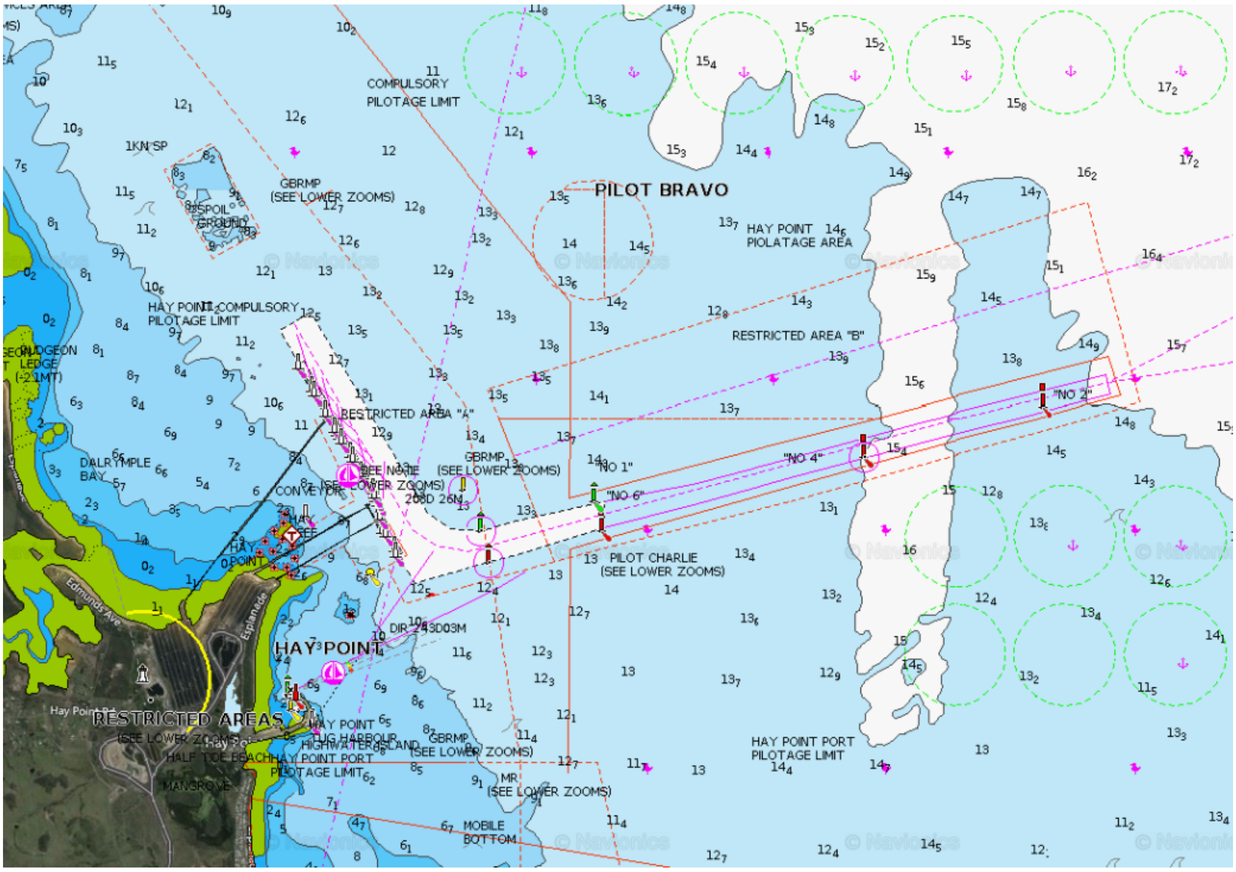
[10] Port Procedures and Information for Shipping – Port of Hay Point, November 2017

[11] Port Procedures and Information for Shipping – Port of Hay Point, June 2017; Note the UKC values are only used during calm weather and may be increased during periods of adverse swell conditions and the Stage II Static Draft (1m +5% of draft) is to be used when the DUKC® is unavailable.

2.1.4 Channel departure and approach depths

NQBP in 2006 completed the development of a dredged departure channel and apron area for shipping at the Port of Hay Point. The departure channel is approximately 9.5km long (Figure 5) from the apron to the sea with an apron manoeuvring area approximately 500 m wide.

Figure 5 Port of Hay Point shipping channel, berth apron, anchorage and pilot boarding ground



Source: Navionics

Table 2 below outlines the available ship manoeuvring depths for inward and outward movements at the Port of Hay Point, with departure depth limited to 14.6m between beacons V.07 and V.08. Departure depths greater than channel depth (at Lowest Astronomical Tide), less the required DUKC levels are assisted with tidal flows, with a Highest Astronomical Tide level of approximately 7.1m.

Table 2 Port of Hay Point Ship manoeuvring available depths

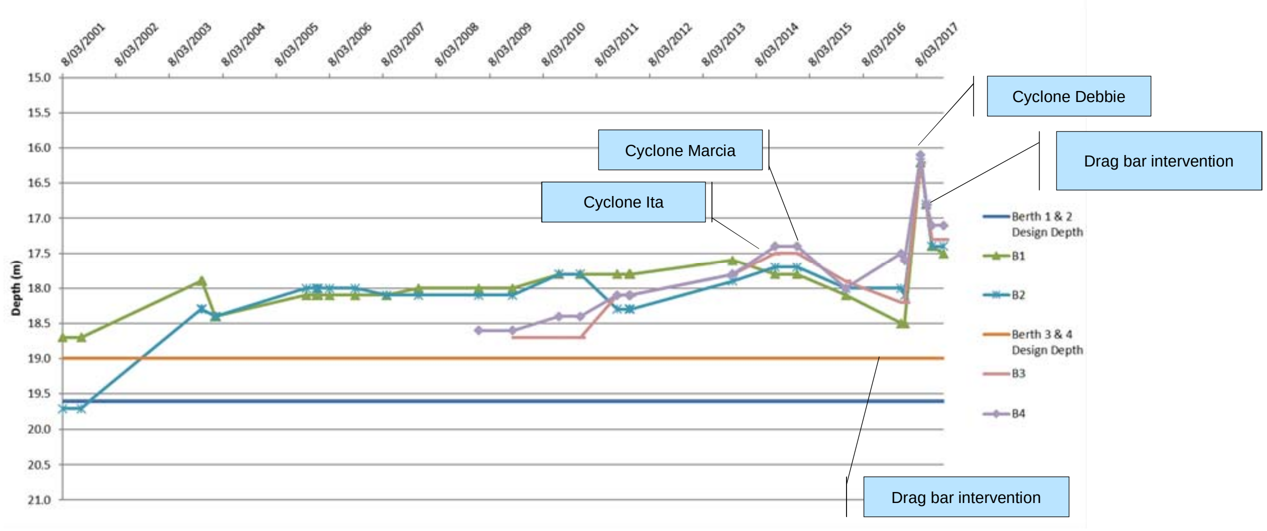
Ship movement	Available Depth (m)
Inward movement (DB3 & 4)	12.7
Inward movement (DB1 & 2)	12.9
Inward movement (HPS Berths, starboard side to)	13.1
Inward movement (HPS Berths, port side to)	11.5
Outward movement via the paddock (Non Channel Departure all berths)	13.1
Channel departure to virtual beacons V.07 & V.08	14.6
Channel departure from virtual beacons V.07 & V.08 to beacon No. 4	14.8
Channel departure seaward of beacon No.4	15.0

Source: Notice to Mariners 401 (T) of 2017, Department of Transport and Main Roads – Maritime Safety Queensland

2.1.5 Berth pocket depth

Operational berth pocket depths are declared by MSQ through the Notice to Mariners based on periodic surveys. As shown in Figure 6, declared depth changes over time, due to both the steady loss through accretion of silt material, and in some cases a rapid loss of depth due to extreme weather events, particularly cyclones.

Figure 6: Declared Berth Pocket Depth - DBCT



Cyclone Debbie

Cyclone Marcia

Drag bar intervention

Cyclone Ita

Drag bar intervention

Source: Adapted from MSQ Notice to Mariners; DBCT P/L

The declared berth pocket depth is based on the shallowest area in the berth pocket, where the profile of silt sediment across the pocket is not necessarily uniform. In order to create a uniform profile in the berth pocket, and to maximise the declared depth, drag barring has been employed to remove high spots, which provides some declared depth benefits; however, the volume of silt in the pocket remains largely the same.

As shown in the figure above, the Declared Depth across all of DBCT berths are less than design, with loss as at June 2017 around 2 metres less than design.

Historical berth pocket data shows an incremental loss across DBCT berth pockets between 2005 and 2010 which equated to around 1.5 metre for berths 1 and 2. Between 2010 and 2014, some recovery of depth was achieved at Berth 2, but levels returned to Berth 1 levels by 2014. Over the same period, berths 3 and 4, demonstrated the more aggressive rate of depth loss to Berth 2, with a loss of around 1 metre, translating to a loss of approximately 1.5 metres from design depth.

Across DBCT, some berth pocket depth recovery was achieved (with the exclusion of Berth 4) in 2016 from drag barring; however, the benefits were offset by the impact of Cyclone Debbie in early 2017. The initial impact saw a reduction in Declared Depth with a range in the order of 1.5 to 2.5 metres at each of the berths, resulting in the majority of berths operating at a depth of 16 m (3 to 3.5 metres less than design). Recovery of some depth to between 17 to 17.5 metres, or around 2 metres less than design. As a result, the inability to remove silt deposits from berth pockets at DBCT has resulted in a 0.5m to 1m reduction following drag bar intervention.

While depth loss from accretion has been observed at DBCT, there has been limited loss at HPCT. However, this does not necessarily mean that HPCT is not subject to accretion or exposed to a risk of a significant deposit of silt as a result of a cyclone (as seen at DBCT) in the future. As shown in Table 1, two of the three berths are at less than design with individual berth losses at June 2017 of 0.5 metres and 0.6 metres for Berth 1 and Berth 3 respectively.

2.1.6 Tides

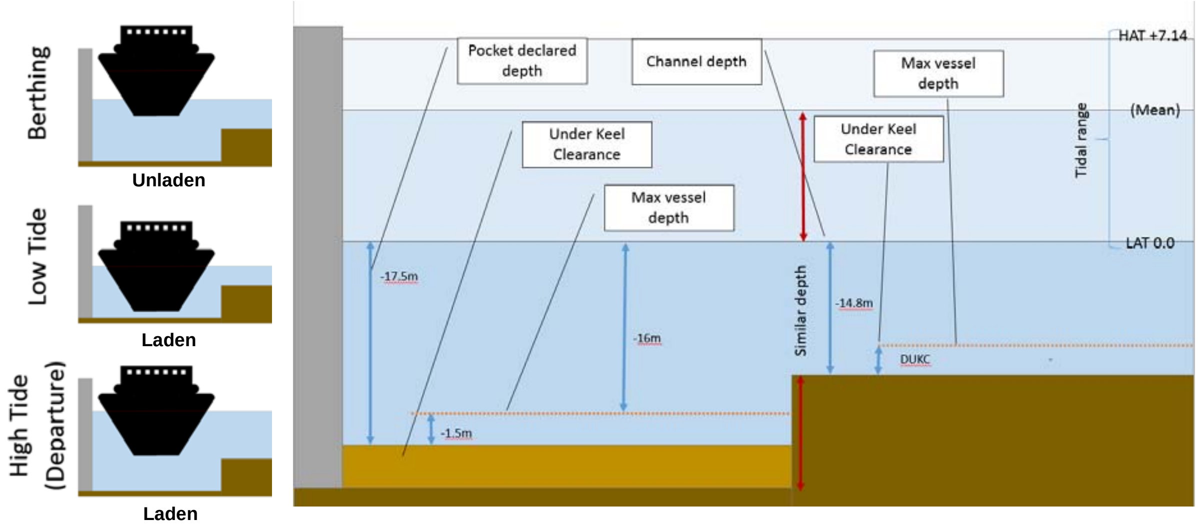
The Port of Hay Point experiences a high tidal range, with mixed semi-diurnal tides with a peak tidal range of 7.14 m and a mean spring tidal range of 4.88 m. Tidal information for Port of Hay Point is shown in Table 3. To maximise the payload, and size of vessels that call to coal terminals at Port of Hay Point, tides are used to increase water depth under the vessel, both in the berth pockets, and in the access channels. An illustrative representation of water depth features with respect to berth pockets and vessel position (with relation to UKC) during a tidal cycle is presented in Figure 7.

Table 3 Tidal information

	Metres
LAT	0.00
HAT	7.14
MLWS	0.90
MHWS	5.78
MLWN	2.22
MHWN	4.46

Source: DTMR (2017) Port Procedures and Information for Shipping – Port of Hay Point; Section 6, pp.41-42

Figure 7: Illustrative representation of water depth features and vessel position during a tidal cycle[12]



Source: GHD

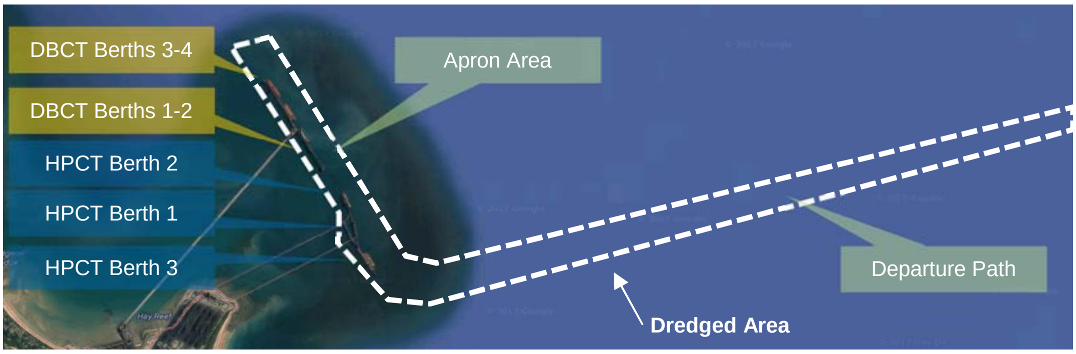
2.1.7 Maintenance dredging areas

Sedimentation over time often results in high spots developing within the navigational (including berth) areas and this results in reduced declared water depths, which without periodic dredging can impact on port efficiency. The general areas of maintenance dredging at the Port of Hay Point is shown in Figure 8 below and includes:

- DBCT Berths 1, 2, 3 and 4
- HPCT Berths 1, 2 and 3
- Apron Areas
- Departure path

In addition to the areas above, the half tide tug harbour approaches, berths and operational areas are also dredged at the Port of Hay Point. The tug harbour is not currently impacted by water depths; however, continued accretion has the potential to affect tug movements to service export vessels. Towage constraints and impacts resulting from water depth loss at the tug harbour have not been addressed as part of this study.

Figure 8 Port of Hay Point Maintenance Dredging Areas



Source: GHD based on Google Maps Imagery

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[12] Based on a declared berth pocket depth of 17.5 metres LAT with a reduction from design depth

3. Previous technical work

There have been previous studies carried out for NQBP on the operational impacts of maintenance dredging. The focus of the below discussion is on the report by Adaptive Strategies, Open Lines Consulting and RMC (hereafter referred to as the Consultants) who collaborated to prepare a single report, entitled ‘Port of Hay Point – Sustainable Sediment Management Assessment – Assessment for Navigational Maintenance’ for NQBP.

3.1 Previous analysis of maintenance-dredging operational impacts

The previous work focused on the section of the Consultants’ report section titled; ‘The effects of sedimentation on Port operations’.[13] In addition, Appendices of the report considered relevant to this report included Section 5 of Appendix F (Port Operation and the Effect of Sedimentation) and Appendix G (Economic Impact of Not Managing Sediments at DBCT).

The Consultants’ report analysed the effect of sedimentation on navigational depths at the Port of Hay Point reaching a general conclusion that not performing maintenance dredging at the facilities (DBCT and HPCT) would lead to reduced navigational depths within the berths and channels.

The Consultant’s report went on to identify that if the depth in the channel is reduced, there is also less opportunity to manage the timeframes around which ships can arrive at or depart berth pockets, and is further limited by UKC requirements. Similarly, it was reported that reduced navigational depths in berth pockets have an effect in reducing available operating windows.

The Consultants’ report stated that reduced navigational depths would result in:

- Reduced maximum cargo exported per ship
- Tidal delays in the vessel’s loading, possibly resulting in loading not being finished in time for the vessel to sail on necessary high tide. This delay has a flow-on effect on other ships in the queue

Given these findings, the Consultants’ report concluded that the operational impact of not undertaking maintenance dredging would result in diminished capacity and throughput at the Port of Hay Point. The Consultant’s report also noted that that lower throughput levels, would culminate in reductions of free-on-board coal revenue (see Figure 11 in Consultants’ report) and associated State-government royalties (see Figure 12 in Consultants’ report).[14]

3.2 Forward inclusions for further analysis

Previous technical work has acknowledged that reduced berth and channel depths will affect vessel selection, including amended cargo requirements, and queuing and loading times at the Port of Hay Point. However, there are a range of additional operational matters that would benefit from more detailed analysis. For the purposes of the analysis in this report, the following have been applied:

- Consideration of *actual* operational impacts based on low level terminal historical data
- Assumptions used in calculation to be based on historical actual trends
- Inclusion, and acknowledgement of, operational improvements and mitigations employed

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[13] See pages 32 to 35 of Consultants’ report for section titled; ‘The effects of sedimentation on Port operations’

[14] As the scope of this report relates to operational impacts only, the Consultants’ calculations for varying coal revenues and royalties have not been considered

4. Operational impact assessment

In order to assess and quantify potential operational impacts from reduced water depth, it is necessary to understand how capacity is influenced. In simple terms, capacity can be calculated using the basic formula, *capacity = load rate * number of loaders * time*.

While the above formula is basic, the derivation of capacity is highly complex, due largely to the inter-dependent relationship of infrastructure with many external dynamic factors. These include, but are not limited to; market forces, environmental conditions, operational requirements and stochastic events.

Capacity can be, and is often, stated in various forms, including theoretical capacity, nameplate capacity, practical capacity, achievable capacity, and declared capacity, which are essentially differentiated by the level of discounting or allowance for loss. Despite this general convention, there are no standards for calculation, and what allowances – by name or by level – that can be included in the calculation. Rather these allowances are typically defined by the infrastructure owner.

Despite the lack of standard in the definition, and its intrinsic variability, the critical aspect of capacity is understanding the nature of the infrastructure, its limitations, and how changes in the operational environment impact performance and ultimately throughput, including any change in cost that is borne by industry, operators and/or consumers.

For each of the variables used to define capacity (as the practical limit of what can be reasonably handled), there are a number of key influencers.

4.1 Load rate

Load rate is the speed in which product is transferred into the ship. The load rate is affected by a number of factors, mostly related to vessel and infrastructure capability and the nature of the product. The load rate is limited by the capability of the slowest element in the outbound system (from stockpile to ships hold).

4.1.1 Terminal infrastructure

There is a range of terminal infrastructure that influences load rates – including reclaimers, conveyors, shiploaders – associated with the outbound shiploading stream. The capability of the handling system is largely defined by design, and is typically aligned with market requirements, which for coal, is a high velocity large scale system due to the low value, high volume nature of the product, similar to iron ore.

4.1.2 Shipping fleet

Vessel capability, and the rate in which they receive cargo, is largely influenced by the size, and class, of ships, where larger vessels are able to load at higher rates. This is due to the stress placed on the vessel during loading, and the deballast rate (removal of ballast water) during loading. Moreover, the number of cargoes (individual consignments for different customers) on board a vessel also affect the loading rates, as the need to reposition stockyard equipment, through a more complex operation throughout the loading sequence, reduces the rate achieved for the vessel.

The size of vessels are, for the most part, market driven (and are ordered by the producer or charter party, not the terminal), where coal typically demands large ships to exploit economies of scale in order to keep shipping costs low on a per product tonne basis. However, the size of ships ordered are limited by the port infrastructure berths/jetties, berth pockets and the associated approach channels, both at the port of origin and the port of destination. Additionally, consumer parcel size preferences (which may for example be limited by the stockpile size at a steel mill or power station) will influence vessel size. As a result, the shipping fleet profile calling at the port of Hay Point, as with most ports, will include a mix of vessel sizes and performance capabilities, which have significant influence over the throughput capabilities, and capacity, of the terminals.

As with any market, there is the potential for change. In the case of coal shipping, changes in the infrastructure capability at the destination port (not just the export port), the markets served from Hay Point, and/or the coal customers, will influence the mix and size of vessels. For example, if the destination port is more constrained than the export port, vessels will be smaller (which can be seen with the calling of smaller vessels at Hay Point); however, if these destination port constraints change, say through infrastructure improvements at the destination port (which releases the constraint), a likely outcome is that that demand for larger vessels will increase, to achieve greater economies of scale.   Therefore, there is the potential that the market may demand larger vessels, and subsequently the calling fleet mix profile.

4.1.3 Product nature

While the design and performance aspects of infrastructure and vessels have a significant role in determining the load rate, so too, does the product itself. Coal, as a general rule, can generally be loaded at high rates, but natural variation in product can have an impact on the rate in which it can be transferred, particularly due to shape and adhesion. Based on discussions with the terminal operators, product nature was not identified as a significant issue or a constraint on the system.

4.2 Number of loaders

The number of loaders in a port has significant influence over capacity, as this influences the number of vessels that can be loaded simultaneously. The number of loaders is dependent on terminal configuration (design); however, depending on the arrangements of berth and shiploading infrastructure, the number of simultaneous loading operations may vary, and consequently impact on capacity. For example, Hay Point Coal Terminal, has three shiploaders and three berths, with two shiploading conveyors, which limits operations to two simultaneous loading operations. While simultaneous shiploading can occur at only two berths, the ability to switch shiploading to the third loader provides operational flexibility, and effective use of a layby berth assists in reducing operational downtime between vessels. DBCT, is similar in that the terminal has four berths with three shiploaders, effectively providing three simultaneous loaders, although the outbound system is not fully interconnected.

4.3 Time

When determining capacity, it is important to understand time, in particular, effective loading time. When effective loading time is combined with the load rate, and number of simultaneous ship loaders, a measure of capacity can be determined. Effective loading time is influenced by a broad range of factors, including availability, outages, and operational practices.

4.3.1 Availability

While berths may be functional 365 days a year, a berth is not always operationally available. The main factor affecting berth availability is planned/scheduled maintenance, which is critical to maintain reliability in the infrastructure and its performance. The number of days for planned maintenance is determined in accordance with the terminal maintenance, or asset management, system/processes. This is also influenced by asset condition and age, with ageing infrastructure requiring increased maintenance time to maintain reliability and performance. The number of days for planned maintenance, as a result, varies from terminal to terminal.

The configuration of terminals, handling equipment and stockyard management, can also influence equipment availability. This is of particular importance for “combination equipment”, where, for instance, shiploading cannot occur through a stacker/reclaimer which is committed to an unloading train, or where stockpiles have not been cleared ahead of an inbound train. Both terminals have implemented systems and operational processes to minimise the impact of such events.

4.3.2 Outages

Outages are a key factor in assessing capacity, and generally come in two forms – breakdowns and weather outages. Despite undertaking planned maintenance, unscheduled and breakdown maintenance occur as part of terminal operations, and are a reflection of infrastructure reliability.

Breakdowns, for the most part, are random events of differing outage periods, and can contribute to a significant reduction in achievable throughput (due to lost operational time). In addition to breakdowns, weather events can result in outages, particularly wind, rain, wave conditions, and cyclones. While some environmental conditions can have a relatively minor impact, some weather events, such as cyclones, can result in significant outage periods due to readiness for storm events (parking and securing terminal equipment and the movement of vessels to sea), damage at the port or terminals and interruption of hinterland supply of product.

Due to the largely unpredictable nature of outages – breakdowns and weather events, loss factors are typically applied as a discount to the achievable loading time based on historical trends for capacity calculations.

4.3.3 Operations

Operational practices have significant influence on the effective loading time of the terminal infrastructure. These include, but are not limited to; vessel changeover, tides, marine services, and product availability. The remainder of this section describes the influence of operations on time.

4.3.3.1 Vessel changeover and commencement

Despite a berth being available, the operation of replacing the vessel at berth and it being ready to load reduces the effective loading time available.   Once a vessel departs a berth, it then transits the channel and heads to sea, the next programmed vessel, once the Pilot is on board and towage is engaged, transits the channel and then to berth. Once secured alongside, there is a period of “readiness for load” that allows for customs and quarantine processes, and confirmation of loading instructions before the vessel Master confirms that loading can commence.

There are a range of strategies regarding the period between loading, particularly where a layby berth is used (this is dependent on the number of berths, and simultaneous loading). The use of a layby berth may include, bringing the vessel alongside early, with a longer wait time at berth until loading commences, or alternatively, hold the vessel at anchorage and bring it to berth close to the time that loading can commence, with the latter providing greater flexibility in the event of a change in operational needs. As a result, berths may be unoccupied; however, this has little to no impact on the throughput tonnes that can be achieved by the infrastructure, it is just the nature of operations for the terminal configuration.

4.3.3.2 Tides

Tides have a significant impact on the operations of a terminal, particularly where a port, and its terminals, are tidally constrained, which is the case at Hay Point (for larger vessels). Tides, for the most part, influence the maximum depth available for vessels to move to and from the terminals, and therefore, influence the number of tonnes that can be loaded on-board (immersion), and/or influence the movement window of the vessel (where tide is used to assist the loaded depth of the vessel on departure).

Tides are influenced by lunar cycles, as well as the standard high and low water levels in each day. As such, tides have a significant impact on vessel loading dynamics, tonnage and the time of sailing. This is further influenced by time of loading completion relative to the water depth, and the level of influence that tides have on required vessel depth (tidal or non-tidal).

To minimise the impact of tidal variation on the loading process while at berth, deep berth pockets are constructed in front of the quay-line or loading jetty to allow vessels (principally the largest ones) to be unaffected by tides during loading.

4.3.3.3 Marine services

In addition to the terminals and vessels, there are a range of marine services that influence effective loading time, namely pilotage, vessel traffic services and towage. These services affect the arrival and departure time of the vessel from a berth, and are provided as a coordinated set of activities. While for the most part, these services are booked in advance, with tolerance around modest changes in times, availability of these services at the time required for a vessel movement, and sequencing of multiple vessels to and from berth at any given time, particularly the high water window, is critical for the on-time arrival/departure of vessels, and therefore the effective time of loading.

4.3.3.4 Product availability

While the infrastructure and vessels may be ready to load product, another key influencer is product availability. Operations typically require all coal to be in the stockyard before commencement of loading, this is to minimise risk to the shiploading operations – where a vessel may be short of contracted tonnes, or that any coal product destined to the terminal fails to arrive in time. This risk can be minimised by direct loading of trains; however, the discharge rates of trains are generally less than shiploading operations and therefore a slower load rate is achieved.

While direct loading of the ship from the train dump can be done, the general operational preference is to not commence loading cargo until assembly is complete in the stockyard.

4.4 Potential impacts from loss of berth pocket depth

The scope of this report is to estimate capacity impacts from the loss of berth pocket depth as a result of the accretion or sudden change in depth of silt in the berth pockets. As such it is necessary to understand what impact loss of berth pocket depth may have on the factors and influencers on capacity, as identified in the previous section above. The remainder of this section discusses the symptoms/impact on the influencers of capacity as a result of depth loss in the berth pocket.

4.4.1 Symptoms of lost berth pocket depth

There are a number of potential impacts resulting from a loss of berth pocket depth, including an increase in stop loading events, an increase in the time to departure, a change in the tonnes on board each vessel, and a change in the fleet mix.[15]

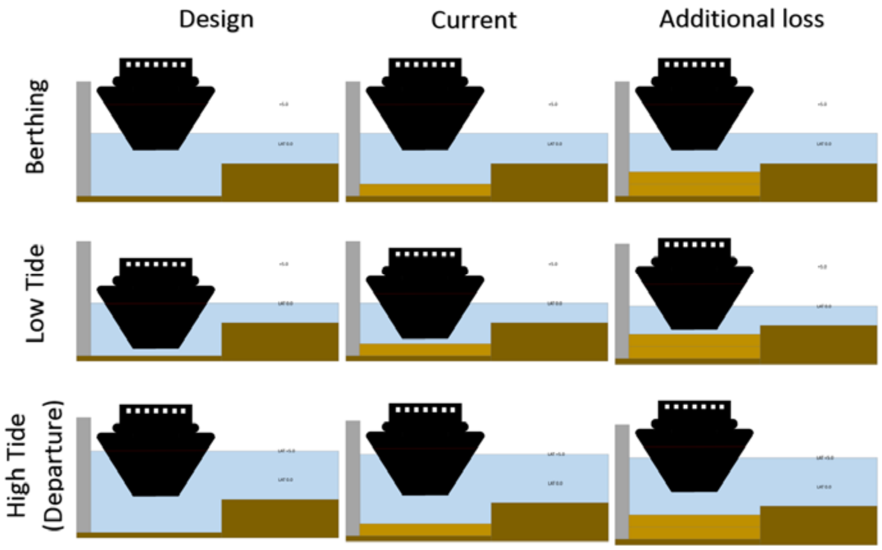
4.4.1.1 Stop loading events - Reduced vessel load rates

With loss of depth in the berth pocket, the ability for a vessel to operate unimpeded by tidal cycles is compromised. While not all vessels are affected by a loss of depth, larger, tidally influenced vessels that require the full design depth of the berth pocket to maximise payload efficiency will be impacted.

With loss of depth in the berth pocket, these (large) vessels have an increased probability of requiring to stop loading while at berth to maintain the minimum under keel clearance. That is, the depth of the vessel at the time of low tide whilst in the berth pocket must have sufficient water under it to stay at berth. To overcome this, affected vessels need to stop loading on a receding tide at or before 'critical' depth, ride through the low tide, and then recommence loading with increasing water levels on the upward tide until departure on the high tide. An illustrative representation of the effects on berth pocket depth loss with vessel loading is provided in Figure 9.

As shown in Figure 9, with the berth pocket at design, the vessel can be fully loaded and remain at berth during the low tide (assuming an LAT 0m); however, with the loss of depth at the berth pocket, the vessel has to be at a shallower depth (less tonnes on board – not fully loaded), which is currently occurring. As shown in Figure 9, additional loss of depth, further reduces vessel depth at low tide, and consequently will have less tonnes on board at the time of the low tide. To manage the UKC of the vessel at low tide, the vessel may need to stop loading ahead of the low tide (which may be several hours) so that minimum clearances are maintained, which in turn increases the time of loading the vessel (commencement to completion time).

Figure 9: Illustrative impact of berth pocket depth loss on vessel depth during loading



Source: GHD

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[15] While there have been some historical apron and channel depth gains and losses, the focus of this work has been on the operational impacts of the more significant constraint of berth pocket depth loss rather than channel and apron loss. Where depth loss in the apron and channel occurs, the impact may place additional constraints on the operations, where departure depth will require higher water levels than design for the same vessel tonnage for tidally affected vessels.

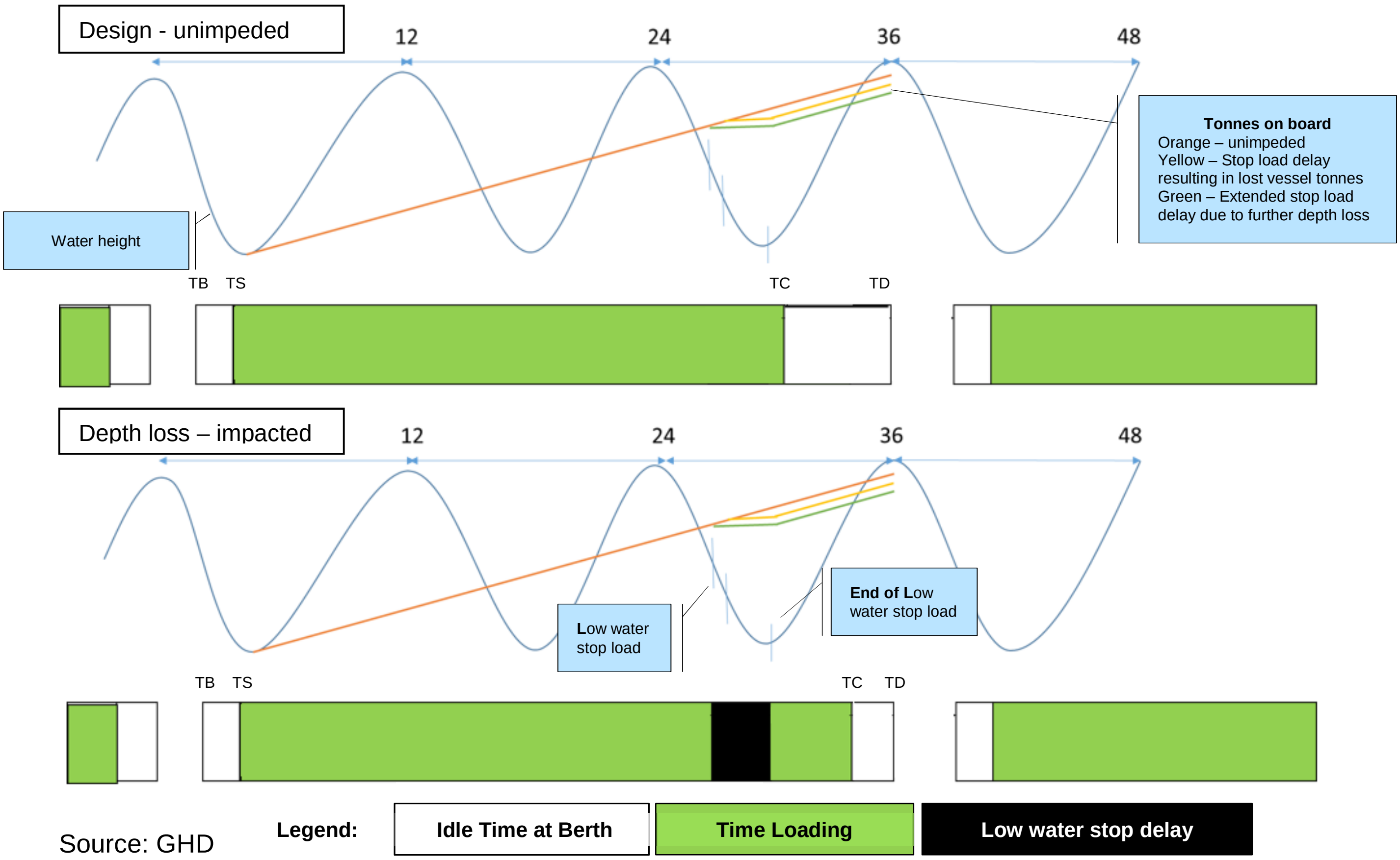
In addition to the need to stop loading to manage under keel clearance at berth during low tide, once loaded tidal vessels cannot stay for an additional high tide, as they are loaded beyond the ‘critical’ depth (minimum under keel clearance) allowable during the low tide cycle.

The stop loading events result in a reduced achievable load rate. A further loss of depth, at the berth pockets, will result in a drop in load rates for vessels with an increased level of non-productive time. Furthermore as depth is lost, some vessels that were not previously affected will find their load rates reduced and now experience stop loading delays.

4.4.1.2 Time to departure

Time to departure is the time from the completion of loading to when it leaves berth. The impacts here are countervailing, where, those vessels that are tidal in the berth pocket (requiring a high tide to enter the channel on departure), due to stop loading delays, will load closer to the departure time for the high tide; while, vessels that are newly impacted, will see an increased time waiting at berth, as they no longer have all tides access. An illustrative representation of the effects on loading time and change in time to departure are presented in Figure 10.

Figure 10: Illustrative impact on loading time and time to departure due to stop loading events[16]



Source: GHD

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[16] TB - Time at berth (first line); TS – Time Load Started; TC – Time Loading Complete; TD – Time of departure (last line)

As shown in Figure 10, the introduction of a stop loading event increases the loading time of the vessel, and consequently, the reduction in the time to departure. Logically, in the illustration, any additional lost time from stop loading events will further erode the wait to depart time, to the point where the vessel must depart with tonnes on board materially lower than that which can be achieved (as it cannot remain at berth through the new tidal cycle and maintain required under keel clearance).

4.4.1.3 Tonnes on board

The payload of a vessel is associated with its immersion depth, and therefore any factor that affects the sailing draught, influences the achievable tonnage of the vessel. If it is assumed that the channel depth remains constant, the tonnage of affected vessels will only be impacted by constraints in the berth pocket and resulting stop loading events as described earlier. However, stop loading events will only impact vessel payload where the vessel cannot load the required product on the rising tide until departure. Further decreases in berth pocket depth, which will require a longer stop loading time (as a further impact to that shown in Figure 10), therefore require a larger amount of cargo to be loaded on the (largely fixed period of time) rising tide (the period after the stop loading event). Given a 4-6 hour post low tide operational window, this may not be sufficient to achieve full or contracted cargo, and therefore a reduction in capacity and throughput will result. Additionally, the effect of tidal (and lunar) cycles and commencement times for loading of vessels, influences the probability and impact of stop loading events with respect to the vessel and water depth combination at low tide, and hence the resulting payload on a per vessel basis.

4.4.1.4 Changes in fleet mix

With a reduction in payload, there are declining economies of scale for the shipping of product (particularly for large vessels that are tidal). Additionally, there may be an increase in vessel time at berth (for vessels that become tidal in the berth pocket), which impact shipping cost due to a longer time in port. The resulting effect, given industry drive to minimise costs per tonne, is for the market to demand the lowest cost vessels. The cost of shipping in smaller vessels, even with increasing delays and inefficiency due to siltation/accretion, will in general still be more expensive than large tidal vessels operating at design depth in the berth pocket. This is due mostly to slower load rate capability. However, there will likely be a point where the loss of payload for larger vessels will result in a higher cost per tonne than smaller vessels, with the tipping point also dependent on the charter rates and fuel prices of the day.

4.4.2 Relationship between pocket depth and operational impacts

Due to the berth pocket depth loss (and variation) particularly at DBCT, identification of the related operational impacts has been explored for the purposes of this analysis for DBCT only. In identifying the relationship, based on potential symptoms discussed in this report, four hypotheses have been identified.

<u>Hypotheses</u>

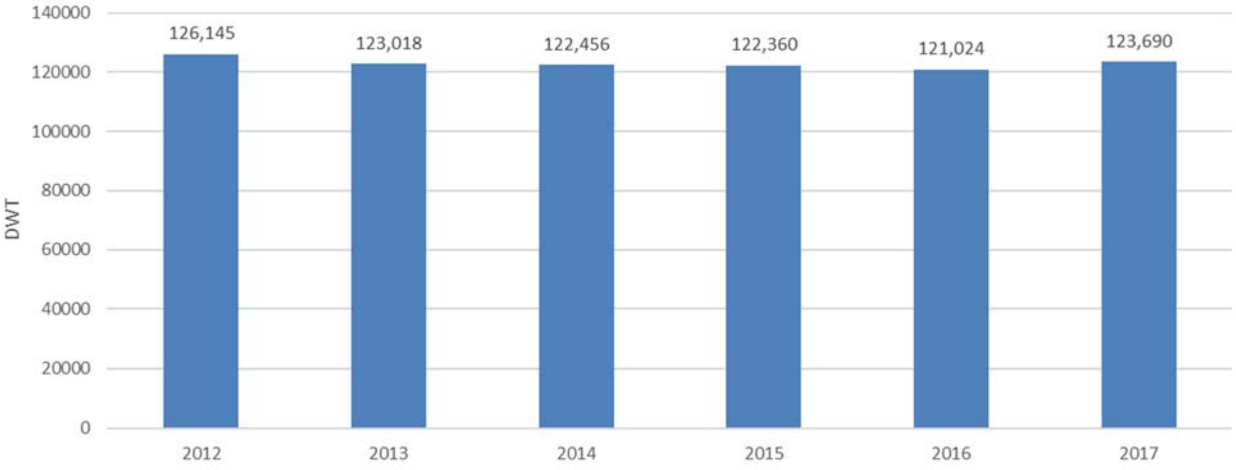
1. *The loss of payload per vessel results in a change from larger tidal vessels to smaller vessels*
2. *There is a reduction in load rates resulting from stop loading delays for tidally affected vessels*
3. *There is a decrease in the wait to depart times for tidal vessels*
4. *There is a reduction in tidal vessel capacity utilisation*

4.4.2.1 Changes in fleet mix

Hypothesis 1 - The loss of payload per vessel results in a change from larger tidal vessels to smaller vessels

Analysis of DBCT historical data indicates that the average DWT of vessels serviced by the terminal has remained relatively constant since 2012, as shown in Figure 11. While there has been a global trend in bulk commodities shipping toward larger vessels, this has not been demonstrated at DBCT as the terminal configuration limits the maximum vessel size to 220,000dwt. Additionally, market factors result in a mix of vessel sizes that form the terminal fleet profile as discussed in Section 4.1.2.

Figure 11: Average Vessel Size – DBCT

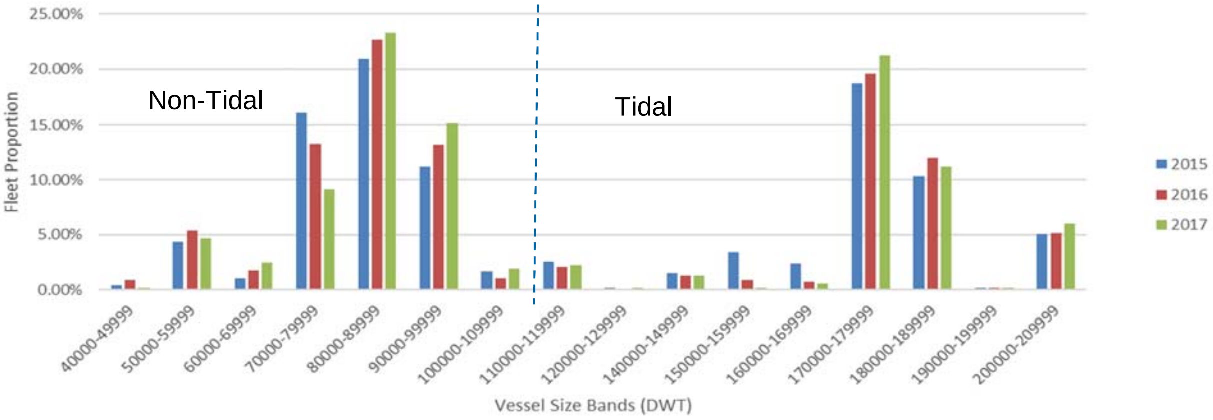


Source: Based on DBCT P/L Vessel Call Data

Despite the trend for larger vessels globally, and the market driven factors that result in a varied fleet profile, an increase in shipping costs resulting from a reduction in economies of scale with depth loss, vessel charter rates also have an impact. Since the GFC, vessel charter rates have been exceptionally low, particularly for larger vessels (which have limited markets) when compared to smaller non-tidal vessels. Therefore the cost per tonne benefit of larger ships is larger than would ordinarily be expected, which in turn would arguably limit a shift to smaller vessels.

A more detailed examination of the vessel fleet mix in Figure 12 shows a modest adjustment in the vessels size, where the non-tidal fleet has seen a shift from Panamax vessels (68,000-78,000dwt) to Post Panamax vessels (88,000-98,000dwt) – of those seeking economies of scale and availability of the ships in the world fleet. The larger tidal vessels of 168,000dwt to 188,000dwt, have seen a very modest change, which is likely to be a transfer from vessels in the 148,000-158,000dwt range to 170,000 to 180,000dwt range. This outcome would be most likely for similar reasons as those in the non-tidal fleet. Additionally, the largest vessels calling at the terminal have remained a small proportion and in the 200,000-210,000dwt range. Nonetheless, with terminal design for the efficient and full loading of vessels above 200,000dwt, and persisting market demand for vessels of this size, it is desirable that infrastructure capability for larger vessels be maintained for full port and terminal operational capacity.

Figure 12: Fleet Profile Breakdown – DBCT[17]



Source: Based on DBCT P/L Vessel Call Data

Conclusion

Based on the above analysis, changes in berth pocket depth around current and recent historical levels, show little evidence of a move from larger vessels to smaller vessels and a limited desire for vessels to be significantly larger. However, a change to smaller vessels may be held back by low Capesize charter rates over recent years, and the commercial decision of exporters/consumers to achieve the lowest delivered cost per tonne rather than seeking terminal operational efficiency and capacity.

Design parameters of the terminals (and port) limit the ability of the shippers to increase the vessel size; however, there has been little change in the number of calls by vessels close to maximum capability, indicating a limited desire for vessels to be significantly larger. However, with terminal design for the efficient and full loading of vessels above 200,000dwt, and persisting market demand for vessels of this size, it is desirable that infrastructure capability for larger vessels be maintained for full port and terminal operational capacity, particularly if there is a change in the fleet mix towards larger vessels in the future.

4.4.2.2 Stop loading events - Reduced vessel load rates

Hypothesis 2 - There is a reduction in load rates resulting from stop loading delays for tidally affected vessels

Analysis of DBCT data indicates the average load rate of vessels serviced by the terminal has not significantly declined since 2012 (Figure 13). Rather, there was an increase of approximately 300 tonnes per hour (approximately 5% improvement) in 2015 for tidal vessels, with a very modest decline since.

The small increase in 2015 is likely a result of process improvement initiatives, a result of a better performing fleet (newer vessels, or better vetting processes), or a reduction in the number of multi-cargo vessels. Noting that stop loading delays for low water are occurring at DBCT, the lack of a trend with berth pocket depth change suggests that the many external factors that influence the load rates mask the impact on an average basis. While it is known that individual vessels are impacted by low water stop load delays, and that some vessel load rates will be affected, the proportion of vessels affected (including the ability to reliably confirm the exact number of vessels), and the impact of other delays limit visibility in the analysis of the DBCT Vessel Call Data.

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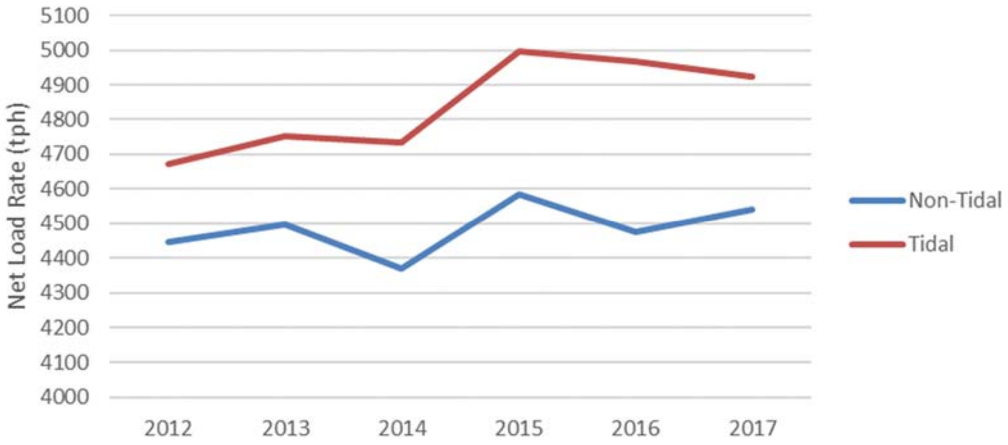
[17] Tidal refers to vessels that are affected by water depth levels under current port conditions

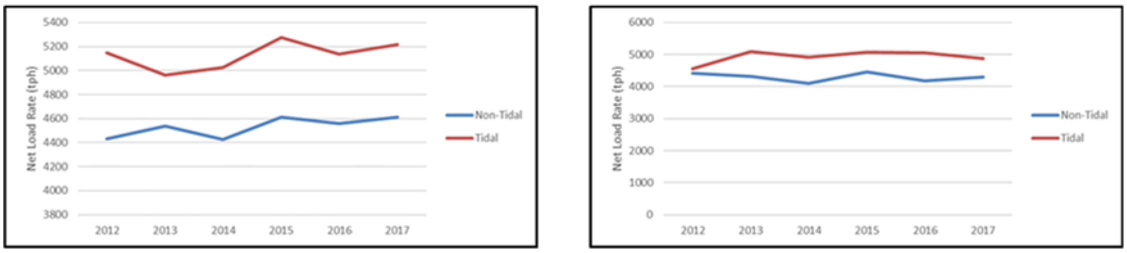
Figure 13: Vessel Load Rates (Tidal and Non-Tidal) - DBCT[18]



Source: Based on DBCT P/L Vessel Call Data

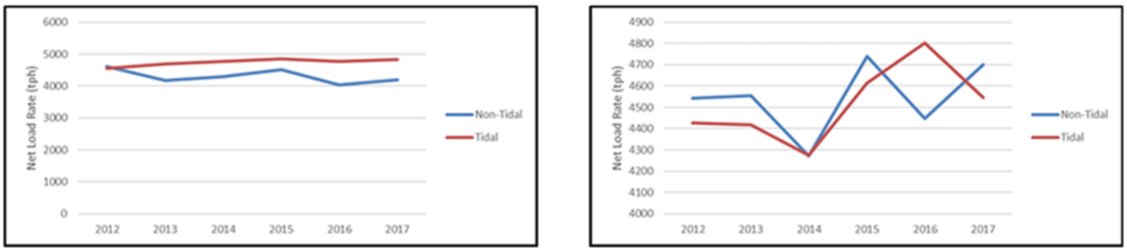
Earlier discussion in this report identified the likely impact from more complicated loading associated with vessels with multiple parcels. As shown in Figure 14, the effect of additional parcels have a significant impact, where the difference between non-tidal and tidal vessels decrease at two parcels, and converge at four parcels. This outcome indicates that the cargo demand profile (driven by the vessel load plan), particularly the mix of multi-cargo vessels over the year, has a stronger influence than changes in berth pocket depth on load rate.

Figure 14: Vessel Load Rates (Tidal and Non-Tidal) by Number of Parcels - DBCT[19]



1 Cargo

2 Cargoes



3 Cargoes

4 Cargoes

Source: Based on DBCT P/L Vessel Call Data

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[18] Tidal refers to vessels that are affected by water depth levels under current port conditions

[19] Tidal refers to vessels that are affected by water depth levels under current port conditions

Conclusion

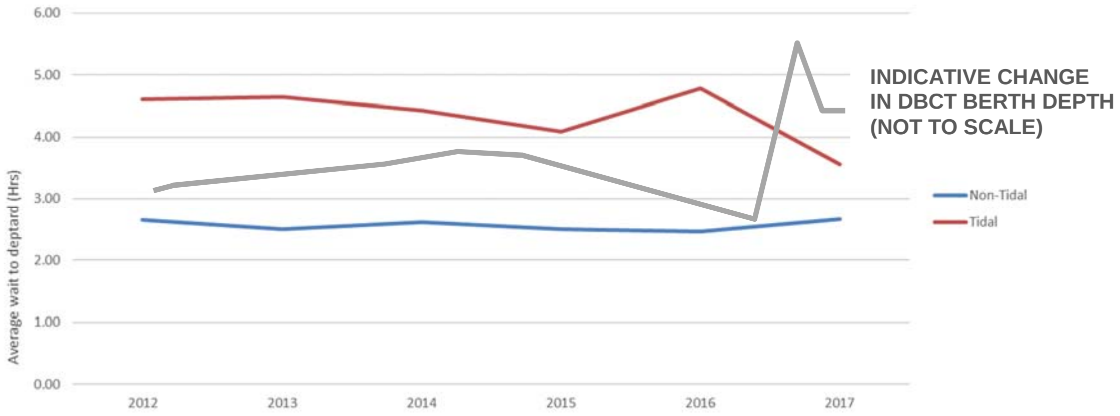
Based on the above analysis, changes in berth depth around current and recent historical levels from the data available, show little evidence, on average, that there is a reduction in load rates resulting from stop loading delays for tidally affected vessels. This outcome, in the average, is not unexpected, due to the many external factors that influence the load rates (such as process improvement initiatives, better performing fleet, and more complicated loading process of multiple cargo vessels), the variable impact of the stop loading delays (which are confirmed to be occurring) on a per vessel basis, and the ability to reliably confirm the exact number of vessels affected by low water delays in the data. However, if the period of stop loading delays increases, which is contrary to the design function of a berth pocket, and the proportion of the fleet affected increases, the effect of lost depth on vessel load rates will become more pronounced in the average.

4.4.2.3 Time to departure

Hypothesis 3 - There is a decrease in the wait to depart times for tidal vessels

Analysis of DBCT data indicates the average wait for departure time for vessels has declined for tidal vessels between 2013 and 2015, and again between 2016 and 2017, as shown in Figure 15. The significant change in 2016, with an increase in waiting times for tides, correlates with the increased berth pocket depth, and the reduction in berth pocket depth in 2017 correlates with the reduction in waiting to depart time. As a result, the impact of stop loading time results in the increasing requirement for vessels to load with the tide and closer to the tidal departure time. Additionally, and as expected, those vessels that are not tidal are largely unaffected.

Figure 15: Vessel Wait Time to Depart (Tidal and Non-Tidal) – DBCT[20]



INDICATIVE CHANGE IN DBCT BERTH DEPTH (NOT TO SCALE)

Source: Based on DBCT P/L Vessel Call Data

Additional analysis considering the relationship between achieved average tonnes per vessel and the average wait for departure time shows that the average tonnes per vessel has remained relatively constant, in line with the relatively steady average vessel sizes (Figure 16). This indicates that tidal vessels are loading closer to their departure time to achieve the same tonnage per vessel. With continued depth loss, the wait time to depart will continue to decline to the operational limit, which includes vessel completion activities, such as draught surveys. Beyond this point, additional depth loss will trigger short loading and tonnage loss on a per vessel basis.

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[20] Tidal refers to vessels that are affected by water depth levels under current port conditions

Figure 16: Vessel Wait Time to Depart v Average Loaded tonnes (Tidal and Non-Tidal) – DBCT[21]

Source: Based on DBCT P/L Vessel Call Data

Conclusion

Based on the above analysis, there is an observed decrease in the wait to depart times for tidal vessels and a correlation with berth pocket depth for tidal vessels. Within the available data, this is an observable outcome of the impact of low water stop loading delays, with the need to load closer to the scheduled departure on the high tide. With continued depth loss, the wait time to depart will continue to decline to the point that will trigger short loading and tonnage loss for tidal vessels, and an increase in the number of dead freight claims.

4.4.2.4 Tonnes on board

Hypothesis 4 - There is a reduction in tidal vessel capacity utilisation

Analysis of DBCT data indicates that the average sailing draft of tidal vessels has remained relatively constant from 2012 at 17.5m.[22] This trend demonstrates that, given a relatively stable average vessel size, that the berth pocket impact has had marginal impact on vessel depth, and therefore tonnes on board.

If the capacity of the vessel (DWT) is compared with the number of tonnes loaded (Figure 17), rather than vessel draught, little change can be observed, with variation largely driven by other factors. While there may be some impact, on occasion, for some individual vessels, on average, vessels are able to meet required tonnage. This trend is in line with the analysis above, which indicates that a reduction in vessel capacity utilisation (tonnes on board) will only become a significant impact when vessels are unable to meet the tonnes required before the departing high tide as a result of stop loading delays resulting through the low tide.

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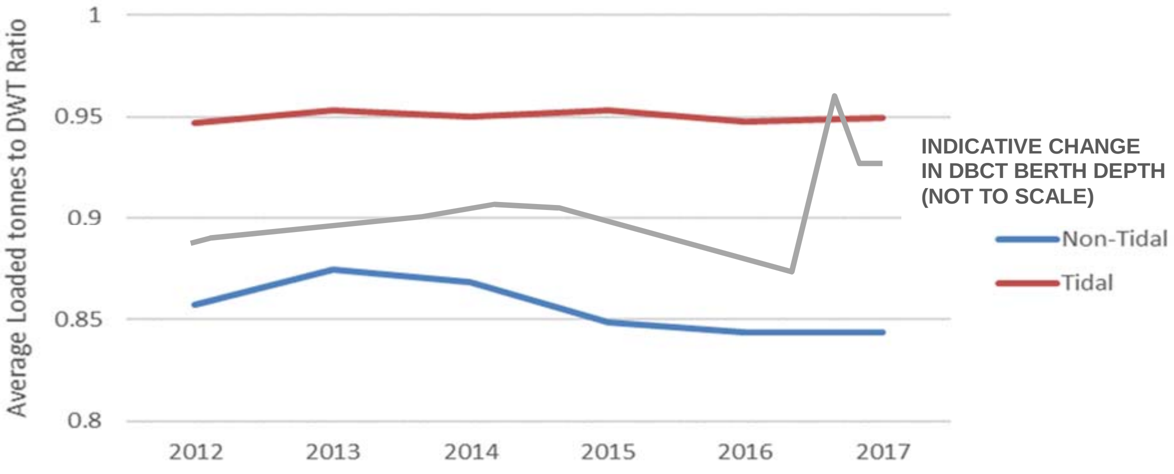
[21] Tidal refers to vessels that are affected by water depth levels under current port conditions

[22] This excludes part loaded vessels

Figure 17: Average Loaded Tonnes to DWT Ratio (Tidal and Non-Tidal) by Number of Parcels – DBCT[23]



Source: Based on DBCT P/L Vessel Call Data

Conclusion

Based on the above analysis, changes in berth depth around current and recent historical levels, shows little evidence that there is a reduction in tidal vessel capacity utilisation in the average from loss of berth pocket depth to date, and that the tidal vessel fleet are currently able to meet required tonnage. This will be largely due to the operators loading with the tide to achieve the required tonnes, which is captured in the reduced wait to depart time outcomes observed in Section 4.4.2.3. As a result, a reduction in vessel capacity utilisation will become significant when the proportion of vessels that are unable to meet the tonnes required before the departing high tide increase, and the duration of stop loading delays during the low tide becomes longer (also reflected in the loss of buffer in the wait to departure time).

4.4.2.5 Findings from the historical analysis

Due to the many external factors that influence operations, the variable impact of low water stop loading delays (which are confirmed to be occurring), and the ability to reliably confirm the exact number of vessels affected by low water delays in the data, it is difficult to isolate all discrete operational impacts unless a significant proportion of the fleet is affected. Despite these data limitations, a correlation for berth pocket depth change and wait time to depart was identified, where a reduction in berth pocket depth resulted in a reduced wait to depart time (or a reduced buffer between the completion of loading and the departure window of the vessel).

4.5 Quantification of capacity impacts

In order to assess the potential capacity impacts a model for each terminal was built to capture the effects on vessel operations resulting from changes in berth pocket depth, and attributable tonnage loss. The model is

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[23] Tidal refers to vessels that are affected by water depth levels under current port conditions

underpinned by operational data, and calculates the additional time required to achieve nameplate capacity in order to back-calculate annual throughput losses with respect to loss in berth depth.[24]

Additional detail on the modelling approach adopted is presented in Appendix A.

4.5.1 Modelling results

Outputs from each of the terminal models have been captured at 0.4m increments from 2016 depths in order to assess key capacity and tonnage loss outcomes independent of the rate of accretion. The 2016 calibration year has been applied, as the latest full calendar year which reflects current operational practices and infrastructure capability without significant impact by cyclone events. Interpretation of the results are therefore based on declared berth pocket depth difference from the 2016 depths as per the table below.

Table 4 Declared depths

Berth	Design Depth (m)	Depth Nov 2016 Calibration (Loss 0m)	Depth June 2017
HPCT 1	16.6	16.3	16.1
HPCT 2	16.7	16.8	16.7
HPCT 3	19.0	18.8	18.4
DBCT 1	19.6	18.5	17.5
DBCT 2	19.6	18.0	17.4
DBCT 3	19.0	18.2	17.3
DBCT 4	19.0	17.5	17.1

Source: Based on various MSQ Notice to Mariners for Hay Point

The remainder of this section of the report discusses each terminal model results with respect to operational and capacity loss, as well as the number of additional vessels required to recover lost tonnage capacity.

4.5.1.1 DBCT

Modelling of depth impacts at DBCT showed that with incremental loss of depth, there is an increase in the stop loading delays for the vessel fleet. The level of increase, as shown in Figure 18, remains relatively constant to around 1.6m additional loss from 2016 Declared Depths (available berth depth of 16.9m), accelerating with additional loss, as a larger proportion of the vessel fleet is affected. In combination with the stop loading delays, the wait to depart delays decrease, as tidal vessels load closer to the high tide (in combination with vessels that were not previously tidal, but now are due to loss of depth in the berth pocket). Where additional vessels are ordered by industry to maintain export volumes, the associated operational delays increase by over three-fold at 4.4m additional loss on 2016 levels (near channel depth).

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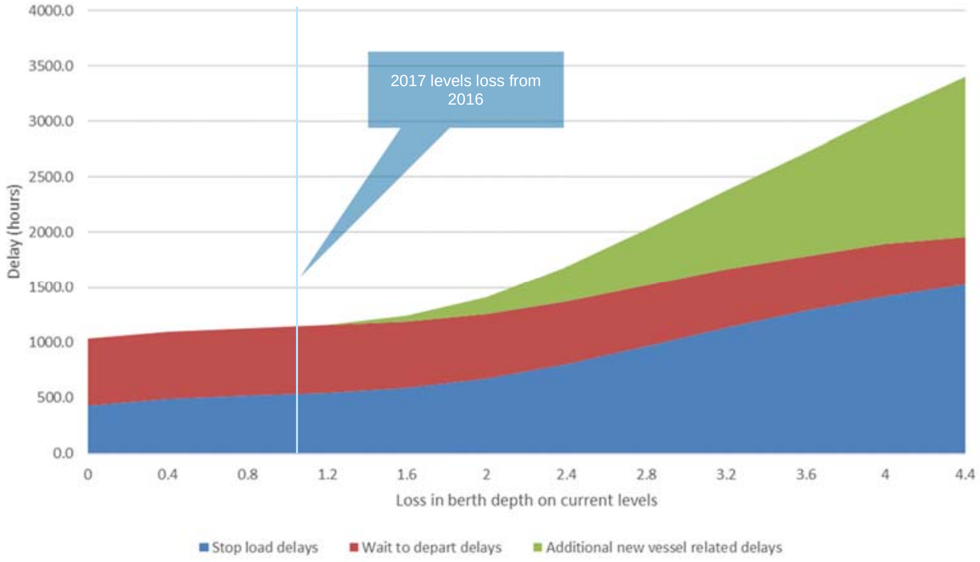
[24] The model assumes a vessel is able to access the deepest berth (DBCT1 and HPCT3) 100% of the time based on the premise that scheduling is fully optimised, in order to mitigate the impact of berth depth loss on capacity throughput – a conservative assumption. Based on this approach, terminal capacity losses have been determined using the model curves based on the change in maximum berth depth at each terminal.

Figure 18: Modelled Aggregate Vessel Delay Times versus Loss of Berth Pocket Depth - DBCT[25]

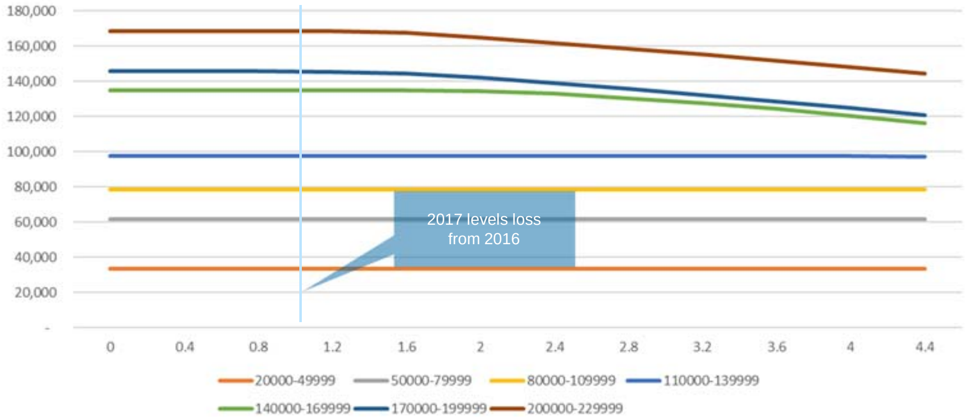


2017 levels loss from 2016

Source: GHD calculations

As a result of the increase in stop loading delays, and the requirement to depart on the next high tide, an associated loss in tonnes per vessel (by group) was observed (Figure 19), particularly beyond a 1.6m loss from 2016 Declared Berth Pocket Depth. [26]

Figure 19: Modelled Average Vessel Payload versus Loss of Berth Pocket Depth - DBCT



2017 levels loss from 2016

Source: GHD calculations

Based on static fleet proportions to meet terminal capacity, significant lost capacity was observed from around 1.6m loss (Figure 20), increasing at approximately 1mtpa per 0.4 metres loss, with a capacity

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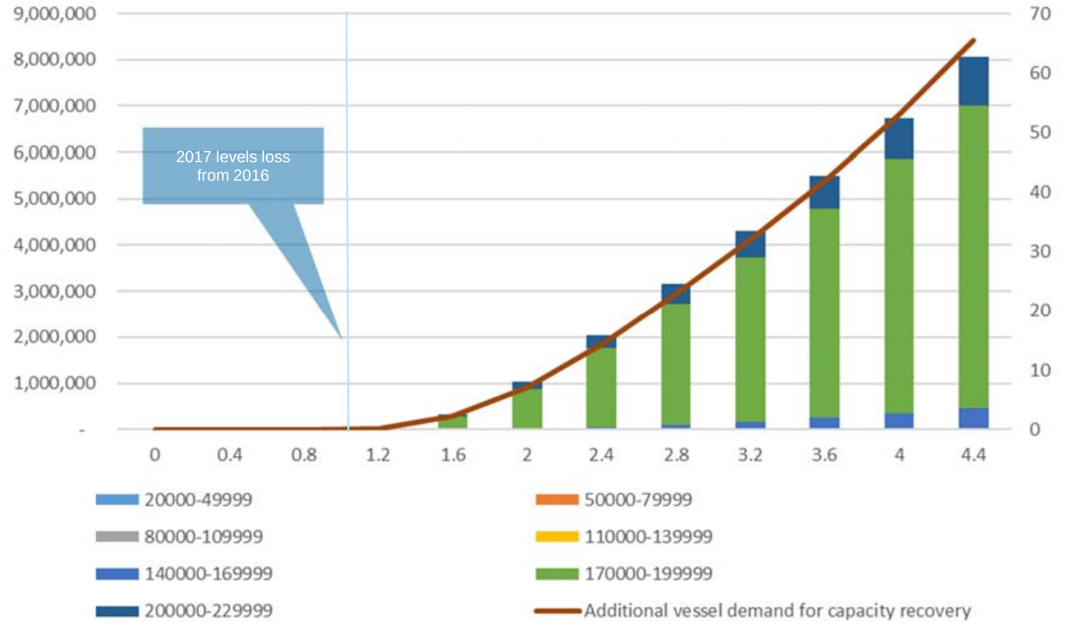
[25] Maximum berth depth in November 2016 (calibration point) for DBCT is 18.5 m at DBCT1. As the modelling calculations assume that tidal vessels target the deepest berth, the June 2017 maximum berth depth of 17.5 m in June 2017 at DBCT1 equates to an effective depth loss of 1 m.

[26] The level of lost capacity would be accelerated with a change in the vessel fleet profile towards larger vessels. This would be a result in the increased probability of low water stop loading events occurring.

tonnage impact in the order of 8mtpa at 4.4m loss beyond 2016 levels. This volume represents the need for approximately 65 additional vessels to recover lost tonnage to meet capacity.

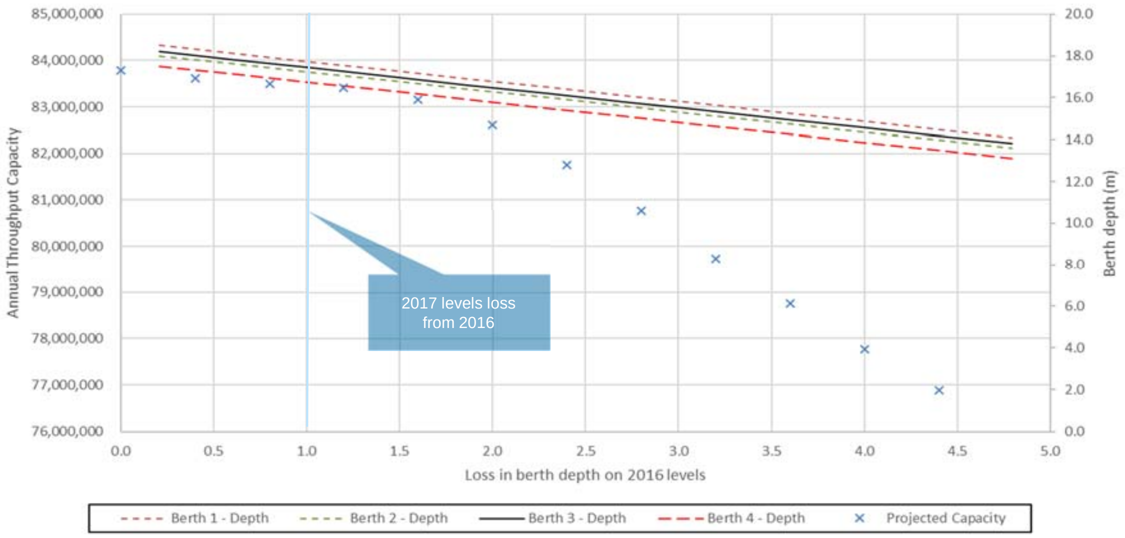
Figure 20: Static fleet loss and required additional vessels versus berth pocket depth loss - DBCT



Source: GHD calculations

Modelling of capacity, based on the above outputs for the DBCT model shows that there is an increase in the rate of capacity loss from an additional 1.6m berth pocket depth from 2016 levels (Figure 21) or an available berth depth of 16.9m.

Figure 21: Terminal throughput capacity versus loss in berth pocket depth – DBCT

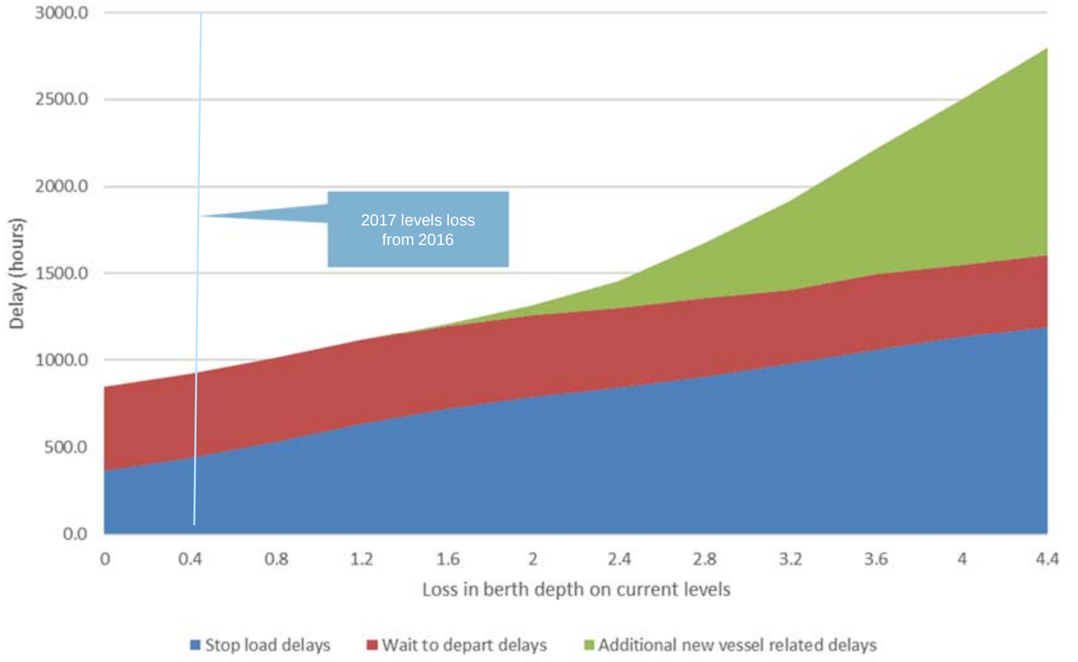


Source: GHD calculations

4.5.1.2 HPCT

Modelling of depth impacts at HPCT showed that with incremental loss of depth, there is an increase in the stop loading delays for the vessel fleet. The level of increase, as shown in Figure 22, remains relatively constant to around 2m additional loss from 2016 Declared Depths (available berth depth of 16.8m), accelerating with additional loss, as a larger proportion of the vessel fleet is affected. In combination with the stop loading delays, the wait to depart delays decrease, as tidal vessels load closer to the high tide (in combination with vessels that were not previously tidal, but now are due to loss of depth in the berth pocket). Where additional vessels are ordered by industry to maintain export volumes, the associated operational delays increase by over two-fold at 4.4m additional loss on 2016 levels (near channel depth).

Figure 22: Modelled Aggregate Vessel Delay Times versus Loss of Berth Pocket Depth - HPCT[27]



Source: GHD calculations

As a result of the increase in stop loading delays, and the requirement to depart on the next high tide, an associated loss in tonnes per vessel (by group) was observed, particularly beyond a 2m loss from 2016 declared berth pocket depth (Figure 23). When compared with DBCT, it can be seen that a larger proportion of the fleet, with vessels down to 80,000dwt affected.[28]

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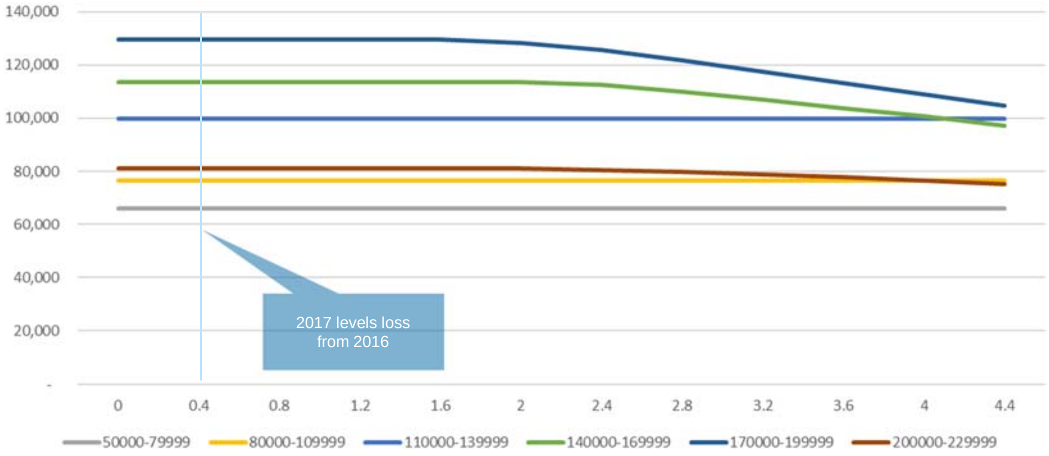
[27] Maximum berth depth in November 2016 (calibration point) for HPCT is 18.8 m at HPCT3. As the modelling calculations assume that tidal vessels target the deepest berth, the June 2017 maximum berth depth of 18.4 m in June 2017 at HPCT3 equates to an effective depth loss of 0.4 m.

[28] The level of impact, and the maximum potential loss is influenced by the assignment and significant difference in berth pocket depth from the apron.

Figure 23: Modelled Average Vessel Payload versus Loss of Berth Pocket Depth - HPCT

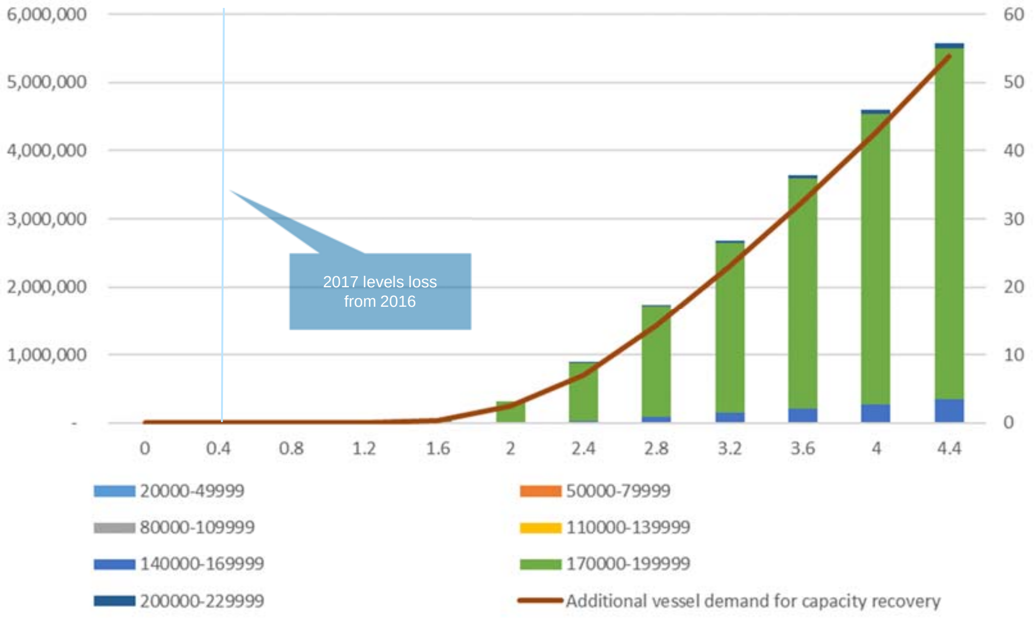


2017 levels loss from 2016

Source: GHD calculations

Based on static fleet proportions to meet terminal capacity, significant lost tonnage was observed from around 2m loss, increasing at approximately 1mtpa per 0.4 metres loss, with a capacity tonnage loss in the order of 5.5mtpa at 4.4m loss beyond 2016 levels (Figure 24). This volume represents the need for approximately 55 additional vessels to recover lost tonnage to meet capacity. [29]

Figure 24: Static fleet loss and required additional vessels versus berth pocket depth loss - HPCT



2017 levels loss from 2016

Source: GHD calculations

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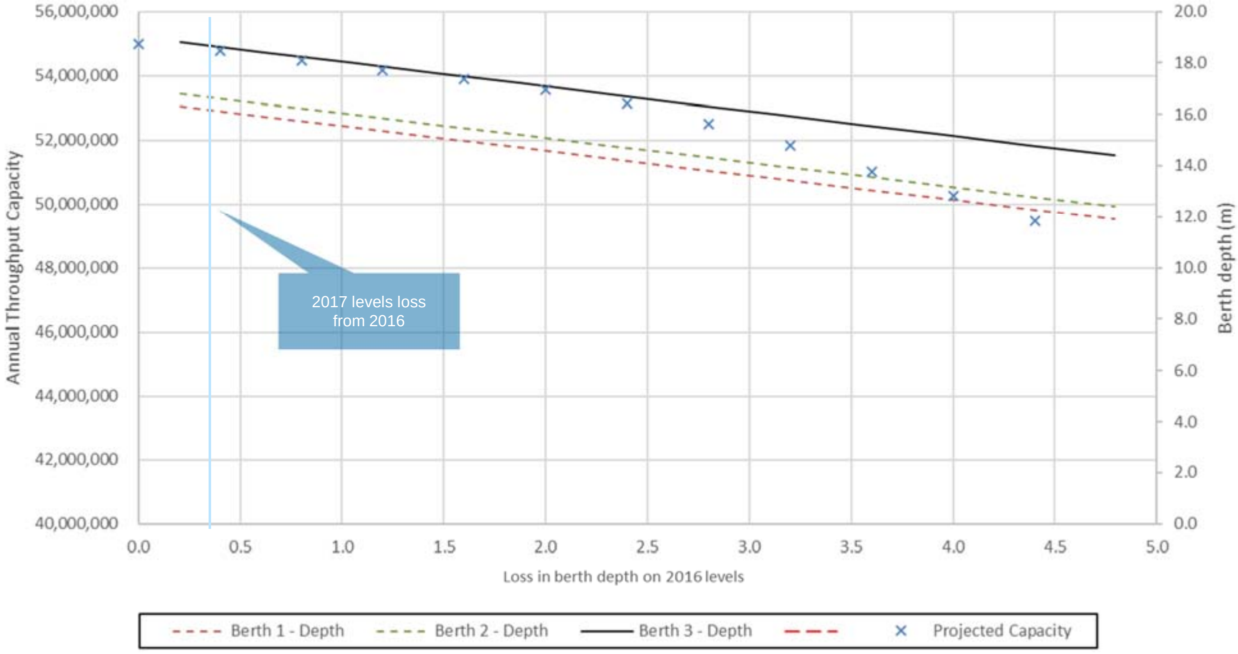
[29] The level of lost capacity would be accelerated with a change in the vessel fleet profile towards larger vessels. This would be a result in the increased probability of low water stop loading events occurring.

Modelling of capacity, based on the above outputs for the HPCT model shows that there is an increase in the rate of capacity loss from an additional 1.6m berth pocket depth from 2016 levels (Figure 25). That is, at approximately 12m depth for the Panamax berths (less than channel depth) and 14m for the Capesize berth (near channel depth), capacity at HPCT is estimated to reduce to 49mtpa from the current 55mtpa stated capacity

Figure 25: Terminal throughput capacity versus loss in berth pocket depth - HPCT



Source: GHD calculations

4.5.1.3 Combined

For the combined terminals, significant lost tonnage based on a static fleet was observed from 1.6m loss, increasing at approximately 2mtpa per 0.4 metres loss, with an actual capacity loss in the order of 13mtpa at 4.4m loss beyond 2016 levels (Figure 26).[30] This volume represents the need for approximately 119 additional vessels to recover lost capacity. [31] If the market driven decision was to reduce the size of vessel, this may translate to approximately double the number of new vessel movements (around 240 vessels).

Modelling of capacity, based on the above outputs of both terminal models shows that there is an increase in the rate of capacity loss from an additional 1.6m berth pocket depth from 2016 levels (Figure 27). That is, at

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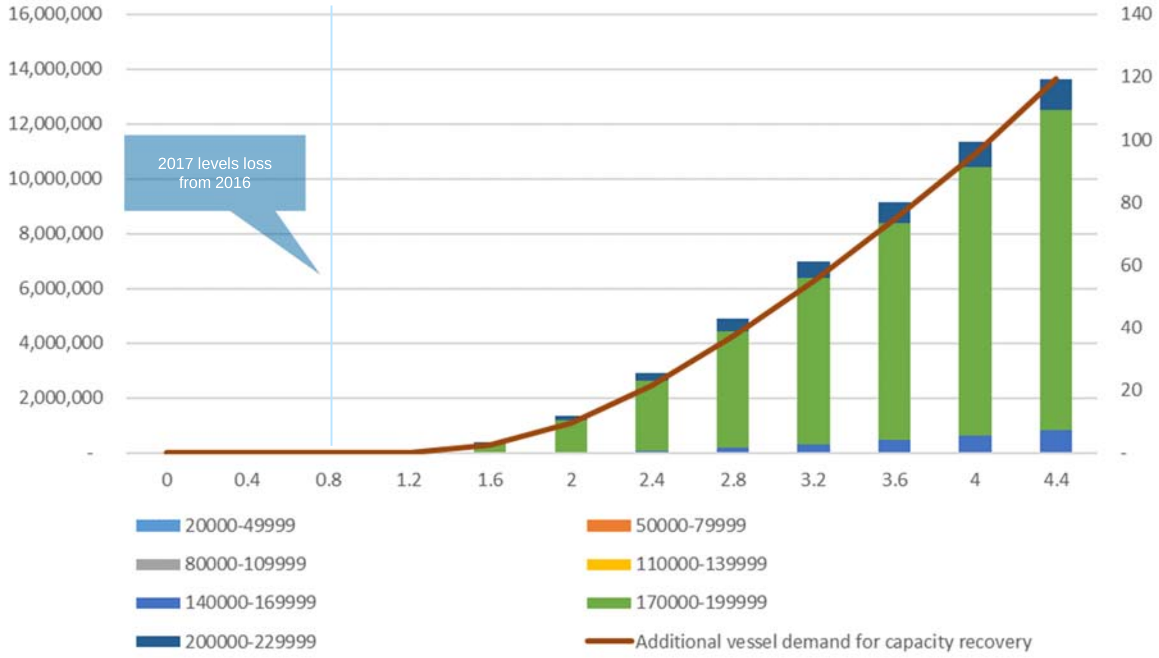
[30] Note – the capacity outcomes are based on incremental loss across all berths at both terminals, and does not take into account the potential for loss at any particular berth at Hay Point. Due to the historical differences in depth loss between terminals, the combined capacity calculations provides a loss potential for terminal capacity.

[31] The level of lost capacity would be accelerated with a change in the vessel fleet profile towards larger vessels. This would be a result in the increased probability of low water stop loading events occurring.

4.4m loss, combined capacity at the port of Hay Point coal terminals is estimated to reduce to 126mtpa from the 139mtpa calculated capacity[32].

Figure 26: Capacity loss and required additional vessels versus berth pocket depth loss[33]



Source: GHD calculations

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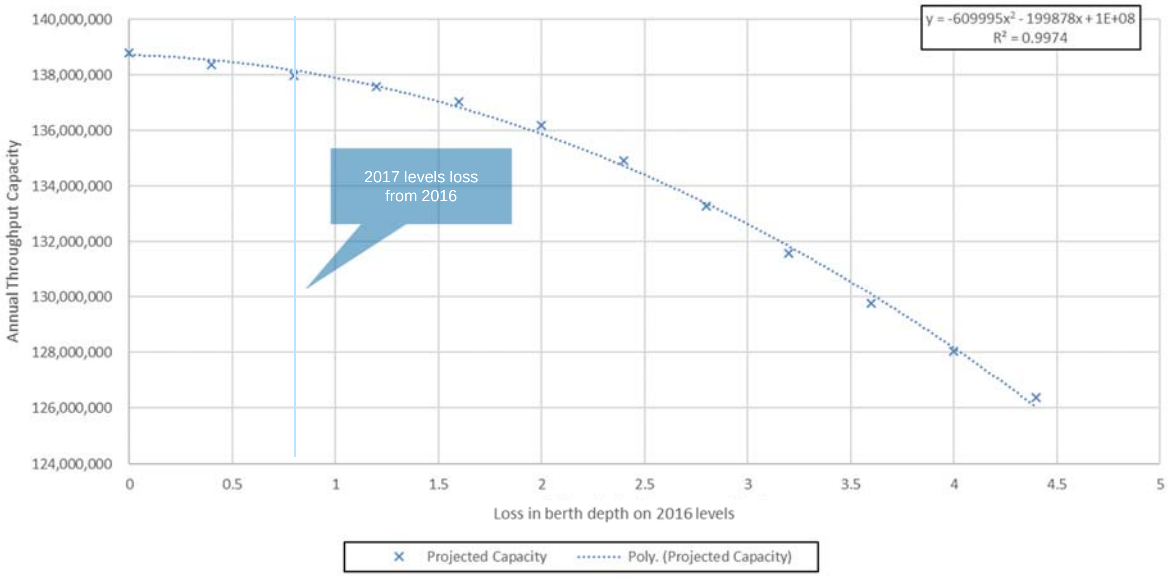
[32] The model has been calibrated for each terminal to stated nameplate to design. As a result, berth depth losses as at Nov 2016 (depth loss of 0m in modelling output charts), result in a 1mtpa reduction in calculated terminal capacity.

[33] A weighted average depth loss based on capacity [1.0 * (85/140) = 0.61, 0.4* (55/140) = 0.16] results in a combined – Jun 2017 loss in berth depth from 2016 levels of 0.77m. In considering the combined terminal impact from berth pocket depth loss, caution should be exercised due to the asymmetry of loss at each terminal as observed earlier in this section

Figure 27: Terminal throughput capacity versus loss in berth pocket depth – Port of Hay Point



Source: GHD calculations

5. Terminal and exporter responses

5.1 Terminal operator responses

It is in the interests of the industry and terminal operators to minimise impacts from the loss of infrastructure capability, which for the purposes of this analysis, is a loss in berth pocket depth. As discussed, the greatest impact on vessel operations that results from a loss in berth pocket depth, is from the vessels affected by stop loading events, associated lost time, and the ability to achieve the required vessel tonnage between the low tide and the departing next high tide.

The potential for lost throughput has a number of potential impacts for terminal operators, including:

- Lower throughput increases the operational cost per tonne due to the reducing revenue base to socialise fixed costs. As a result, the terminal either absorbs the increased costs (reduced profitability), or passes costs on to industry (reducing competitiveness and potentially demand)
- Supply chain velocity, efficiency and productivity decreases, having a system wide effect. As a result receival capacity, stockyard capacity, as well as shiploading capacity are all reduced.

In order to minimise the levels of these loss impacts, terminal operators have implemented a number of programmes and initiatives to maximise capacity, maintain efficiency and keep costs as low as possible in order to maintain competitiveness.

5.1.1 Operational practices

There are a number of operational practices that can minimise the impact of lost effective loading time for a vessel.

The first, which has already been discussed, is the operational practice of loading with the tide. Typically this is used by terminals to achieve vessel payloads greater than that contracted, and is generally opportunistic in nature. However, as discussed above, loading with the tide is standard practice at Hay Point in order to offset capacity loss.

The second operational practice that is used to maximise terminal throughput, where there are periods of lost effective loading time, is to commence the vessel at the layby berth early. In this way the outloading systems remain productive, while the current vessel is unable to receive cargo. The terminals at Hay Point have an effective layby berth system, allowing a vessel to be at berth waiting to load. While this keeps the terminal productive, performance metrics will be influenced, as the load time of the ‘early start’ vessel will show a lower load rate performance than was truly achieved. Nevertheless, in terms of achievable throughput, this practice minimises impacts for the system.

The third operational practice applied at the terminals is the introduction of ‘double shuffle’ berth movements. This process, which is also seen in Port Hedland, reduces the replacement time of vessels to berth where the exchange of vessels is performed in the off-berth (apron) area, as opposed to the end of the channel and Pilot Boarding area. This process effectively reduces the replacement time of the vessel at berth for the equivalent time that a vessel takes to transit the channel.

5.1.2 Process improvement initiatives

Both of the Hay Point terminals have pro-active process improvement initiatives to improve efficiency, which ultimately results in an increase in capacity. The exact quantum of impact of implementing these initiatives in isolation is not known, due to the many other external factors, however, these initiatives assist by increasing efficiency and thereby reduce the impacts of degrading infrastructure capability. While these initiatives, help offset the impacts, they ultimately reach a point where the upside potential diminishes, and the rate of degradation exceeds improvement, thereby resulting in a net loss.

5.2 Exporter responses

It is in the interests of the industry to minimise impacts from the loss of infrastructure capability, largely as a result of shipping cost impacts. Shipping impacts are largely a result of the ship performance as a result of the terminal operations and capabilities.

The potential shipping related impacts for exporters include:

- Longer port stay increases vessel cost (days of charter hire)
- Longer at port time increases the potential for demurrage (contract dependent) and dead freight claims
- Decrease in vessel size increases number of vessels required and lowers terminal capacity

5.2.1 Tonnage recovery

Where the export volume remains constant, and the payload per vessel declines, the market can respond, and would, through the ordering of additional vessels in order to meet demand (which may be a contract commitment). However, the number of additional vessels is limited by the level of berth occupancy, as well as landside operational constraints with respect to stockyard management, product availability, and rail scheduling. As such the recovery potential is limited, and compounded by the inability to meet future (including short term) increased demand, especially where new throughput demands larger vessels[34]

5.2.2 Change vessel size

With the reduction in economies of scale per vessel, and the increase in at-port time, the shipping cost on a per tonne increases. With continued degradation these prices continue to increase to the point where, in this case, the market could potentially demand smaller vessels (which are ordered by exporters or charter parties, and not the terminals). As shown in Figure 28 below, there is a potential changeover point in the cost of shipping, which may trigger a change in the fleet mix, which is contrary to the true nature of the market in seeking greater economies of scale. As a compounding impact, these vessels tend to perform at a slower rate, which will result in additional terminal capacity loss (although there will be an improvement in other delays, such as stop loading delays), and the cost per tonne that must be borne by the market may result in a reduction in demand, as consumers source coal from other ports and/or regions.

Analysis of the shipping cost impacts, based on loss of payload resulting from berth pocket depth is estimated to increase by approximately USD2 per tonne for every tonne on Capesize vessels from Hay Point, with a tipping point for smaller vessels observed at 3.2-3.6m loss.[35]

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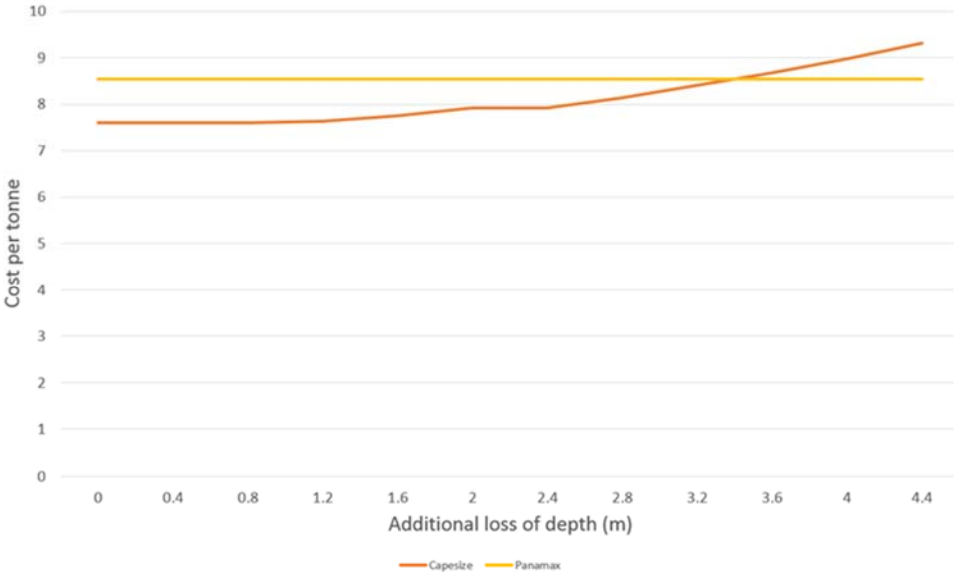
[34] Despite supressed market demand over recent year, which has seen a reduction in some contracted volume, recent negotiations for new contracted tonnage indicates an increasing level of confidence that may translate to higher throughput volumes at the terminals

[35] Applies December 2017 1 Year Time Charter rates and published Hong Kong IFO fuel prices for a round trip voyage Hay Point to Shanghai. Load rates based on historical terminal load rate performance. The analysis excludes port time related impacts beyond those that are intrinsic in historical load rates. The analysis excludes port charges, towage and other marine services.

Figure 28: Coal shipping costs with reducing payload (Hay Point – Shanghai) USD per tonne



Source: GHD calculations

6. Conclusions

Based on the discussion and analysis in previous sections of this report, a number of conclusions can be drawn with respect to terminal capacity from operational impacts from berth pocket depth loss.

Berth pocket depth loss at Hay Point

Historical berth pocket data, despite some fluctuations resulting from accretion and drag-bar intervention has shown an incremental loss across DBCT berth pockets between 2005 and 2014 to approximately 1.5 metres less than design depth. Some berth pocket depth recovery was achieved (with the exclusion of Berth 4) in 2016 from drag barring resulting in a 0.25m gain[36]. While depth loss from accretion has been observed at DBCT, there has been limited loss at HPCT – which in 2016 was approximately 0.13m. However, this does not necessarily mean that HPCT is not subject to accretion or exposed to a risk of a significant deposit.

Sudden significant depth loss

Despite the depth recovery achieved in 2016 (from drag barring), gains in berth pocket depth were offset by the impact of Cyclone Debbie in early 2017. The initial impact saw a reduction in Declared Depth in the order of 1.5 to 2.5 metres at each of the DBCT berths. This resulted in the majority of berths operating at 3 to 3.5 metres less than design. Recovery of some depth to around 2 metres less than design was achieved, however, with the inability to remove silt deposits from berth pockets an additional 0.5m to 1m loss was observed (to around 2m less than design).

Depth loss from cyclones, as a result, is a significant risk due to the sudden and shock impact from high volume sediment deposits, particularly when this is combined with accretion and the inability to remove material from the berth pockets. With the historical use of drag-barring, no further depth recovery will be achievable without the removal of sediment from the berth pockets. Additional berth pocket loss, as a result, will have an increased incidence and impact on operations, and therefore terminal capacity, especially with the overarching risk of sudden depth loss potential from cyclones.

Operational impacts resulting from berth pocket depth loss

Analysis of historical DBCT data (as the predominantly affected terminal) for berth pocket depth change and operations over the last five years identified:

- There is little evidence of a move from larger vessels to smaller vessels and a limited desire for vessels to be significantly larger. However, a change to smaller vessels may be held back by low Capesize charter rates over recent years, and the commercial decision of exporters/consumers to achieve the lowest delivered cost per tonne rather than seeking terminal operational efficiency and capacity. Nonetheless, with terminal design for the efficient and full loading of vessels above 200,000dwt, and persisting market demand for vessels of this size, it is desirable that infrastructure capability for larger vessels be maintained for full port and terminal operational capacity, particularly if there is a change in the fleet mix towards larger vessels in the future.
- There is little evidence, on average, that there is a reduction in load rates resulting from stop loading delays for tidal vessels. This outcome, in the average, is not unexpected, due to the many external factors that influence the load rates (such as process improvement initiatives, better performing fleet, and more complicated loading process of multiple cargo vessels), the variable impact of the stop loading delays (which are confirmed to be occurring) on a per vessel basis, and the ability to reliably

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[36] Berth 1 and Berth 3 received the greatest benefit. Little gain was achieved at Berth 2, while depth loss occurred at Berth 4

confirm the exact number of vessels affected by low water delays in the data. However, if the period of stop loading delays increases, which is contrary to the design function of a berth pocket, and the proportion of the fleet affected increases, the effect of lost depth on vessel load rates will become more pronounced in the average.

- There is an observed decrease in the wait to depart times for tidal vessels and a correlation with berth pocket depth for tidal vessels. This is an outcome of the impact of low water stop loading delays, and the need to load closer to the scheduled departure on the high tide. With continued depth loss, the wait time to depart will continue to decline to the point that will trigger short loading and tonnage loss for tidal vessels, and an increase in the number of dead freight claims.
- There is little evidence that there is a reduction in tidal vessel capacity utilisation in the average from loss of berth pocket depth to date, and that the tidal vessel fleet are currently able to meet required tonnage largely due to the operators loading with the tide to achieve the required tonnes, which is captured in the reduced wait to depart time outcomes. However, a reduction in vessel capacity utilisation will become significant when the proportion of vessels that are unable to meet the tonnes required before the departing high tide increase, and the duration of stop loading delays during the low tide becomes longer (also reflected in the loss of buffer in the wait to departure time).

Due to the many external factors that influence operations, the variable impact of low water stop loading delays (which are confirmed to be occurring), and the ability to reliably confirm the exact number of vessels affected by low water delays in the data, it is difficult to isolate all discrete operational impacts unless a significant proportion of the fleet is affected. Despite these data limitations, a correlation for berth pocket depth change and wait time to depart was identified, where a reduction in berth pocket depth resulted in a reduced wait to depart time (or a reduced buffer between the completion of loading and the departure window of the vessel).

Capacity effects from reduced pocket depth

Modelling of the change in operational impacts and capacity from an incremental loss in berth pocket depth identified:

- For DBCT, significant lost capacity was observed from around 1.6m loss from 2016 levels (available berth depth of 16.9m), increasing at approximately 1mtpa per 0.4 metres loss (which would be greater with an increase of large vessels in the fleet profile), with a capacity tonnage loss in the order of 8mtpa at 4.4m loss beyond 2016 levels (around channel depth). This volume represents the need for approximately 65 additional vessels to recover lost capacity.
- For HPCT, significant lost capacity was observed from around 2m loss from 2016 levels (available berth depth of 16.8m), increasing at approximately 1mtpa per 0.4 metres loss (which would be greater with an increase of large vessels in the fleet profile), with an actual capacity loss in the order of 5.5mtpa at 4.4m loss beyond 2016 levels. This volume represents the need for approximately 55 additional vessels to recover lost capacity.
- For the combined terminals, significant lost capacity was observed from a 1.6m berth pocket loss from 2016 levels (available berth depth of 16.9m), increasing at approximately 2mtpa per 0.4 metres loss (which would be greater with an increase of large vessels in the fleet profile). This translates to an actual capacity loss in the order of 13mtpa at 4.4m loss beyond 2016 levels (a calculated capacity of 126mtpa from the current 140mtpa nameplate capacity, or 2016 calculated 139mtpa); however,

the combined terminal impact calculation masks the true effect due to loss asymmetry, and will likely understate the impact.

Terminal and exporter responses to reduced pocket depth

The potential for lost throughput has a number of key impacts for terminal operators which include; increased operational cost per tonne, and a reduction in supply chain velocity and efficiency which reduces capacity. Terminal operators have implemented operational practices (loading with the tide, utilisation of layby berths, reducing vessel changeover time and the like), and process improvement initiatives to maximise capacity, maintain efficiency and keep costs as low as possible in order to maintain competitiveness against reducing infrastructure capability.

For exporters, impacts from the loss of infrastructure capability, largely relate to shipping cost impacts resulting from longer port stays, potential for demurrage and dead freight claims, and ultimately a decrease in vessel size (which increases number of vessels required and further lowers terminal capacity). With the potential loss of vessel capacity and the need to meet contracted volumes, which have the potential to increase with a recent improvement in market confidence, exporters need to order additional vessels, however, the number of additional vessels is limited by the level of berth occupancy, as well as landside operation constraints for stockyard management, product availability, and rail scheduling. As such the recovery potential is limited.

Reduction in economies of scale per vessel from continued loss of payload, which is contrary to the demands of the market resulting from berth pocket depth is estimated to increase by approximately USD2 per tonne at 4.4m loss beyond 2016 levels for every tonne on Capesize (tidal) vessels from Hay Point, with a tipping point (at around USD1 per tonne above current Capesize rates) for tidally unaffected smaller Panamax vessels at 3.2-3.6m loss.

Government policy and strategy

There has been no major maintenance dredging programme in the Port of Hay Point since 2010, apart from drag bar operations. As demonstrated in the analysis undertaken as part of this report, further berth pocket loss will result in the loss of throughput and terminal capacity, which even if recovered through additional vessels (achievable only to a point) will be transported at higher cost (which will reduce the competitiveness and/or viability of the industry)

The findings of the analysis in this report, and the need to undertake maintenance dredging to provide a competitive and sustainable industry are consistent and confirmed by the State of Queensland Maintenance Dredging strategy, noting that:

- *Maintenance dredging is required to maintain designated channel and berth depths to ensure the continued efficient passage of vessels utilising the port*
- *Most ports cannot sustainably function without maintenance dredging, and maintenance dredging has occurred in Queensland since ports were first established*
- *Dredging to maintain navigation depths is critical to the effective operation of ports to facilitate export of Queensland’s agricultural, pastoral and mineral commodities*

Appendices

Appendix A – Modelling Approach

6.1.1 Modelling process

For the purposes of modelling, the following rules and assumptions have been applied

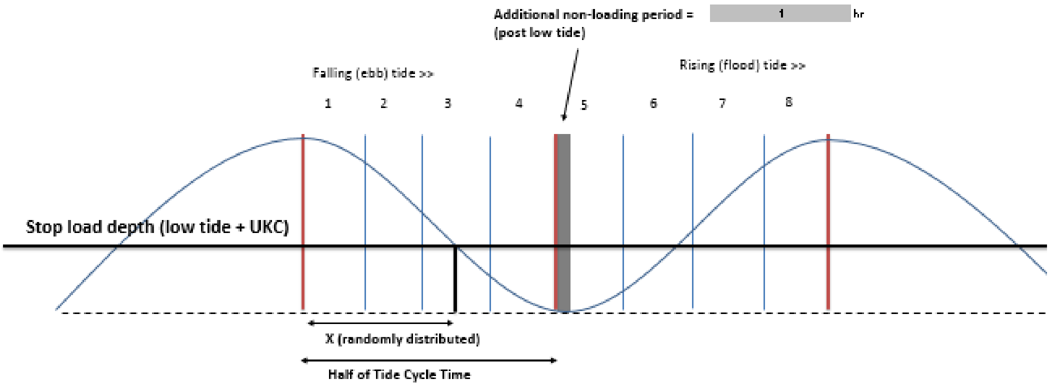
6.1.1.1 General assumptions

- Incremental operational losses are calculated using 2016 throughput capacity as the Base Case
- The DBCT Model is calibrated to achieve 85mtpa at design depth
- The HPCT Model is calibrated to achieve 55mtpa at design depth
- Vessel fleet proportions are held constant for forecast berth depth changes

6.1.1.2 Stop loading delays

- Vessels are required to stop loading when draft = low tide + UKC in order to maintain safe clearance
- Historical tidal states are split up into quartiles and applied against the historical vessel departure draft distribution in order to forecast the proportion of vessels that experience stop loading delays
- Due to random arrival/departure times 50% of vessels are assumed to exceed the stop load depth on a rising tide and are able to depart on the high tide without incurring a stop loading delay. The remaining 50% of vessels that exceed the stop load depth are assumed to do so on a falling tide and must stop loading at low tide
- Delayed vessels are assumed to reach the stop load depth evenly between high and low tide and based on this even distribution, the average stop delay time is taken as half the average time between high and low tide (see Figure 29)
- Loading is assumed to not commence until 1 hour post low tide due to the slow rate of depth change at this point in the tidal cycle

Figure 29 Stop loading delays

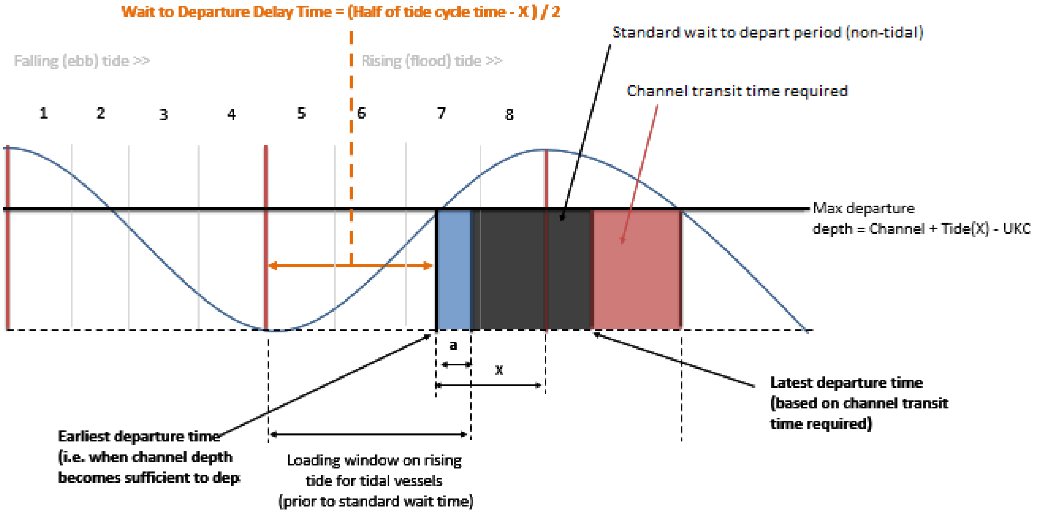


Source: GHD

6.1.1.3 Wait to depart delays

- Tidally constrained vessels must depart within a defined departure window in order to maintain appropriate under keel clearance whilst transiting the channel and the vessel departure draft determines the available departure window.
- The average tidal state is modelled and assessed against the historical vessel departure draft distribution to determine the departure window available on the rising tide.
- Vessels that complete loading prior to there being sufficient water depth in the channel must wait in the deepened berth pockets to depart
- Due to the impact of random vessel arrivals, tidally constrained vessels are assumed to be ready for departure at an even distribution between low tide and the latest available departure time that enables under keel clearance requirements to be met whilst transiting the channel
- Based on this even distribution the incremental wait time (on top of historical standard wait time for non-tidal vessels) is calculated based on the mid-point time between low tide and commencement of standard wait time (see Figure 30).
- For additional vessels, total wait time to depart is added.
- Average additional wait time assumed to be (half of the average tide cycle time - x) / 2; where, x = [arccos((Y-D) / A) - C] /B; where, y = A Cos (Bx + C) + D [37]

Figure 30 Wait to depart delays



Source: GHD

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[37] A = amplitude from the middle line to the peak; B = frequency divided by 2pi radians (360 deg); C = horizontal phase offset; D = Vertical offset

6.1.1.4 Replacement vessels

- The model assumes that vessel calls are optimised to be able to access the deepest berth at each terminal, which maximises achievable loading depth.
- Eventually loss in berth depth reaches a point where the maximum berth depth at the terminal is insufficient to fully load larger vessel sizes. At this point the model calculates lost loaded tonnes for different vessel size groupings by converting lost loaded depth into lost loaded tonnes.
- The model then calculates the additional vessel calls required to maintain throughput at nameplate capacity. That is the model calculates how many additional vessels are required to export lost loaded tonnes.
- Non-loading events are duplicated as a result of additional vessel calls being required to throughput the same volume of product. That is new vessel calls duplicate non-loading events such as vessel changeovers and berth to loading commencement. New vessel calls are also still subject to stop loading delays and wait to depart delays.

6.1.1.5 Terminal capacity loss

- The model takes into account the stop loading, wait to depart and duplication of non-loading events for additional vessels with respect to loss in berth depth to calculate the amount of time that would be required to throughput the nameplate capacity.
- Annual capacity throughput losses are then back-calculated based on the effective loading rate achieved.

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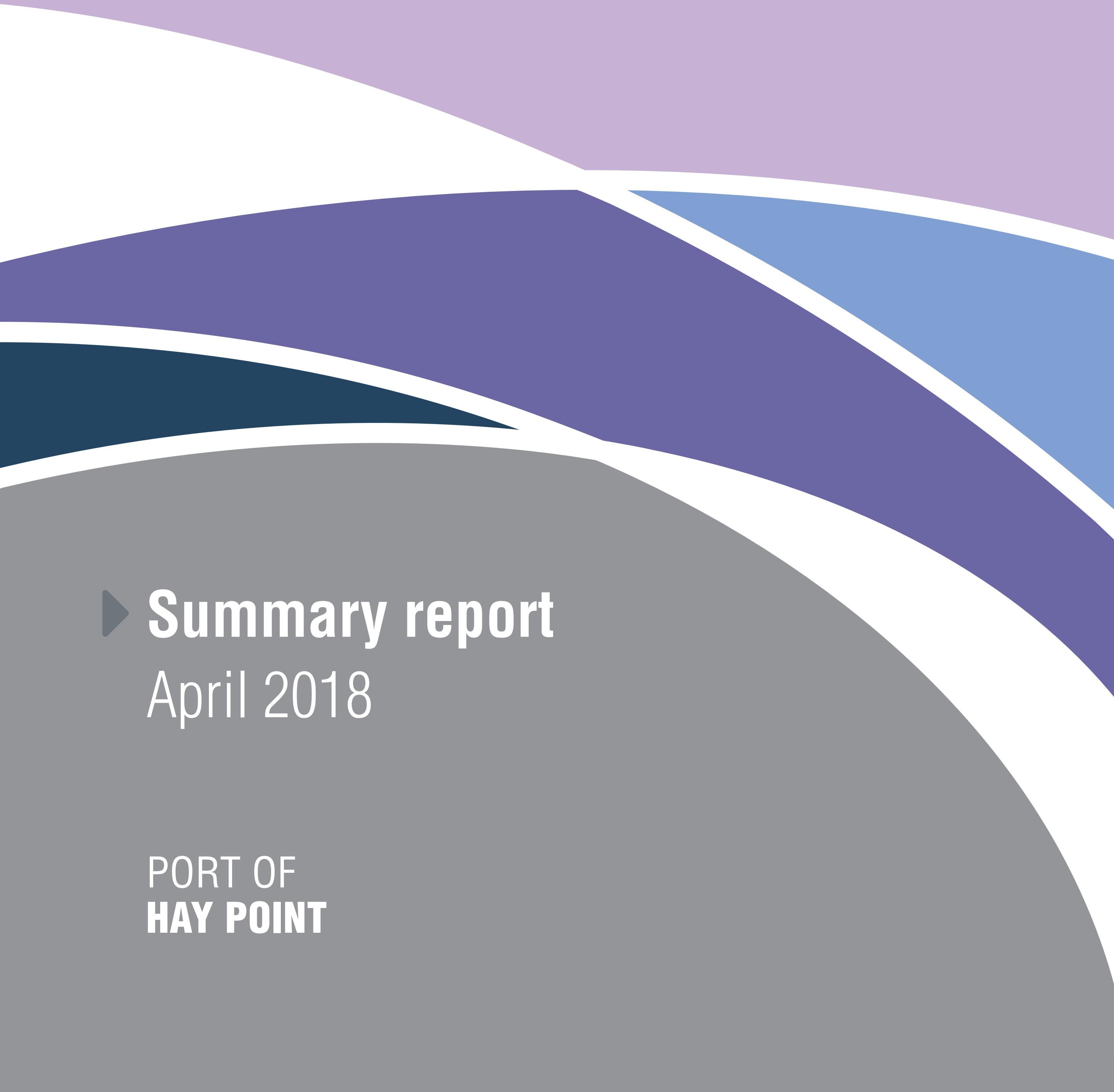
Independent Review:

Economic Impact of No Maintenance Dredging at the Port of Hay Point



Summary report

April 2018

PORT OF
HAY POINT

REPORT TO
NORTH QUEENSLAND BULK PORTS CORPORATION
16 APRIL 2018

ECONOMIC IMPACT OF NO MAINTENANCE DREDGING AT THE PORT OF HAY POINT

INDEPENDENT ASSESSMENT BY JEROME FAHRER

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EXECUTIVE SUMMARY

The maintenance of safe navigational depths at ports is essential for a small open economy like Australia to bulk trade its goods efficiently. North Queensland Bulk Ports Corporation (NQBP) has been conducting a series of investigations towards a long-term strategy for ongoing management of marine sediments at the Port of Hay Point, known as the Port of Hay Point – Sustainable Sediment Management (SSM) Assessment for Navigational Maintenance (The SSM Project). As part of the SSM project, to assist in evaluating and contextualising sediment management options, NQBP has sought an independent analysis of the economic impacts that could be associated with natural siltation of the Port's navigational infrastructure, particularly the siltation that has occurred and is predicted to occur in Berth Pockets, if maintenance dredging of the Port is not carried out.

NQBP has engaged Jerome Fahrer of ACIL Allen Consulting (ACIL Allen) to provide an independent report on the potential economic impacts which result of the accumulation of marine sediments in the existing port navigational infrastructure at the Port of Hay Point in Queensland i.e. the impacts on the local, regional and national economies if this accumulation is not controlled by maintenance dredging.

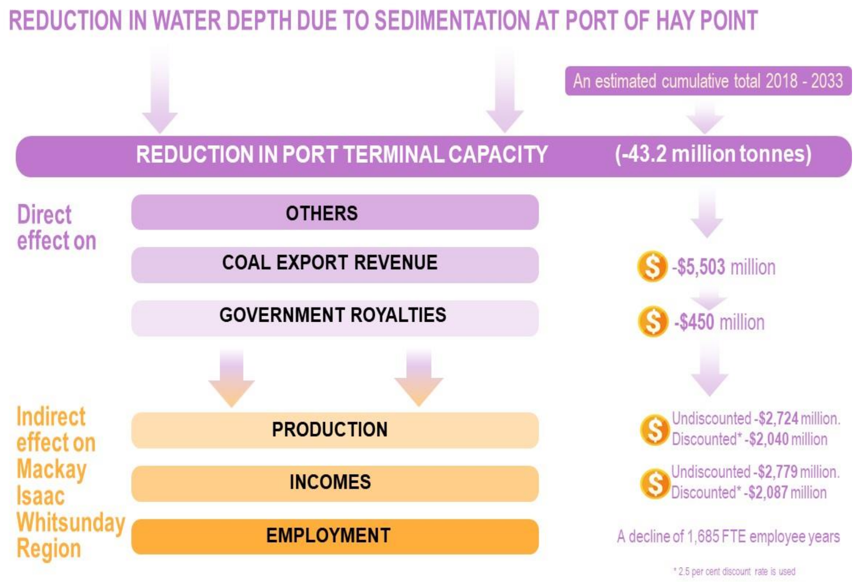
This report develops a scenario based on the data and information contained in the SSM Project Report and the data provided by GHD. This scenario was analysed using the ACIL Allen's economy wide computable general equilibrium model — *Tasman Global Model*. The model captures the dynamic, intra-industry and inter-industry linkages in the Mackay Isaac Whitsunday (MIW) Region of Queensland, rest of Queensland, rest of Australia and rest of the World.

Key scenarios

- **Reference case scenario** — in this scenario, there will be a regular maintenance dredging at the Port of Hay Point for next 16 years.
- **A change in current water depth scenario (loss scenario)** — port capacity losses over 16 years that potentially would occur when there is a loss of declared water depth level of up to four metres due to sedimentation at the Port of Hay Point.

A summary of potential economic impacts of no regular dredging at Port of Hay Point is provided in **Figure ES 1**.

FIGURE ES 1 POTENTIAL ECONOMIC IMPACTS OF NO REGULAR MAINTENANCE DREDGING AT PORT OF HAY POINT, FY2018 TO FY2033



SOURCE: ACIL ALLEN CONSULTING MODELLING

Key inputs

GHD inputs

Different levels of water depth losses are based on data prepared by GHD Advisory (GHD). The GHD data includes port capacity losses associated with the declared water depth losses. Recent declared water depths at port berths are provided in **Table ES 1**.

TABLE ES 1 CURRENT DECLARED DEPTHS AS PER NOTICE MARINERS

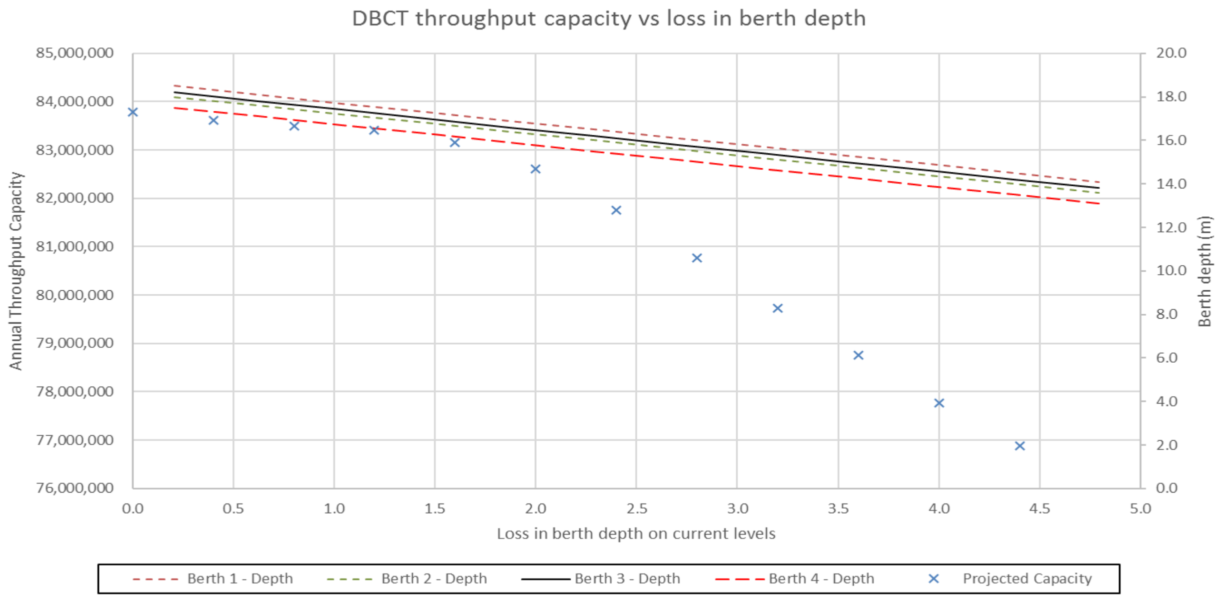
Berth	Design Depth (metres)	Depth, November 2016	Depth, June 2017
HPCT1	16.6	16.3	16.1
HPCT2	16.7	16.8	16.7
HPCT3	19.0	18.8	18.4
DBCT1	19.6	18.5	17.5
DBCT2	19.6	18.0	17.4
DBCT3	19.0	18.2	17.3
DBCT4	19.0	17.5	17.1

SOURCE: GHD

The GHD model assumes a vessel is able to access the deepest berth (DBCT1 and HPCT3) 100 per cent of the time based on the assumption that scheduling is fully optimised, in order to mitigate the impact of berth depth loss on capacity throughput. The GHD model has estimated the terminal capacity losses using the model curves based on the change in maximum berth depths at each terminal. For example, at DBCT the maximum berth depth in November 2016 is 18.5 metres at DBCT1. The maximum depth reduces to 17.5 metres at DBCT1 which equates to an effective depth loss (starting point) of 1 metre (or 2.1 metres above design depth).

The impact of already occurred depth loss on DBCT capacity is provided in **Figure ES 2**.

FIGURE ES 2 DBCT THROUGHPUT CAPACITY VERSUS LOSS IN BERTH DEPTH

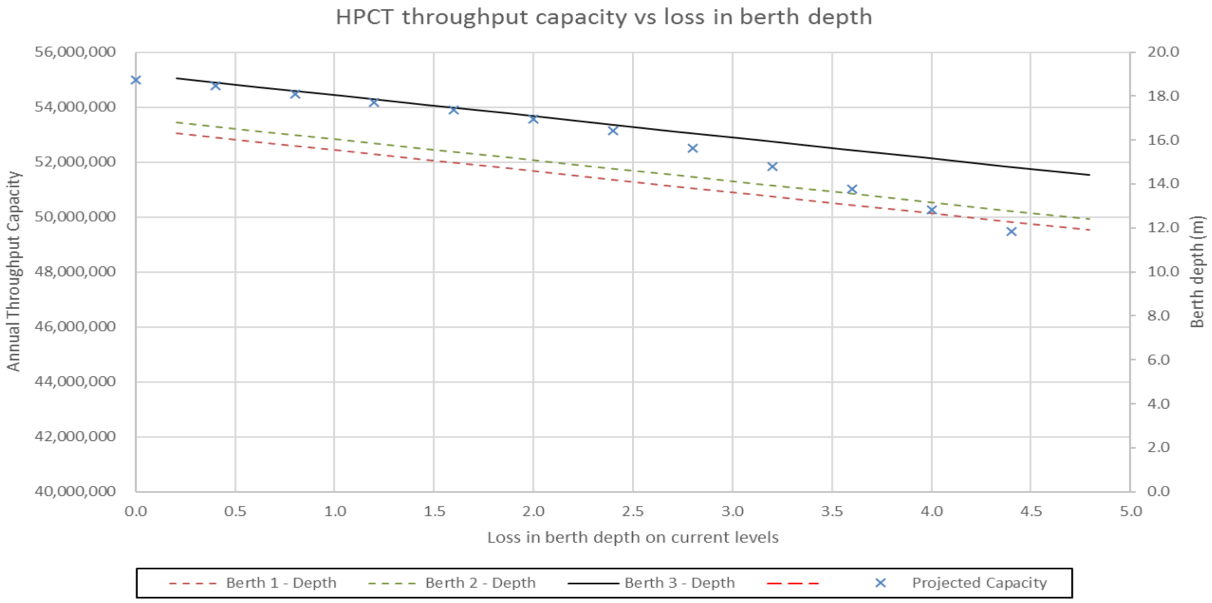


SOURCE: GHD

Alternatively, at HPCT the maximum berth depth reduces by 0.4 metres at HPCT3 between November and June 2017. The estimated starting position is 0.4 metres for HPCT. The impact of this depth loss on HPCT capacity is provided in **Figure ES 3**.

The estimated curves show an asymmetry of loss at each terminal.

FIGURE ES 3 HPCT THROUGHPUT CAPACITY VERSUS LOSS IN BERTH DEPTH



SOURCE: GHD

The weighted average depth loss is estimated as:

DBCT: 1.0*(85/140) = 0.61 metres

HPCT: 0.4*(55/140) = 0.16 metres

Total combined loss at June 2017 was 0.77 metres.

Economic model inputs

To annualise the declared water depth losses over 16 years, consistent with the GHD estimated capacity losses with starting losses (0.77 metres since 2016) that has been already occurred, a 20 cms declared water depth loss per annum is assumed in this study by ACIL Allen. This is consistent with the Hay Point Bathymetric Analysis undertaken in March 2016.[1]

The Bathymetric Analysis reported that nearly 87cms of declared water depth loss in three years if there is no maintenance dredging at the DBCT. This will be around 29 cms per annum. The GHD analysis estimated that 4.4 metres declared water depth leads to a loss of 55.7 million tonnes port capacity. This study has used GHD estimates up to four metres declared water depth loss which leads to port capacity losses of 43.2 million tonnes over 16 years. A share weighted average coal price of A$127.3 per tonne is assumed in this study to translate the port capacity losses into revenue losses. The estimated cumulative revenue losses over 16 years will be around $5.5 billion.

The relationship between terminal capacity losses and declared water depth losses are non-linear and will be affected by a number of factors.

The key characteristics of hypothetical modelling scenarios are summarised in **Table ES 2**.[2]

TABLE ES 2 KEY FEATURES OF ECONOMIC MODELLING SCENARIO

	Cumulative total reduction in declared water depth in next 16 years	Cumulative total reduction in terminal capacity in next 16 years	Cumulative total reduction in coal export revenue in next 16 years
	metres	Million tonnes	A$m
A water depth loss scenario	4	43.2	5,503

SOURCE: ACIL ALLEN CONSULTING BASED ON GHD DATA

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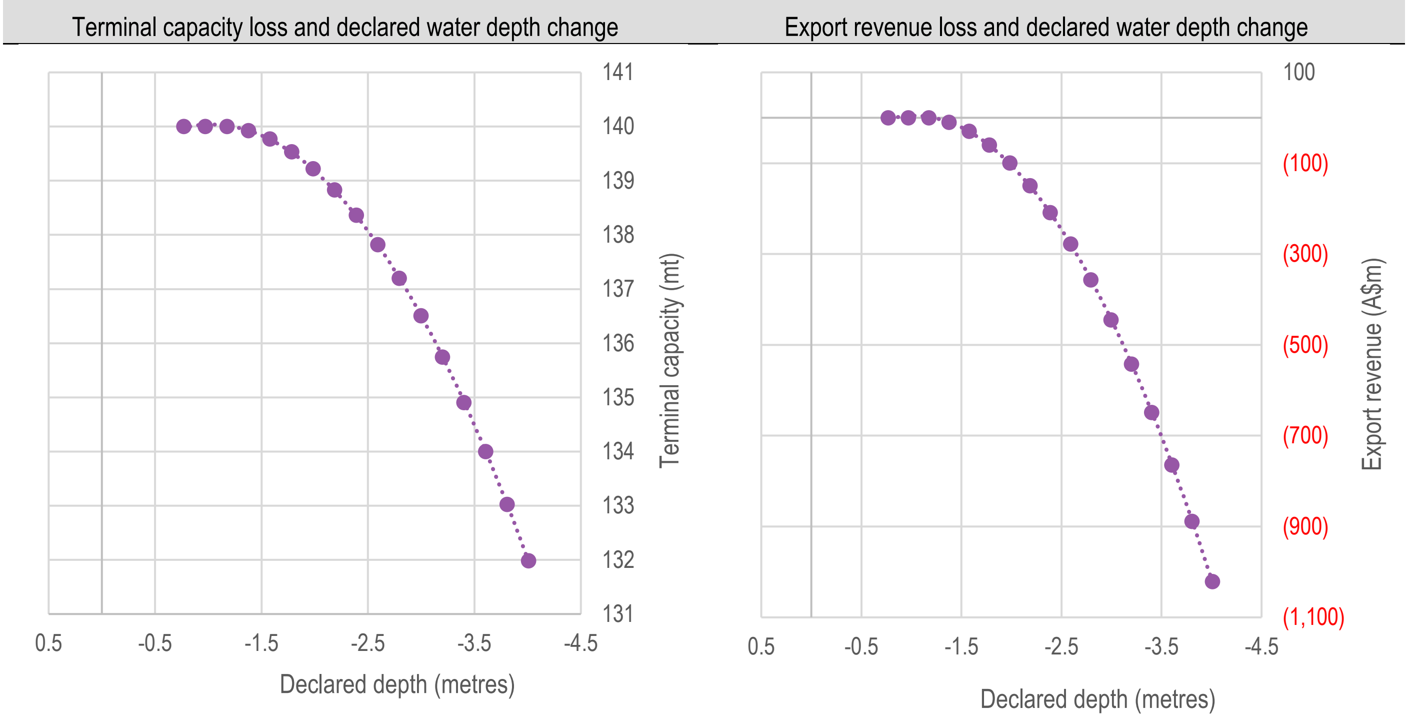
[1] RoyalHaskoningDHV 2016, Hay Point Bathymetric Analysis Predictive Model, March 2016 (unpublished)

[2] An important assumption is that loss of capacity at Hay Point is not offset by the coal being shipped out of other ports in the region.

The annual estimated combined terminal capacity losses and associated coal export revenue losses are provided in **Figure ES 4**.

FIGURE ES 4 KEY INPUTS



SOURCE: ACIL ALLEN CONSULTING BASED ON GHD DATA

Key economic impacts

If maintenance dredging does not occur at the Port there will be several economic impacts. The capacity of the two terminals will be decreased and there will be delays in loading and unloading ships, resulting in reduced export earnings. There will be flow-on, indirect negative impacts on other industries, particularly coal supply chain industries. The indirect impacts will also flow through to the broader MIW Region and Queensland economies as the income losses by residents affect their spending on goods and services. The economic impact of water depth changes is assessed against a reference case of regular maintenance dredging over the next 16 years.

Real economic output

The indirect macroeconomic impacts of loss of declared water depth at Port of Hay Point have been estimated over the period to 2032-33 using ACIL Allen's *Tasman Global* computable general equilibrium (CGE) model. The results point to significant output impacts as shown in **Figure ES 5** and **Table ES 3**. The biggest negative impacts will be felt in the mining industry. There will be small positive impacts in other industries (e.g. service industries) as the economy adjusts, but these will be much less than the negative impact on the mining industry.

Over the period 2017-18 to 2032-33, the loss of water depth at Port of Hay point is projected to decrease the real economic output of the MIW Region (i.e. real GRP) by a cumulative total of $2,724 million (with a present value of $2,040 million, using a 2.5 per cent real discount rate[3]). To place these projected changes in economic output estimates in perspective, annual average real undiscounted economic output losses associated with the no regular maintenance dredging at the Port of Hay Point are estimated to be $170.2 million.

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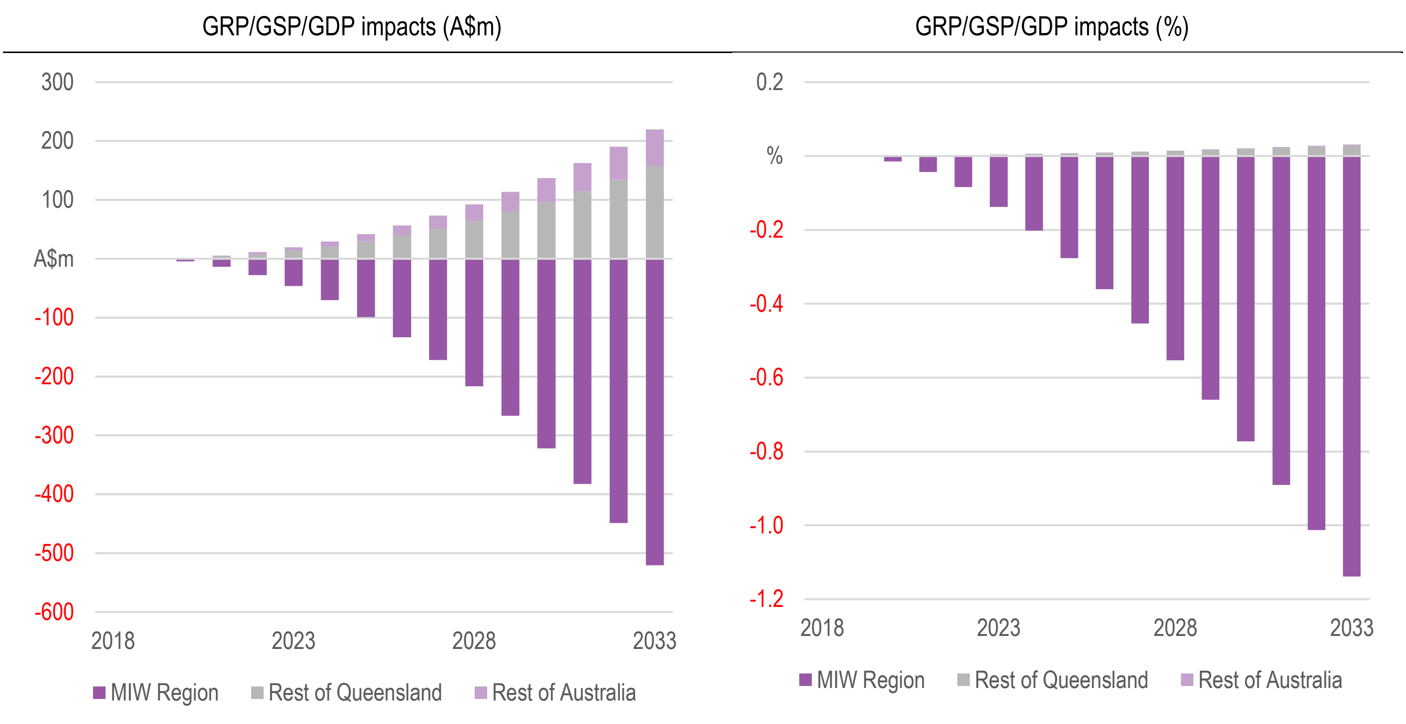
[3] Most of the economic impact assessment suggest using either 4 per cent or 7 per cent discount rate. For this study ACIL Allen has used 2.5 per cent real discount rate consistent with the current macroeconomic conditions and inflation levels.

FIGURE ES 5 PROJECTED CHANGE IN REAL ECONOMIC OUTPUT AS A RESULT OF NO REGULAR MAINTENANCE DREDGING AT THE PORT OF HAY POINT, RELATIVE TO A REFERENCE CASE



SOURCE: ACIL ALLEN CONSULTING MODELLING

TABLE ES 3 REAL OUTPUT IMPACTS RELATIVE TO THE REFERENCE CASE, 2017-18 AND 2032-33

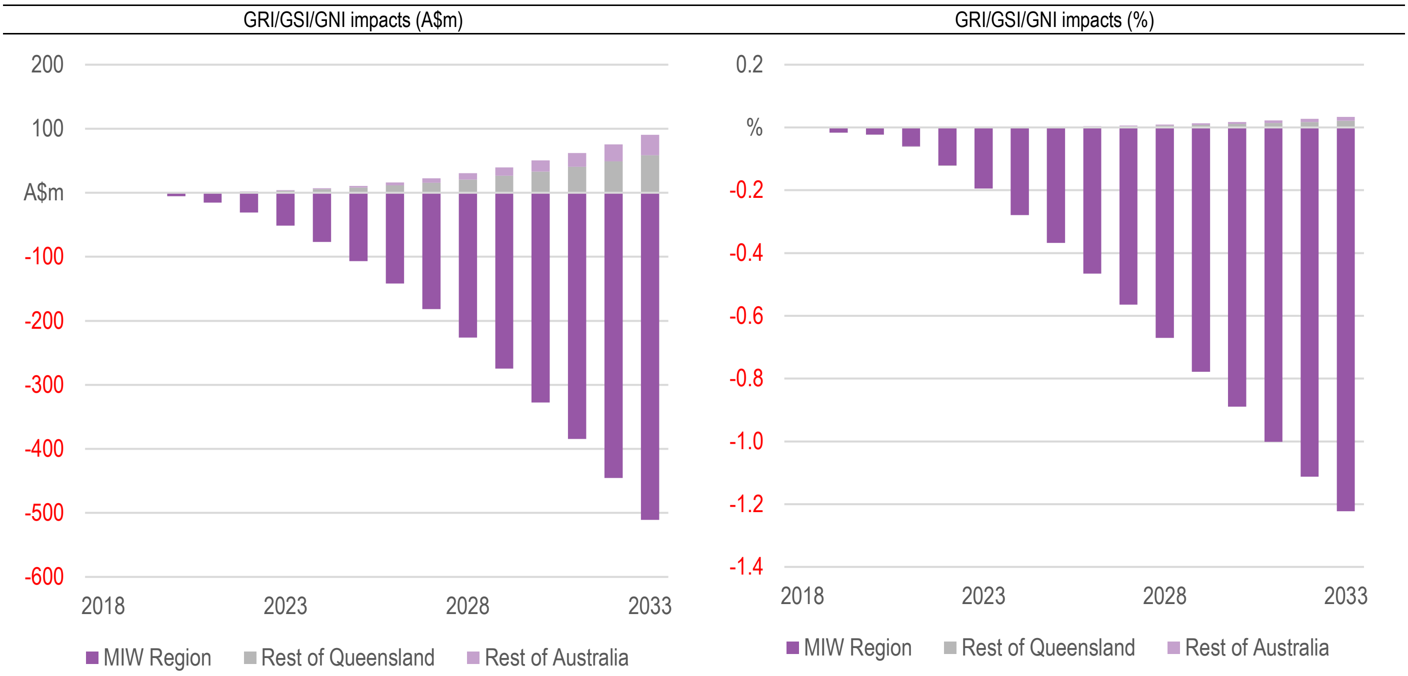
Scenarios/regions	Cumulative change (2017-18 to 2032-33)		
	Average annual	Total	PV (@ 2.5%)
	2016-17 A$m	*2016-17 A$m*	*2016-17 A$m*
MIW Region (GRP)	(170)	(2,724)	(2,040)
Queensland (GSP)	(119)	(1,910)	(1,431)
Australia (GDP)	(98)	(1,567)	(1,174)

SOURCE: ACIL ALLEN CONSULTING MODELLING

Real income

An alternative macroeconomic measure of the economic loss associated with the water depth loss and port capacity losses is provided by the change in real income. Real income is a measure of the ability of residents to purchase goods and services, adjusted for inflation and is a measure of the change in well-being in an economy. The results point to a significant income impacts as shown in **Figure ES 6** and **Table ES 4**. Over the period 2017-18 to 2032-33, the port capacity losses due to the loss of declared water depth at Port of Hay Point is projected to decrease the real income of MIW Region by a cumulative total of $2,779 million loss relative to a reference case (of no loss in port capacity) with a present value of $2,087 million, (using a 2.5 per cent real discount rate) as shown in **Figure ES 6**.

FIGURE ES 6 PROJECTED CHANGE IN REAL INCOME AS A RESULT OF NO REGULAR MAINTENANCE DREDGING AT THE PORT OF HAY POINT, RELATIVE TO A REFERENCE CASE



SOURCE: ACIL ALLEN CONSULTING MODELLING

To place these projected changes in income in perspective, the discounted present values (using a 2.5 per cent real discount rate) are equivalent to a one-off annual decrease in the *average* real income of all current residents of MIW Region by $654 per person. This is a significant decrease in the well-being of MIW Region residents. The peak percentage loss of real income is about equal to the expected peak percentage loss of real income in Adelaide from the closure of the automotive manufacturing industry.

TABLE ES 4 REAL INCOME IMPACTS RELATIVE TO A REFERENCE CASE, 2017-18 AND 2032-33

Scenarios/regions	Cumulative change (2017-18 to 2032-33)		
	Average annual	Total	PV (@ 2.5%)
	2016-17 A$m	*2016-17 A$m*	*2016-17 A$m*
MIW Region (GRI)	(174)	(2,779)	(2,087)
Queensland (GSI)	(157)	(2,506)	(1,884)
Australia (GNI)	(148)	(2,368)	(1,782)

SOURCE: ACIL ALLEN CONSULTING MODELLING

It was estimated in the SSM Project that the cost of maintenance dredging of the Port would be nearly $39 million over 20 years in current price, or about $2 million per year on average.[4] [5]Thus, for an annual expense of $2 million per year,the MIW region would avoid (average) annual output losses of $170 million.

Employment

Over the assessed period of 16 years, it is projected that MIW Region will lose 1,685 additional employee years of full time equivalent (**Figure ES 7**). That is, employment in the MIW Region will be reduced by approximately 105 FTE on average. The total employment loss in the MIW region is projected to be greatest during the period where high siltation is expected to occur, in the later years. The loss of jobs will occur because of the decline in economic activity in the region. There will be an offsetting amount of employment gain in the rest of Queensland and in the rest of Australia (mostly outside Queensland), as the economy adjusts to

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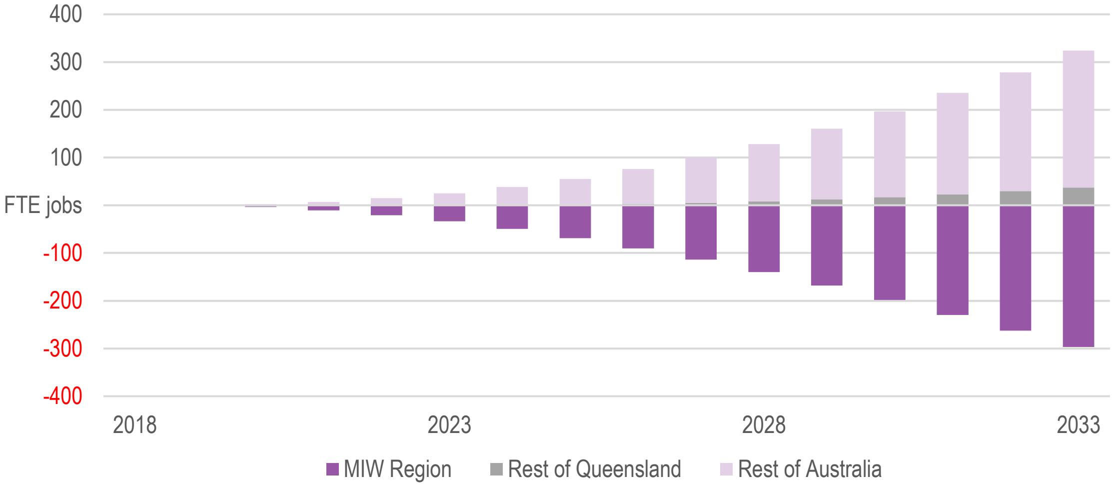
[4] Source: Port of Hay Point - Assessment for Navigational Maintenance p25, report by Royal HaskoningDHV 19 August 2016

[5] This is includes all dredging costs associated with mobilization/demobilization, standby, environmental monitoring, project management and permit/approvals processes.

the impact of reduced exports from the MIW region e.g. the exchange rate will depreciate improving the competitiveness of industries in other States that compete with imports, and real wages will fall because of the weakened economy, resulting in increased employment in the other States.

FIGURE ES 7 EMPLOYMENT IMPACTS

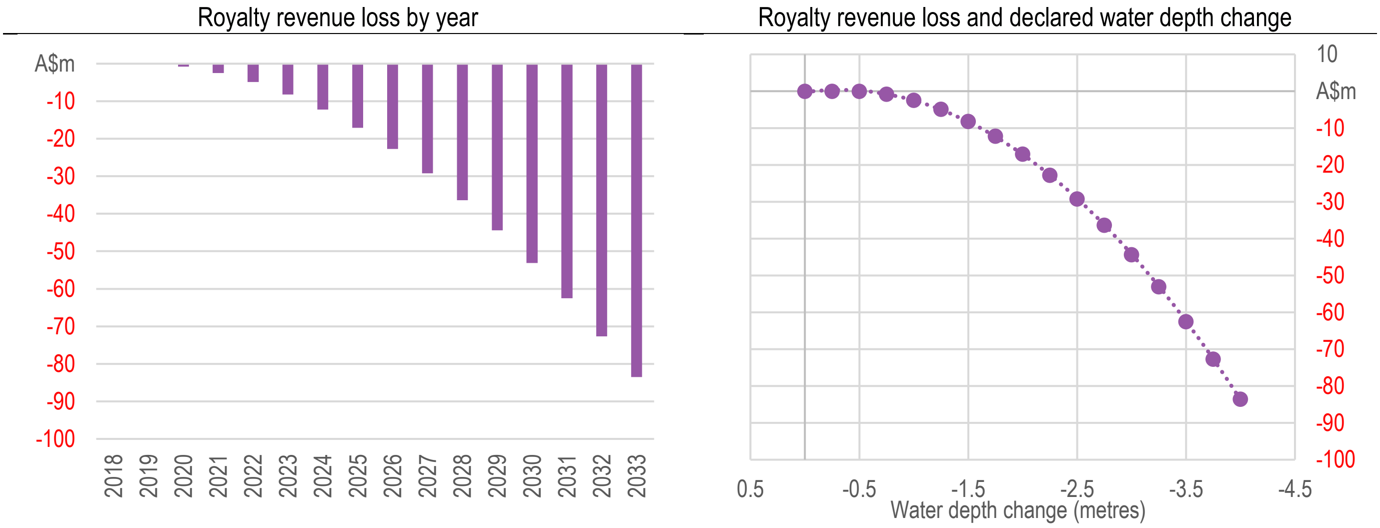


SOURCE: ACIL ALLEN CONSULTING MODELLING

Royalty revenue

Coal is the major royalty revenue source for Queensland Government. Over the period 2017-18 to 2032-33, if no maintenance dredging occurs at the Port of Hay Point coal royalty revenue is projected to fall by a cumulative total of $450 million relative to the reference case (with a present value of $338 million, using a 2.5 per cent real discount rate) as shown in **Figure ES 8**. The estimated coal royalty revenue losses are broadly equivalent to an annual average decline of $28 million in current prices or 1.2 per cent of Queensland Government coal royalties.

FIGURE ES 8 COAL ROYALTY REVENUE LOSS RELATIVE TO THE REFERENCE CASE, 2017-18 TO 2032-33



Note: Royalty payments are calculated according to Schedule 3 of the Mineral Resources Regulation (2013) in Queensland

SOURCE: ACIL ALLEN CONSULTING MODELLING

GLOSSARY

BMA	BHP Billiton Mitsubishi Alliance
CGE	Computable General Equilibrium Modelling
cms	Centimetres
DBCT	Dalrymple Bay Coal Terminal
DBCTM	DBCT Management Pty Ltd
Demurrage	Refers to the charges that the shipowners pay to the charter for its delayed operations of loading and unloading
Employment	The number of net full time equivalent job years created as a result of a project. Employment is the direct and indirect (flow on) employment as a result of a project. The impact is created as a result of spending in the economy. It is a **net** effect meaning that it takes into account transfers of labour from one job to another (crowding out effects).
GDP/GSP/GRP	A measure of the size of an economy. The real economic output is a measure of the output generated by an economy over a period of time (typically a year). It represents the total dollar value of all goods and services produced over a specific time period and is a measure of the size of the economy. At a national level, the real economic output is referred to as Gross Domestic Product (GDP). At the state level, economic output (or GDP equivalent) is called Gross State Product (GSP) and at a regional level is usually called Gross Regional Product (GRP).
GNI/GSI/GRI	A measure of the well-being of residents in an economy through their ability to purchase goods and services and to accumulate wealth. Although changes in real economic output are useful measures for estimating how much the output of the economy may change due to a decline in port capacity, changes in real income are also important as they provide an indication of the change in the economic welfare of the residents of a region through their ability to purchase goods and services. Real income measures the income available for final consumption and saving after adjusting for inflation. An increase in real income means that there has been a rise in the capacity for consumption as well as a rise in the ability to accumulate wealth in the form of financial and other assets. The change in real income from a project is a measure of the change in the economic welfare of residents within an economy. GNI is defined as the sum of value added by all producers who are Australian residents, plus any product taxes (minus subsidies) not included in output, plus income received from abroad such as employee compensation and property income. It represents the gross domestic product plus net foreign income flows. Positive deviation of GNI from the baseline implies that the regular maintenance dredging is welfare enhancing for Australians. At the state level, the gross income (or GNI equivalent) is called Gross State Income (GSI) and the regional level is usually called Gross Regional Income (GRI).
HPCT	Hay Point Coal Terminal
Job years	Employment is measured in job years. A job year is an employment of one full time equivalent (FTE) person for one year. Alternatively in can be expressed as one 0.5 FTE person for two years.
Metallurgical coal	Coal used in steel production, particularly steel smelting and metallurgical processes.
MIW	Mackay Isaac Whitsunday (MIW) Region
mtpa	million tonnes per annum
NPV	Net Present Value of a future stream of income (or expenses) converted into current terms by an assumed annual discount rate. The underlying premise is that receiving, say, $100 in 10 years is not ‘worth’ the same (i.e. is less desirable) than receiving $100 today.
NQBPC	North Queensland Bulk Ports Corporation
Real and nominal dollars	Nominal dollars are dollars that are expressed in the actual dollars that are spent or earned in each year, including inflation effects. Real dollars have been adjusted to exclude any inflationary effects and therefore allow better comparison of economic impacts in different years. Over time, price inflation erodes the purchasing power of a dollar thereby making the comparison of a dollar of income in 2033 with a dollar of income in 2017 invalid. Adjusting nominal dollars into real dollars overcomes this problem.

SA4	Statistical Area Level 4 of the Australian Bureau of Statistics.
SSM	Sustainable Sediment Management
Thermal coal	Used for generation of power and heat.
tph	tonnes per hour
VLC	Very large cape size

INTRODUCTION

1

The maintenance of safe navigational depths at ports is essential for a small open economy like Australia to bulk trade its goods efficiently.

North Queensland Bulk Ports Corporation (NQBP) has been conducting a series of work towards a long-term strategy for ongoing management of marine sediments at the Port of Hay Point, known as the Port of Hay Point – Sustainable Sediment Management (SSM) Assessment for Navigational Maintenance (The SSM Project).

As part of the SSM project, to assist in evaluating and contextualising sediment management options, NQBP has sought an independent analysis of the economic losses that could be associated with natural siltation of the Port's navigational infrastructure, particularly the siltation that has occurred and is predicted to occur in Berth Pockets, if maintenance dredging of the Port is not carried out.

NQBP has engaged Jerome Fahrer of ACIL Allen Consulting (ACIL Allen) to provide an independent report on the potential economic impacts which result of the accumulation of marine sediments in the existing port navigational infrastructure at the Port of Hay Point in Queensland i.e. the impacts on the local, regional and national economies if this accumulation is not controlled by maintenance dredging.

This report develops a scenario based on the data and information contained in the SSM Project Report and data provided by GHD Advisory (GHD).

The scenario was analysed using the ACIL Allen's economy wide computable general equilibrium model — *Tasman Global Model*. The model captures the dynamic, intra-industry and inter-industry linkages in the Mackay Isaac Whitsunday (MIW) Region of Queensland, rest of Queensland, rest of Australia and rest of the World.

1.1 The Port of Hay Point

The Port of Hay Point is one of the largest coal export ports in the world and is located 40 kilometres south of Mackay. The port comprises two separate coal terminals.

- Hay Point Coal Terminal (HPCT)
- Dalrymple Bay Coal Terminal (DBCT)

These terminals service coal mines in Central Queensland's Bowen Basin, and are linked to the mines by an integrated rail-port network. The port primarily exports metallurgical coal, a key resource in the steel-making process. Aurizon owns the below rail component of the rail network — track, signalling and overhead wiring, which provides access to the above rail service providers — rolling stock and locomotives.

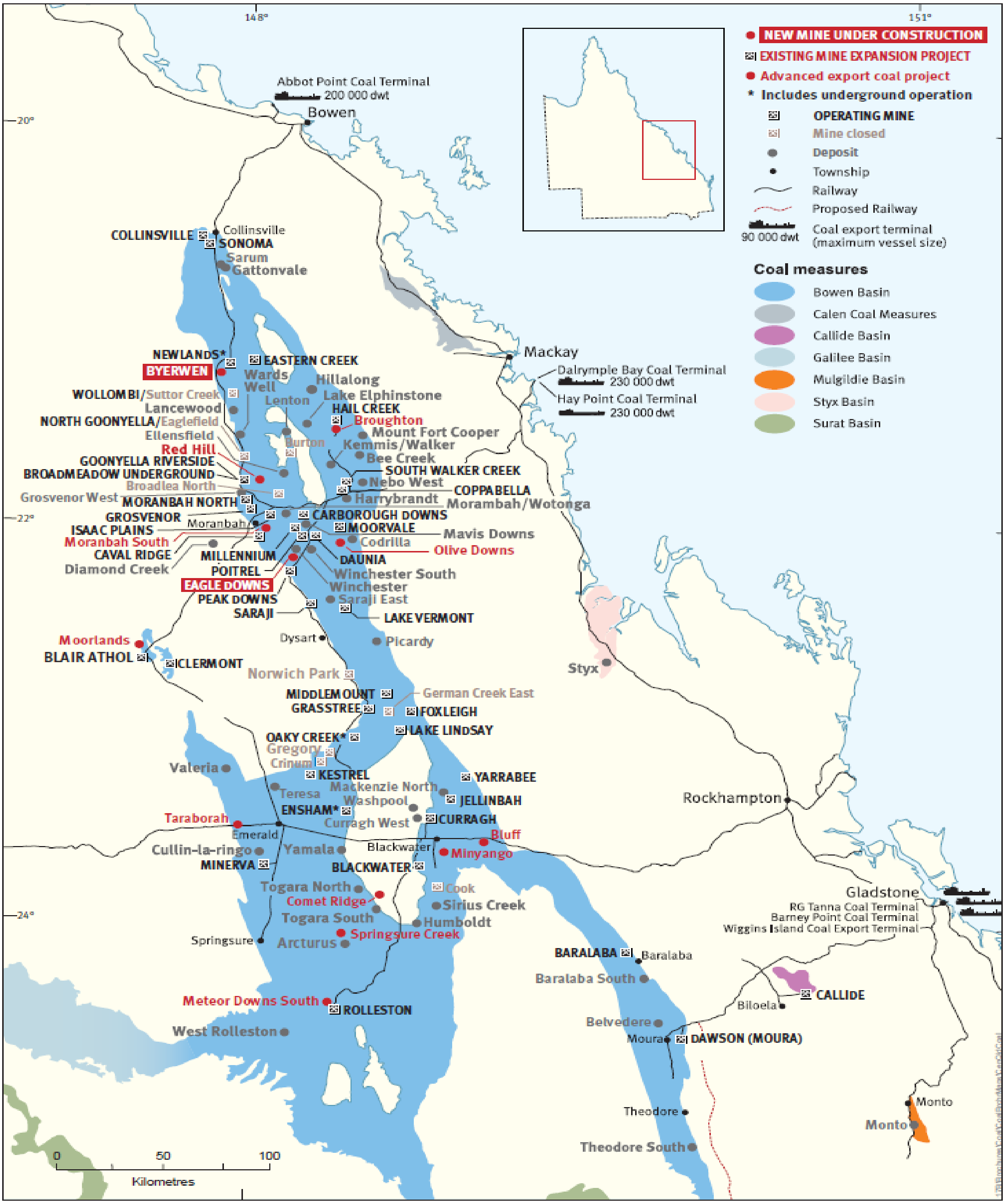
DBCT leased from Queensland Government by DBCT Management Pty Ltd (DBCTM) and HPCT owned by BHP Billiton Mitsubishi Alliance (BMA) and operated by Hay Point Services.

DBCT is the larger of the two terminals with a total capacity of 85 mtpa. It is a multi-user facility that services a large number of coal mines in the Bowen Basin coalfield area. DBCT consists of four berths.

HPCT has a capacity of 55 mtpa and has three berths.

The geographic location of Port of Hay Point is shown in **Figure 1.1**.

FIGURE 1.1 LOCATION OF PORT OF HAY POINT



SOURCE: QLD DEPARTMENT OF NATURAL RESOURCES AND MINES 2017, QUEENSLAND COAL –MINES ADVANCED PROJECTS, PAGE 4.

1.2 The Mackay, Isaac, Whitsunday regional economy

The regional economy for this study encompasses the Mackay, Isaac and Whitsunday regional councils; the MIW region – Mackay Statistical Division (SD) or SA4.

The population of the region is 166,811 with total employment of 78,148. Gross Regional Product in 2015-16 was $14,930 billion, giving GRP per capita of around $89,000, significantly higher than Australian GDP per capita ($77,000) and Queensland GSP per capita ($73,000).[6]

The largest sector of the MIW economy, on all measures, is mining (specifically, coal mining) as shown in **Table 1.1**. The mining sector plays an important role in the MIW region.

TABLE 1.1 MACKAY ISAAC WHITSUNDAY REGIONAL PROFILE, 2015-16

Industry	Employment		Output		Value-add	
	No	%	A$m	%	A$m	%
Mining	13,398	17.1%	$11,455	33.9%	$4,569	32.4%
Retail Trade	7,443	9.5%	$4,850	14.3%	$1,601	11.4%
Construction	7,139	9.1%	$3,968	11.7%	$1,260	8.9%
Accommodation	6,224	8.0%	$2,482	7.3%	$903	6.4%
Manufacturing	6,108	7.8%	$1,692	5.0%	$771	5.5%
All others	37,836	48.1%	$9,377	28.0%	$4,986	35.4%
Total	**78,148**	**100.0%**	**$33,823**	**100.0%**	**$14,090**	**100.0%**

SOURCE: REMPLAN DATA

1.3 Key objectives

A key objective of this study is to provide an estimate of potential economic impacts of no regular maintenance dredging over a period of 16 years at the Port of Hay Point as result of the accumulation of marine sediments in the existing port navigational infrastructure. It considers the current siltation that has occurred at the Port and if no maintenance dredging was to occur for the next 16 years.

1.4 Economic modelling scenarios

To answer key objectives by considering the scope of the study, ACIL Allen developed following hypothetical economic impact modelling scenarios.

- **Reference case scenario** — in this scenario, there will be a regular maintenance dredging at the Port of Hay Point for next 16 years.
- **A change in current water depth scenario (loss scenario)** — port capacity losses that would potentially occur when there is a loss of declared water depth level of up to four metres due to sedimentation at the Port of Hay Point at its two terminals.

This hypothetical scenario illustrates the potential economic losses associated with various degrees of siltation and sedimentation at the Port of Hay Point in Queensland without a regular maintenance dredging. The economic modelling scenarios are developed and assessed using ACIL Allen regional computable general equilibrium (CGE) model — *Tasman Global Model*.

The modelling results provide an economic impact, measured in terms of real economic output, real income and employment of no regular maintenance dredging at the Port of Hay Point on the economies of

- Mackay Isaac Whitsunday (MIW) Region (SA4)[7]
- Rest of Queensland
- Rest of Australia.

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[6] REMPLAN website, http://www.economyprofile.com.au.

[7] Statistical Area Level 4 (SA4) sub-state geographic areas of the Australian Bureau of Statistics.

1.5 Report structure

The structure of this report is as follows:

- Chapter 2 provides a framework for assessing the impact of the reduction in declared water depth due to sedimentation. This framework provides measurable direct economic impacts of various degrees of sedimentation at ports.
- Chapter 3 provides data sources and assumptions used to estimate the direct and indirect impacts of sedimentation. This chapter includes annual loss of declared water depth at Port of Hay Point terminals, expected thermal and metallurgical coal prices and export volume assumptions.
- Chapter 4 provides the computable general equilibrium modelling results of the total economic impacts — gross regional product and gross state product and employment.
- Chapter 5 provides the coal royalty revenue losses to the Queensland Government due to the loss of port capacity

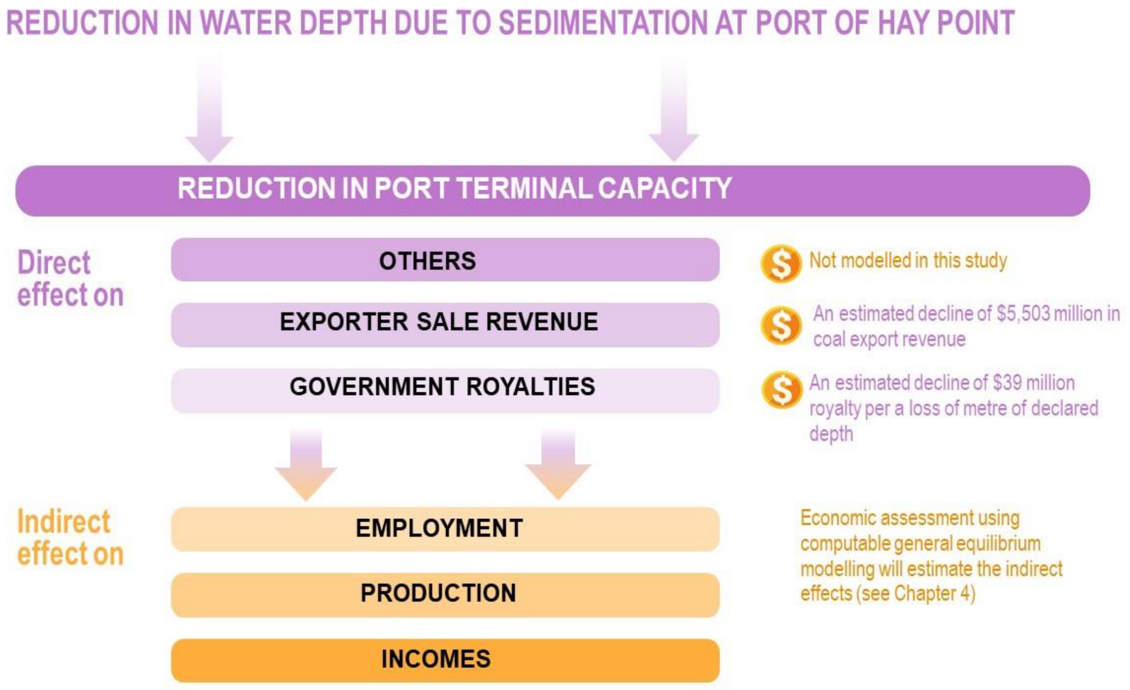
Appendix A sets out the detailed methodology, analytical techniques and modelling tools to assess the economic impact of the reduction in water depth due to sedimentation at Port of Hay point in Queensland. This includes discussion on ACIL Allen's computable general equilibrium model.

A FRAMEWORK

2

There are a number of direct effects of a reduction in declared water depth due to sedimentation at ports as shown in **Figure 2.1**.

FIGURE 2.1 KEY EFFECTS FROM WATER DEPTH REDUCTIONS AT PORTS



SOURCE: ACIL ALLEN BASED ON PORT AND LGISTICS SOLUTIONS PTY.LTD (2016), PORT OF HAY POINT SUSTAINABLE SEDIMENT MANAGEMENT ASSESSMENT FOR NAVIGATION MAINTENANCE, PORT OPERATION AND THE EFFECTS OF SEDIMENTATION

The direct effects have impacts on delays in loading, loss of terminal capacity which can lead to loss of export revenue for exporters and a decline in government coal royalty revenue.

The direct impacts have flow-on impacts on the region and the rest of the economy in terms of employment, production and income. The potential indirect impacts are shown in Chapter 4 using the data and assumptions reported in Chapter 3.

Reduction in water depth due to sedimentation could decrease the use of larger vessels, increases the reliance on smaller (older) vessels which could result in reduced terminal capacity. This may have an impact on the supply chain efficiency of the cargo.

Any reduction in water depth will cause 'stop loading' delays to deep drafted vessels due to the port regulation to maintain a static distance between the bottom of the ship and the seabed. As the tide falls during the loading operation, the terminals will be forced to stop loading and wait for the rising tide to ensure the preservation of the minimum under keel clearance. These delays will reduce the terminal capacity and affect the revenues of the exporters, port authority, ship owners and Queensland Government.

The economic impact assessment of the following direct effects of the reduction in port capacity is considered in this study.

2.1 Sales revenue of exporters

Cargo throughput falls as a result of the reduction in water depth. Cargoes will take longer to load at the port and this leads to a lower terminal capacity. The relationship between the loss of water depth and loss in cargo throughput as a result of the loss in terminal capacity is unlikely to be linear, depending on a number of geophysical characteristics, vessel sizes, the nature of tides, the prevalence of the cyclones and weather conditions.

Port Authority revenues could be indirectly affected due to the reduction in throughput, particularly when port levies are based on the volume of exports.

2.2 Government royalties

Exporters of coal pay more supply chain costs per tonne and experience delays in shipping due to the loss of port capacity, as a result, earn less revenue. Less throughput means lower royalties so, the Government is expected to collect less royalty revenue from the exporters.

DATA SOURCES AND ASSUMPTIONS 3

A number of data sources were used to estimate the direct economic losses related to a reduction in declared water depth due to sedimentation at Port of Hay Point. Key considerations included in the economic assessment are:

— Coal prices — thermal and metallurgical

— Coal export volumes

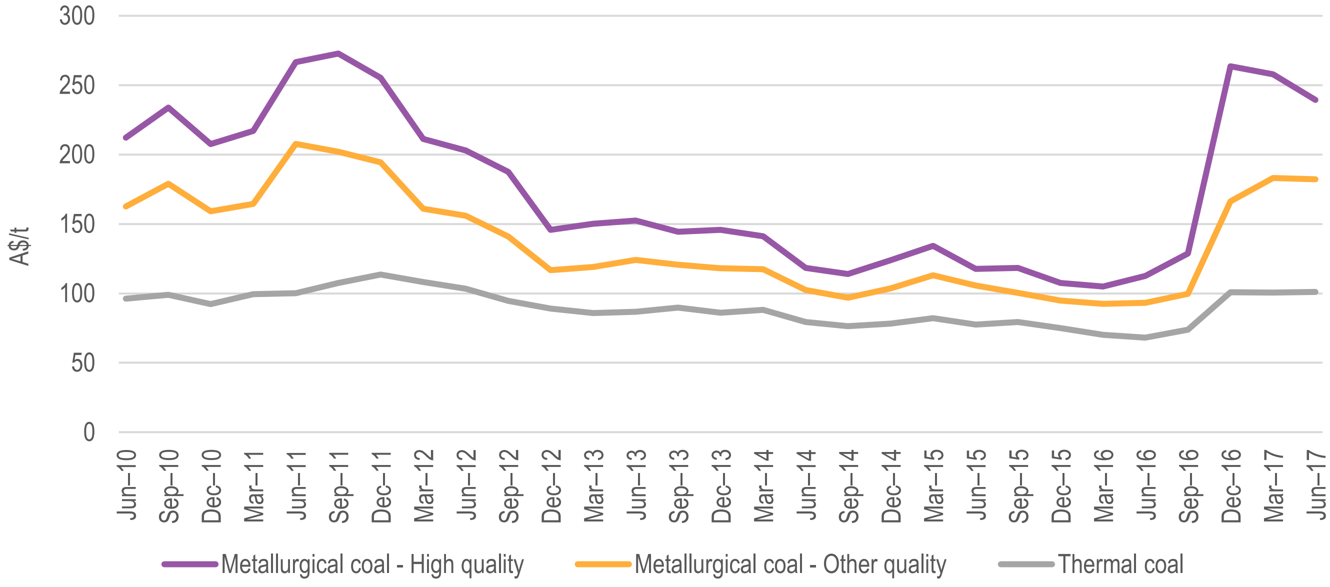
— Terminal capacity

— Royalty revenue.

3.1 Coal prices

Historical thermal and metallurgical coal prices in Australia are provided in **Figure 3.1**. Coal prices (along with gas and oil) move together due to their short and long-run production and demand relationships (co-integrated). Coal prices appear to recover during the past six months since declining from their historical peak in 2011.

FIGURE 3.1 COAL PRICES [A]



[a] Average unit export value

SOURCE: HTTPS://WWW.INDUSTRY.GOV.AU/OFFICE-OF-THE-CHIEF-ECONOMIST/PUBLICATIONS/RESOURCESANDENERGYQUARTERLYSEPTEMBER2017/INDEX.HTML

Coal export revenues are based on tonnes loaded to the vessel and the price of coal — average unit export value. To calculate export revenue and coal royalties related to expected loss in declared water depth at Port of Hay Point, a weighted average price of A$127.3/tonne was used in this study.[8]

3.2 Coal export volumes

Historical coal export volumes from the Port of Hay Point are provided in **Table 3.1**. Over 50 per cent of Queensland coal exports go through the Port of Hay Point.

TABLE 3.1 COAL EXPORT VOLUMES FROM MIW REGION 2011-12 TO 2016-17, MILLION TONNES

Year	DBCT	HPCT	Port of Hay Point Total	Abbot Point	MIW Region Total
2011-12	50.8	32.0	82.9	13.6	96.5
2012-13	62.2	34.3	96.5	17.7	114.3
2013-14	67.5	40.8	108.3	22.9	131.2
2014-15	71.6	43.4	115.0	28.7	143.7
2015-16	67.5	48.3	115.8	27.1	142.8
2016-17	63.0	43.4	106.5	25.4	131.9

SOURCE: HTTP://NQBP.COM.AU

For the economic assessment, an assumption is made that the two terminals at the Port of Hay Point will together have a capacity of around 140 million tonnes of coal each year for the next 16 years and exports from Abbot Point terminal would increase its capacity in the baseline as reported in their 2018-19 corporate plan. However, there will be no impact on the Abbot Point terminal capacity in the no regular maintenance dredging scenario at the Port of Hay Point.

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[8] Weighted average price is calculated based on 20 per cent thermal coal price and 80 per cent metallurgical coal.

3.3 Dredging costs

All costs in current prices associated with the dredging including mobilisation/demobilisation, standby, environmental monitoring, project management and permit/approvals processes are provided in **Table 3.2**. The estimated annual average maintenance dredging costs will be around $2 million.

TABLE 3.2 ESTIMATED MAINTENANCE DREDGING COSTS OVER 20 YEARS AT PORT OF HAY POINT

Year	Volume (m^3)	Costs
Year 0 (Permit SSM)	0	$1,500,000
Year 1	357,000*	$8,350,000
Year 5	200,000	$4,704,225
Year 10	200,000	$4,704,225
Cyclone (Year 1 —Year 10)	200,000	$4,704,225
Year 10 (Permit SSM)	0	$1,000,000
Year 15	200,000	$4,704,225
Year 20	200,000	$4,704,225
Cyclone (Year 11 —Year 20)	200,000	$4,704,225
TOTAL	**1,557,000**	**$39,075,352**
Yearly average	**77,850**	**$1,953,768**

* Approx

3.4 Terminal capacity and berth pocket declared depth

The Integrated Logistics Company in 2012 modelled the impact of terminal capacity relative to reductions in berth pocket declared depth. Their report determined that loading delays commenced once berth pocket depths were less than 18.5 metres initially impacting very large cape size (VLC type) vessels followed by Cape vessels. Based on the above study, DBCT Pty Ltd in 2016[9] modelled the terminal capacity in mtpa, time and declared depth in metres.

RoyalHaskoningDHV in 2016[10] developed a predictive model and estimated that loss of depth after 3 years at DBCT berth pockets 1& 2 is 87 cms.

GHD provided detailed data on key terminal capacity loss parameters at two terminals at Port of Hay Point:

- Loss in average berth depth (metres)
- Stop load delays
- Wait to depart delays
- Additional new vessel delays
- Incremental increase in time
- Time taken to load same amount of product inclusive of delays.

3.4.1 GHD inputs

Different levels of water depth losses are based on data prepared by GHD. The GHD data includes port capacity losses associated with the declared water depth losses. Recent declared water depths at port berths are provided in **Table 3.3**.

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[9] Dalrymple Bay Coal Terminal Pty Ltd 2016, Economic impact of not managing sediments at DBCT, 2016 (unpublished).

[10] RoyalHaskoningDHV 2016, Hay Point Bathymetric Analysis Predictive Model, March 2016 (unpublished)

TABLE 3.3 CURRENT DECLARED DEPTHS AS PER NOTICE MARINERS

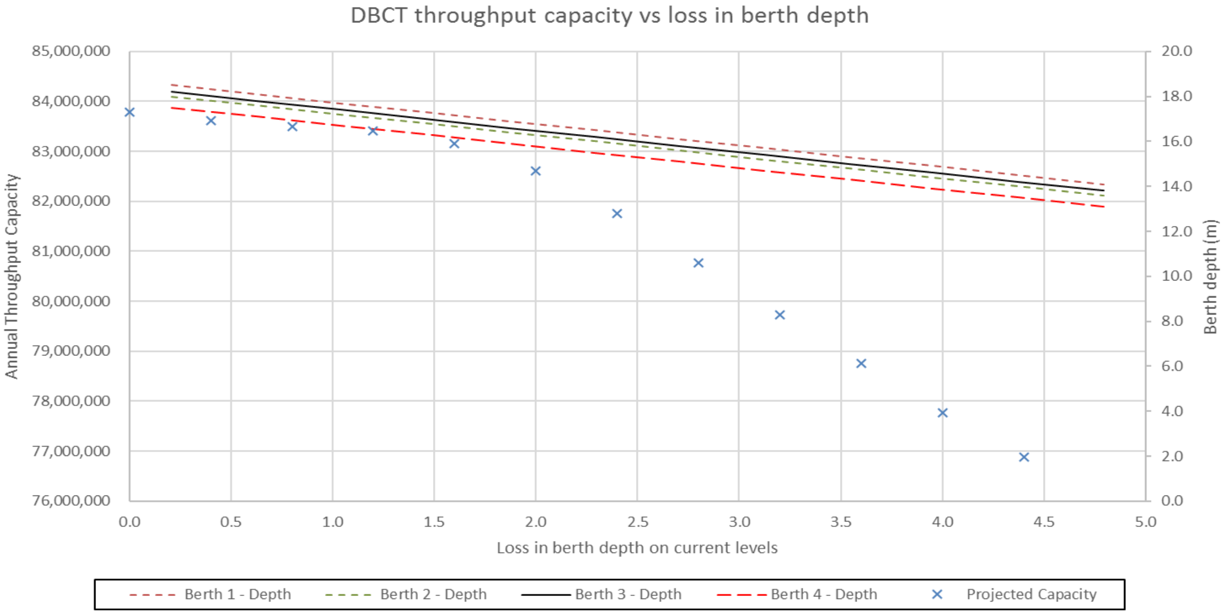
Berth	Design Depth (metres)	Depth, November 2016	Depth, June 2017
HPCT1	16.6	16.3	16.1
HPCT2	16.7	16.8	16.7
HPCT3	19.0	18.8	18.4
DBCT1	19.6	18.5	17.5
DBCT2	19.6	18.0	17.4
DBCT3	19.0	18.2	17.3
DBCT4	19.0	17.5	17.1

SOURCE: GHD

The GHD model assumes a vessel is able to access the deepest berth (DBCT1 and HPCT3) 100 per cent of the time based on the assumption that scheduling is fully optimised, in order to mitigate the impact of berth depth loss on capacity throughput. The GHD model has estimated the terminal capacity losses using the model curves based on the change in maximum berth depths at each terminal. For example, at DBCT the maximum berth depth in November 2016 is 18.5 metres at DBCT1. The maximum depth reduces to 17.5 metres at DBCT1 which equates to an effective depth loss (starting point) of one metre.

The impact of already occurred depth loss on DBCT capacity is provided in **Figure 3.2**.

FIGURE 3.2 DBCT THROUGHPUT CAPACITY VERSUS LOSS IN BERTH DEPTH

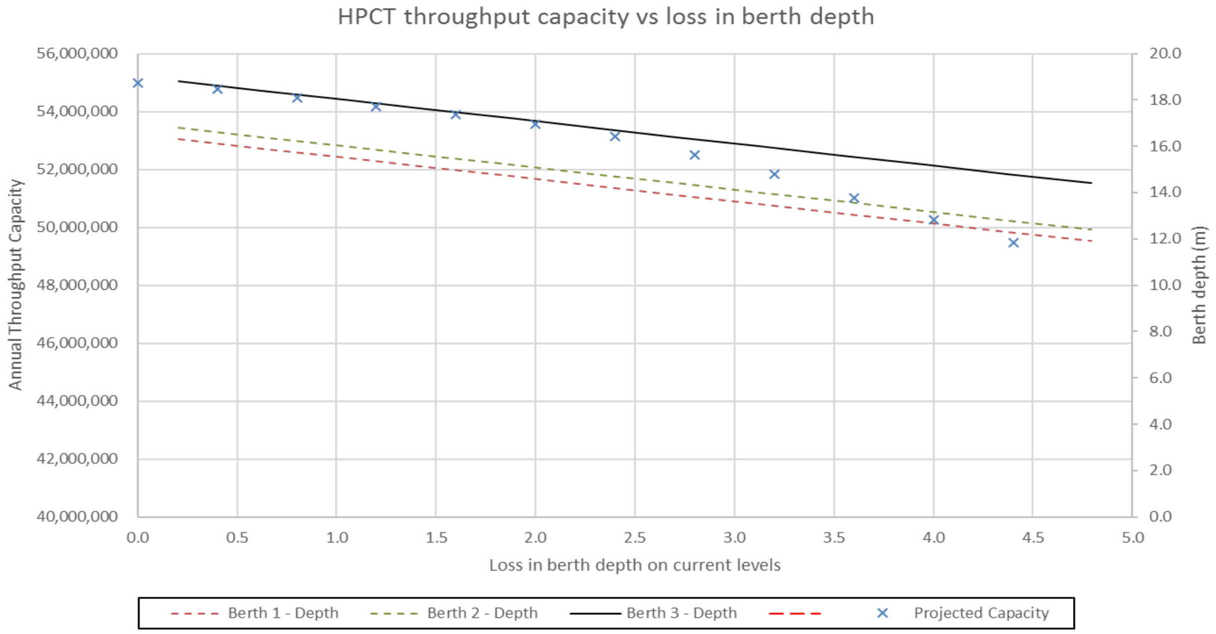


SOURCE: GHD

Alternatively, at HPCT the maximum berth depth reduces by 0.4 metres at HPCT3 between November and June 2017. The estimated starting position is 0.4 metres for HPCT. The impact of this depth loss on HPCT capacity is provided in **Figure 3.3**.

The estimated curves show an asymmetry of loss at each terminal.

FIGURE 3.3 HPCT THROUGHPUT CAPACITY VERSUS LOSS IN BERTH DEPTH



SOURCE: GHD

The weighted average depth loss is estimated as:

DBCT: 1.0*(85/140) = 0.61 metres

HPCT: 0.4*(55/140) = 0.16 metres

Total combined loss at June 2017 was 0.77 metres

3.4.2 Economic analysis of inputs

Based on these parameters and data, GHD has estimated the loss in throughput capacity and loss in water depth on current levels. The GHD data includes port capacity losses associated with the declared water depth losses. To annualise the declared water depth losses over 16 years, consistent with the GHD estimated capacity losses, a 20 cms declared water depth loss per annum is assumed in this study. This is consistent with the Hay Point Bathymetric Analysis undertaken in March 2016. The Bathymetric Analysis reported that nearly 87cms of declared water depth loss in three years if there is no maintenance dredging at the DBCT, or around 29 cms per annum. This report assumes a loss of 20 cms per annum. The estimated annual profile is shown in **Figure 3.4**. A four metre loss in average berth water depth over 16 years would result in a total loss of 43.2 million tonnes of export throughput capacity at the Port of Hay Point. To estimate the value of potential export losses from the thought losses, a profile of estimated loss in coal export revenue based on the weighted average price (A$127.3/tonne) in hypothetical terminal capacity loss scenario is shown in **Figure 3.5**. It is estimated that a cumulative export revenue loss at the Port of Hay Point over the next 16 years will be $5.5 billion. This loss in coal export revenue represents a 5 per cent cumulative loss in coal export revenue relative to the reference case in the MIW Region.

Note that the actual loss of water depth will be will depend on the timing, location, frequency and intensity of cyclones. Cyclone Debbie in March 2017 caused an immediate loss of depth of about two metres (varying somewhat between berth pockets) which soon was reduced to a loss of about one metre due to natural consolidation of suspended sediments. Complicating forecasting further is the likelihood that the future patterns of cyclones will be different from the past, with research pointing to less frequent, but more intense cyclones on the whole, with more frequent high-intensity cyclones. [11]

This said, the risk of faster-than-assumed siltation is likely to be asymmetric i.e. future cyclones could accelerate loss of water depth at the berth pockets, but it is difficult to envisage events that will have the opposite effects. If water depth loss occurs at a faster rate than is assumed in this report, then the economic losses will occur sooner, and the total economic losses over the period

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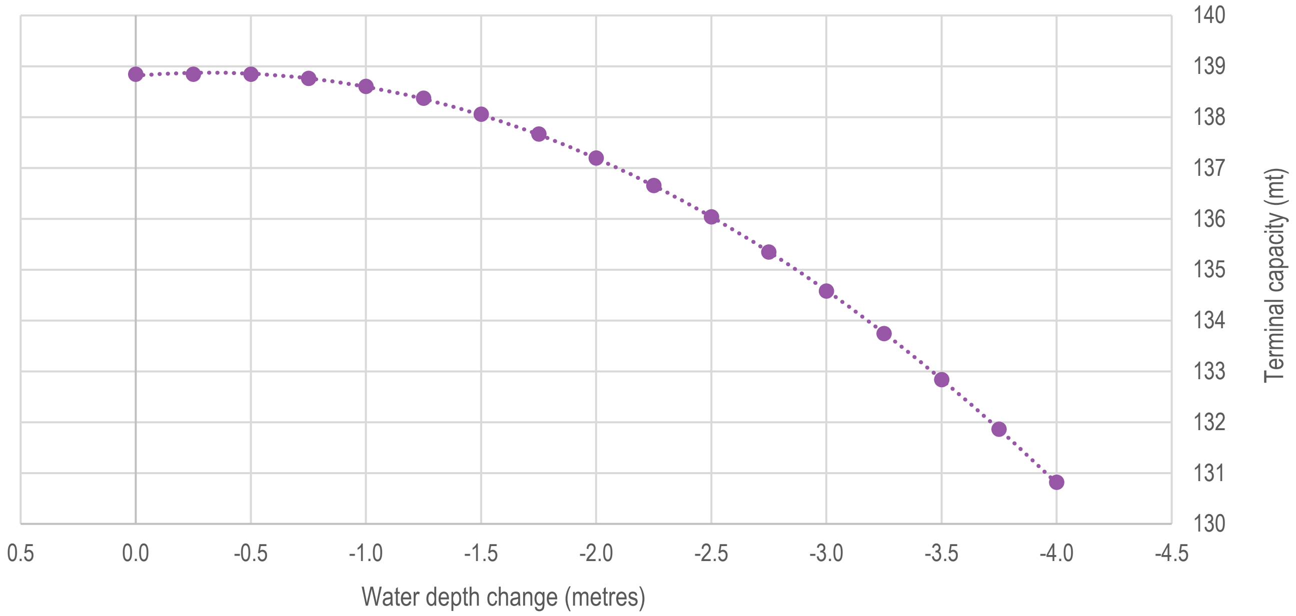
[11] Thomas R. Knutson et al, “Tropical cyclones and climate change”, Nature Geoscience 3, 157–163 (2010), https://www.nature.com/articles/ngeo779?foxtrotcallback=true

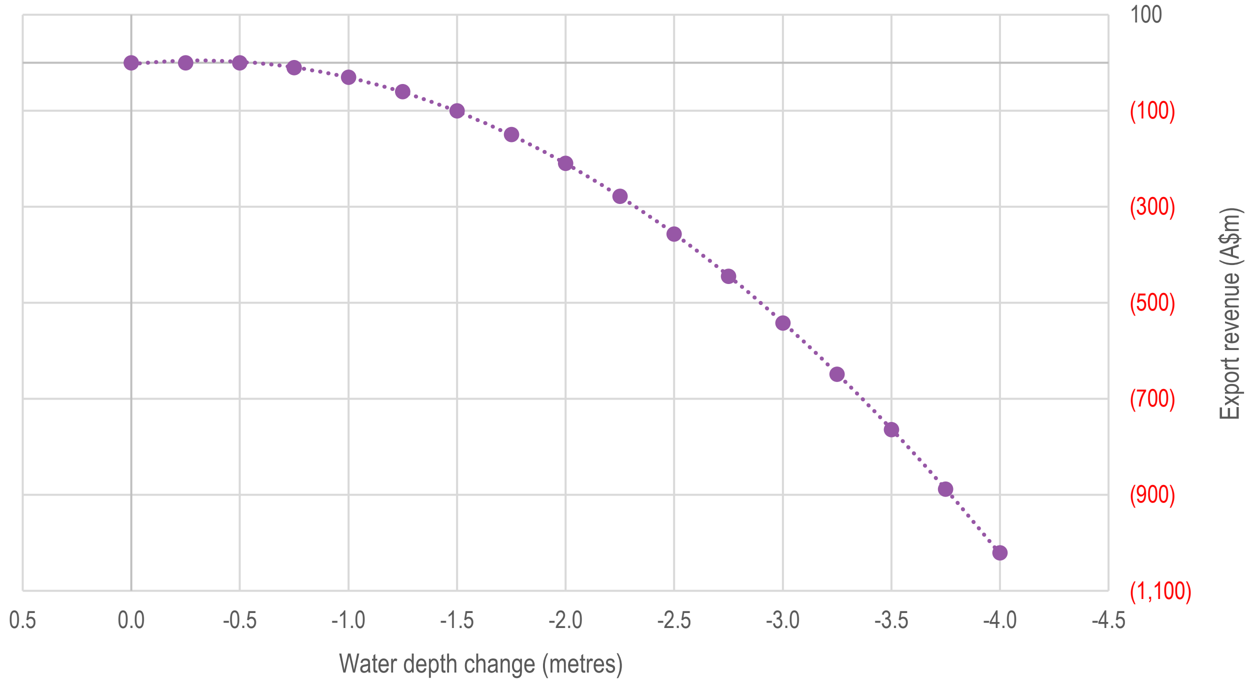
under review will be larger, possibly much larger. For example, instead of 16 years, if the declared water depth of 4 metres would lost in ten years, the estimated cost would be larger.[12]

FIGURE 3.4 ESTIMATED TERMINAL CAPACITY LOSS AND DECLARED WATER DEPTH CHANGE



SOURCE: ACIL ALLEN CONSULTING BASED ON GHD DATA

FIGURE 3.5 ESTIMATED POTENTIAL EXPORT REVENUE LOSS AND DECLARED WATER DEPTH CHANGE



SOURCE: ACIL ALLEN CONSULTING BASED ON GHD DATA

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[12] Chapter 4 reports the economic losses over a period of 16 years, A sensitivity analysis whereby the same water depth is lost over 10 years indicates (in NPV terms at 2.5 per cent) estimates that the total economic output losses will be over $200 million higher relative to the losses estimated over a 16 year period in MIW region. Undiscounted losses are more than $600m higher.

3.5 Port charges

Port charges are a cost to the coal export industry and change when the volume of coal that is shipped changes.

Effective as at 1 July 2017,[13] harbour charges at the rate of $0.062 per tonne ($0.068 per tonne inclusive of GST) are payable in respect of all coal, coke or similar material shipped from Hay Point Coal Terminal.

Effective as at 1 July 2017, harbour charges at the rate of $0.072 per tonne ($0.079 per tonne inclusive of GST) are payable in respect of all coal, coke or similar material shipped from Dalrymple Bay Coal Terminal.

Harbour charges at the rate of $5,749.28 per ship ($6,324.21 per ship inclusive of GST) plus $1.07 per tonne ($1.17 per tonne inclusive of GST) are payable in respect of all goods not otherwise specified herein unloaded within or adjacent to the Hay Point Tug Harbour.

Harbour charges are not payable on ships stores when shipped in the port for consumption or use by the loading ship.

Tonnage charges at the rate of $0.288 per gross registered tonne ($0.317/GRT inclusive of GST) are payable in respect of each ship in excess of 1,000 gross registered tonnes – note that the security charge of $0.002/GRT is included within the Tonnage charge.

3.6 Royalty rates

Royalty payments are calculated according to Schedule 3 of the Mineral Resources Regulation (2013) in Queensland.[14] Royalties are a liability arising from the sale of certain minerals. The value of the royalty is calculated by the gross value of the sale after deducting certain permitted expenses.

For example, in the case of coal and after the price upturn of 2012, the State Government introduced three levels of coal royalties.

- Up to and including $100 per tonne, a 7 per cent of the value of the sale
- Over $100 and up to $150 per tonne, first $100 per tonne is 7 per cent of value, then 12.5 per cent for the balance
- More than $150 per tonne, first $100 is 7 per cent of value, then for the next $50 it is 12.5 per cent, then finally 15 per cent for the balance

The sale value must also include:[15]

- any exchange rate losses or gains between the time of the sale and receipt of the proceeds
- any contractual dispatch paid at the load port because of early loading
- any reimbursement for royalties paid by the buyer of the coal
- the value of the mineral, even if the product has been traded for no monetary consideration.

Permitted deductions from the value include:

- Demurrage incurred at a loading port due to late contractual loading
- Freight and insurance (generally this will not be applicable to Australian coal sales which are made on free-on-board (FOB) terms, where the coal buyer arranges and pays for the ocean freight and insurance.

The supply chain delivery costs are not considered to be a permitted deduction.

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[13] http://nqbp.com.au/wp-content/uploads/2017/06/11-7-1-Pricing-Schedule-Hay-Point-2017-18.pdf

[14] https://www.legislation.qld.gov.au/LEGISLTN/CURRENT/M/MineralReR13.pdf

[15] Port and Logistics Solutions Pty. Ltd 2016, Port operation and the effect of sedimentation, Port of Hay Point, Sustainable Sediment Management, Assessment for Navigation Maintenance (SSM Project), April 2016.

ECONOMIC ASSESSMENT 4

This chapter uses quantitative analysis to assess the potential progressive economic impacts of loss of declared water depth at Port of Hay Point in the next 16 years. The aim of this economic analysis is to highlight the importance of maintenance dredging at ports in general and Port of Hay Point in particular.

Economic impacts at the Port of Hay Point, as a result of the accumulation of marine sediments in the existing port navigational infrastructure, are undertaken using ACIL Allen's regional CGE model (*Tasman Global* Model).

Details of economic assessment methodology and *Tasman Global Model* are provided in Appendix A.

4.1 Overview of economic modelling

The following hypothetical scenarios have been analysed using Tasman Global Model.

- ***A Reference case (regular maintenance dredging) scenario*** — this scenario provides a baseline of regular maintenance dredging at Port of Hay Point as business as usual.
- **A change in current water depth scenario with no regular maintenance dredging (loss scenario)** — this scenario analyses the impact on the economy of not regularly undertaking maintenance dredging at Port of Hay Point. An estimated loss of declared water depth at both terminals would be around four metres from the current declared water depth. It is assumed that the loss in depth at terminals results in a loss in terminal capacity and the loss in terminal capacity leads to loss in coal export revenue. It is estimated that terminal capacity will be reduced by a cumulative total of 43.2 million tonnes over the next 16 years.

Key features of the economic modelling scenario are summarised in **Table 4.1**.

TABLE 4.1 KEY FEATURES OF ECONOMIC MODELLING SCENARIO

	Cumulative total reduction in declared water depth in next 16 years	Cumulative total reduction in terminal capacity in next 16 years	Cumulative total reduction in coal export revenue in next 16 years
	metres	Million tonnes	A$m
A water depth loss scenario	4	43.2	5,503

SOURCE: ACIL ALLEN CONSULTING BASED ON GHD DATA

The magnitude of the estimated loss of export revenue is based on the current level of activity at the Port of Hay Point. It is benchmarked to existing data to ensure that it is realistic and consistent given Port of Hay Point's current export volumes, declared water depths and assumed coal prices.

As mentioned above, the analysis of a hypothetical scenario was undertaken using the Tasman Global model. Tasman Global is a multi-regional Computable General Equilibrium (CGE model) of the Australian and world economies that has been used for similar modelling by the ACIL Allen in the assessment of resource and infrastructure projects. For this economic assessment, the model's database has been updated to reflect the most recent macroeconomic and external accounts data. The model is dynamic and captures a range of stock-flow relationships, intra and industry linkages in the economy. This allows time for the longer term consequences of revenue gains related to sustainable port management in the MIW region in Queensland to be observed.

To isolate the impact of losses that could potentially happen with no regular maintenance dredging are compared to a reference case where there is a regular maintenance dredging.

Each of the scenarios was modelled for a sixteen year period from 2017-18 to 2032-33.

All of the reported economic impacts represent changes relative to a reference case.

The economic impacts are shown in 2016-17 dollars.

All present value (PV) calculations use a 2.5 per cent real discount rate.

4.2 Real economic output

Gross Domestic Product (GDP) is one of the primary indicators used to gauge the health of an economy. It measures the amount of economic activity happening in the country and represents the total dollar value of all goods and services produced over a specific time period. It can be thought of as the size of the economy. At the state level, this measure is defined as Gross State Product (GSP) and at the regional level, it is defined as Gross Regional Product (GRP).

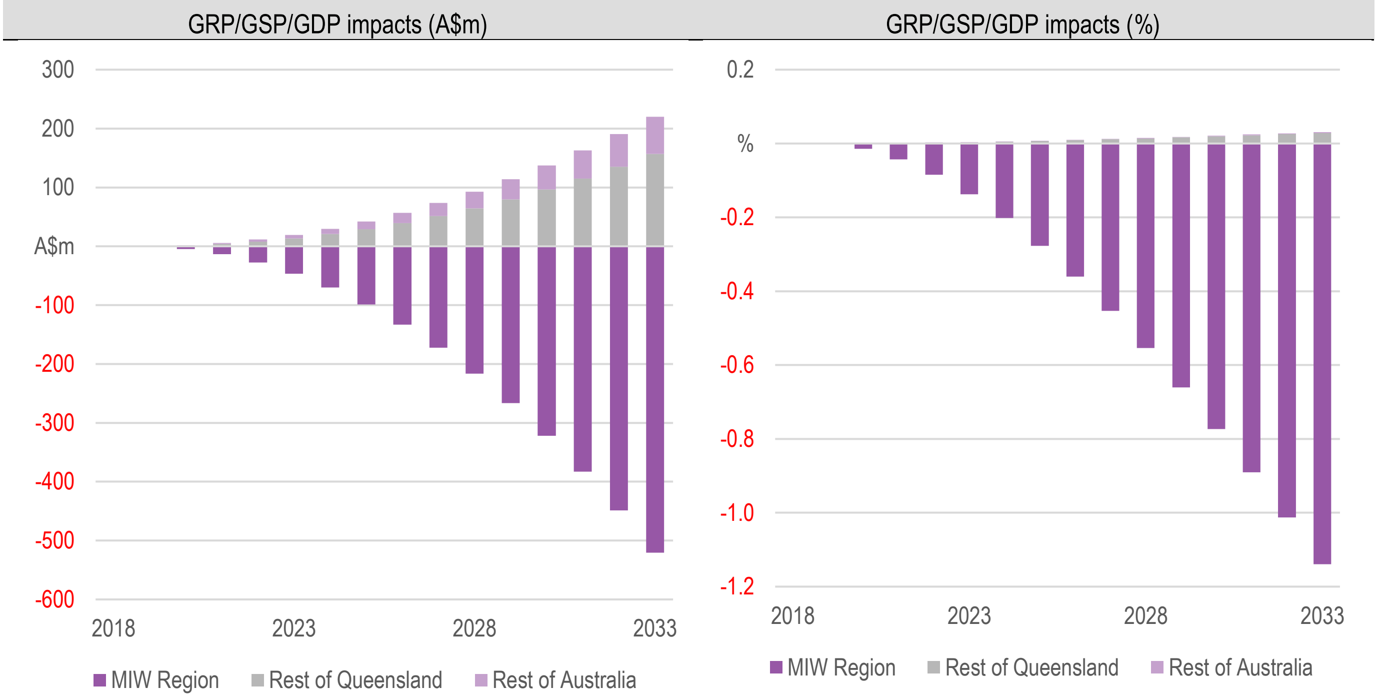
The projected changes in real GRP in MIW Region are presented in **Figure 4.1**. As shown in this figure, there will be economic losses associated with no regular maintenance dredging at the Port of Hay Point.

Table 4.2 shows the total impacts of no maintenance dredging at the Port of Hay Point for next 16 years.

Over the period 2017-18 to 2032-33, no maintenance dredging would project to decrease the real economic output of the MIW Region (i.e. real GRP) by a cumulative total of $2,724 million over the period of 16 years (with a present value of $2,040 million, using a 2.5 per cent real discount rate), or around $170 million per year on average, .equivalent to a loss of 1.1 per cent of MIW Region's current GRP. [16]

It was estimated in the SSM Project that the cost of maintenance dredging of the Port would be nearly $39 million over 20 years in current price, or about $2 million per year on average. Thus, for an annual expense of $2 million per year, the MIW region would avoid (average) annual output losses of $170 million. [17]

FIGURE 4.1 PROJECTED CHANGE IN REAL ECONOMIC OUTPUT AS A RESULT OF NO REGULAR MAINTENACE DREDGING AT THE PORT OF HAY POINT, RELATIVE TO A REFERENCE CASE



Note: Real economic output for Mackay region is equivalent to real GRP while real economic output at the Queensland level is equal to real GSP. All dollars are in 2016-17 terms.

SOURCE: ACIL ALLEN CONSULTING MODELLING

TABLE 4.2 PROJECTED CHANGE IN REAL ECONOMIC OUTPUT OF NO REGULAR MAINTENANCE DREDGING AT THE PORT OF HAY POINT, RELATIVE TO A REFERENCE CASE

		Cumulative change (2017-18 to 2032-33)	
Regions	Average annual	Total	PV (@ 2.5%)
	2016-17 A$m	*2016-17 A$m*	*2016-17 A$m*

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[16] Based on the estimated MIW region GRP in 2016-17 of $14,935 million.

[17] This is purely dredging cost and includes all dredging costs associated with mobilization/demobilization, standby, environmental monitoring, project management and permit/approvals processes.

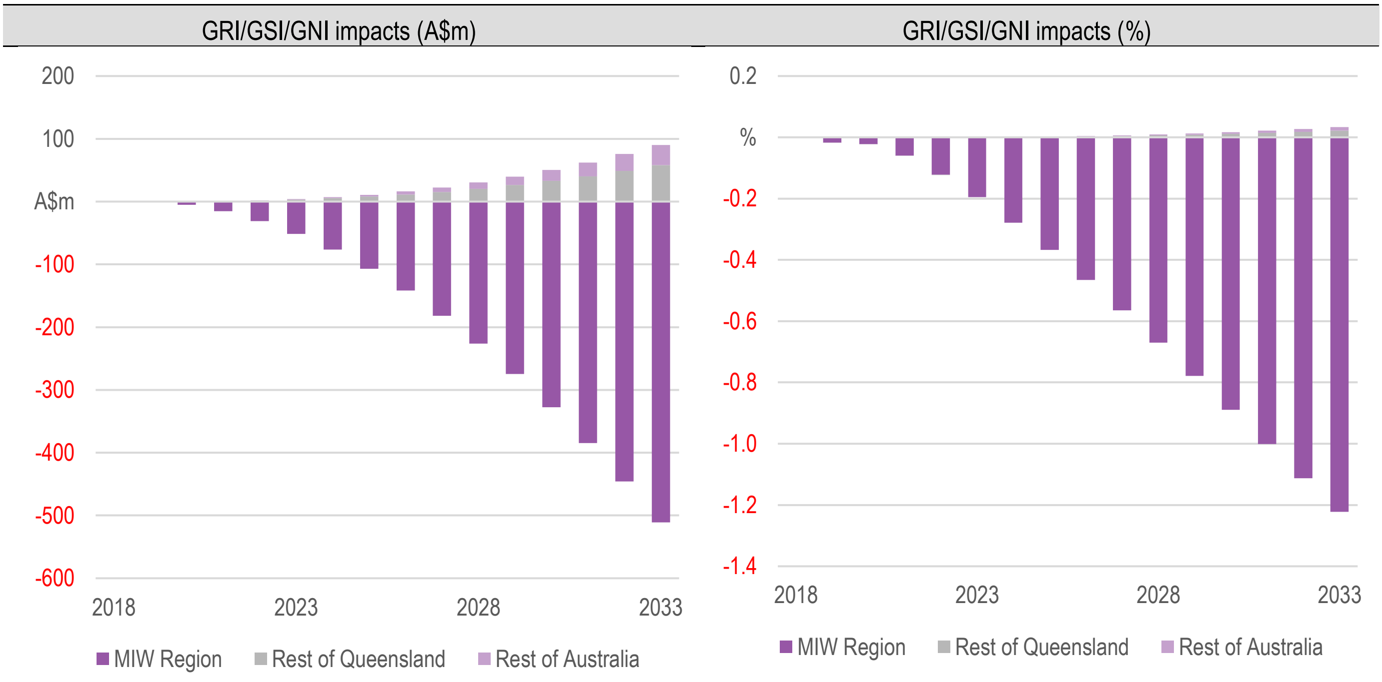
		Cumulative change (2017-18 to 2032-33)	
Regions	**Average annual**	**Total**	**PV (@ 2.5%)**
MIW Region (GRP)	(170)	(2,724)	(2,040)
Queensland (GSP)	(119)	(1,910)	(1,431)
Australia (GDP)	(98)	(1,567)	(1,174)

SOURCE: ACIL ALLEN CONSULTING MODELLING

4.3 Real income

Real income is a measure of the ability of residents to purchase goods and services, adjusted for inflation. A rise in real income indicates a rise in the capacity for current consumption, but also an increased ability to accumulate wealth in the form of financial and other assets. The change in real income arising from a regular dredging with the full operational capacity of a port is a measure of the change in the well-being the residents of the MIW Region, Queensland and Australia. The real income impacts are shown in **Figure 4.2**. The extent to which the local residents will benefit from the additional economic output from maintenance dredging (depends on the level of ownership of the assets at the Port (in particular the terminals) as well as any wealth transfers undertaken by Australian governments as a result of the taxation revenues generated by the Port of Hay Point. Given (by assumption) that a high proportion of the employees of the Port live in MIW Region, a significant amount of the additional personal incomes that are generated by the Port of Hay Point are estimated to stay in the MIW Region with the operation of the port at nameplate capacity. However, as (by assumption) only a small proportion of the port assets is owned by local residents, a significant portion of the capital income generated by the Port's economic activity is transferred outside of MIW Region. The Queensland Government will receive fewer royalties from the export of coal when the port is not fully operational, and the Australian Government will also receive less income tax and GST. Income losses to governments are assumed to be affected in each region of Australia in proportion to its population.

FIGURE 4.2 PROJECTED CHANGE IN REAL INCOME AS A RESULT OF NO REGULAR MAINTENACE DREDGING AT THE PORT OF HAY POINT, RELATIVE TO A REFERENCE CASE



Note: Real economic output for Mackay Isaac Whitsunday region is equivalent to real GRP while real economic output at the Queensland level is equal to real GSP. All dollars are in 2016-17 terms.

SOURCE: ACIL ALLEN CONSULTING MODELLING

Table 4.3 shows the total income impacts of no maintenance dredging at the Port of Hay Point for next 16 years.

More specifically, over the period 2017-18 to 2032-33, potential lower terminal capacities at Port of Hay Point would project to decrease the real income of MIW Region residents by:

- a cumulative total of $2,779 million loss relative to a reference case (with a present value of $2,087 million, using a 2.5 per cent real discount rate)
- To place these projected changes in income in perspective, the discounted present values (using a 2.5 per cent real discount rate) are equivalent to a one-off decrease in the *average* real income of all current residents of MIW Region of approximately $654 per person. This is a noticeable decrease in well-being of MIW Region residents.[18] The peak percentage loss of real income is about equal to the expected peak percentage loss of real income in Adelaide from the closure of the automotive manufacturing industry.[19]

TABLE 4.3 PROJECTED CHANGE IN REAL INCOME OF NO REGULAR MAINTENANCE DREDGING AT THE PORT OF HAY POINT, RELATIVE TO A REFERENCE CASE

Regions	Annual average	Cumulative change (2017-18 to 2032-33) Total	 PV (@ 2.5%)
	2016-17 A$m	*2016-17 A$m*	*2016-17 A$m*
MIW Region (GRP)	(174)	(2,779)	(2,087)
Queensland (GSP)	(157)	(2,506)	(1,884)
Australia (GDP)	(148)	(2,368)	(1,782)

SOURCE: ACIL ALLEN CONSULTING MODELLING

A decomposition of key elements in real income are provided in **Table 4.4**. These components can be divided in to three main categories – GDP (which is further divided in to real consumption, investment and net trade); price effects and foreign net income transfers. All expenditure side GDP components are affected due to the loss of export revenue. Real consumption losses are due to the loss of wage income and other sources of income to the residents of MIW region. Negative net international trade contributions directly related to the export revenue losses associated with port capacity losses.

TABLE 4.4 REAL GNI DECOMPOSITION

Real income components	MIW Region	Rest of Queensland	Rest of Australia	Total Australia
Real consumption	-616	210	164	-242
Investment	-12	-8	-31	-51
Net foreign trade	-2,096	613	210	-1,274
Real exports	-4,023	791	516	-2,716
Real imports	1,927	-178	-303	1,446
Real economic output	**-2,724**	**814**	**343**	**-1,567**
Price deflator effect	-349	36	46	-268
Terms of trade	-797	25	499	-273
Net income transfers	1,090	-601	-749	-260
Real income	**-2,779**	**273**	**139**	**-2,368**

SOURCE: ACIL ALLEN CONSULTING MODELLING

4.4 Labour market

A key issue when estimating the impact of a policy or project is determining how the labour market will respond.[20] Typically there are two extreme choices:

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[18] Median household weekly income in the MIW region is $1436, according to the 2016 census (http://www.qgso.qld.gov.au/products/tables/median-household-income-sa4/index.php).

[19] http://www.acilallen.com.au/cms_files/ACILAllen_FCAI_September2013.pdf, page 45.

[20] As with other CGE models, the standard assumption within Tasman Global model is that all markets clear (i.e. demand equals supply) at the start and end of each time period, including the labour market. CGE models place explicit limits on the availability of factors and the nature of the constraints can greatly change the magnitude and nature of the

- a fully constrained labour market where there will be no change in employment relative to a reference case and real wages adjust
- a fully unconstrained labour market where the supply of labour (at the reference case wage rates) is fully responsive to changes in demand

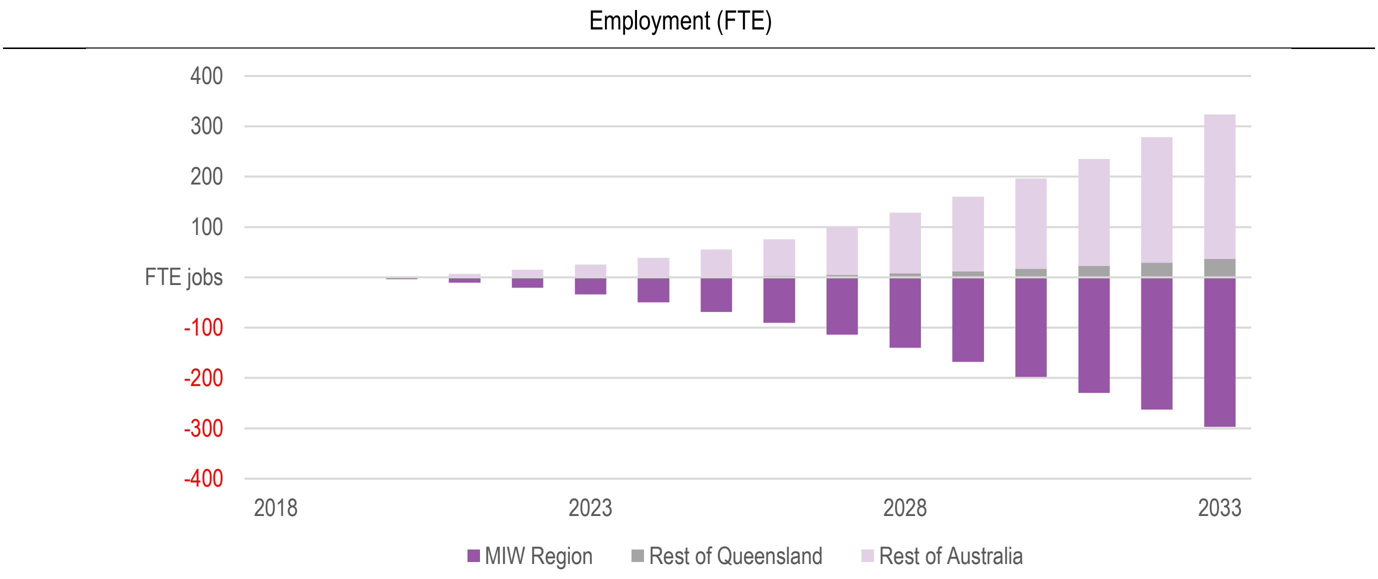
For the purposes of this analysis, a hybrid approach has been chosen whereby real wages are assumed to be unchanged initially, but where the unemployment rate in the long-term is unchanged relative to the reference case. Under this approach, the unemployment rate changes relative to the reference case in the first few years in response to changes in the demand for labour. Over time, lower real wages gradually help employment move back to reference case levels. The impacts of no maintenance dredging at Port of Hay Point on employment is shown in **Figure 4.3**. As shown in this figure, lower coal exports as a result of no regular maintenance dredging at the Port of Hay Point would result in lower employment in the MIW Region. The potential decrease in coal exports would decrease domestic demand of goods and services through reduced efficiency in the coal supply chain, transport and port sectors. Other transport services is a major employer and hence reduced port capacity and demand for Other transport services would have second round effects through the economy in terms of employment and consumption.

Decreases in the demand for labour in MIW Region when the port is not fully operational can have an impact on the labour market though three mechanisms:

- Decreasing migration from the rest of Queensland and rest of Australia
- Decreasing participation rates and/or average hours worked
- By increasing the unemployment rate

In the model framework, the first two mechanisms are driven by changes in the real wages paid to workers in MIW Region while the third is a function of the additional labour demand relative to the Reference Case. Given the moderate unemployment rate assumed throughout the projection period, changes in the real wage rate account for the majority of the reduced labour supply.

FIGURE 4.3 LABOUR MARKET IMPACTS FROM THE REFERENCE CASE



SOURCE: ACIL ALLEN CONSULTING MODELLING

Over the assessed life of 16 years when the port loses four metres of declared water depth from current existing levels, it is projected that MIW Region will lose 1,685 additional employee years of full time equivalent. More specifically, it is projected that the change in water depth levels at Port of Hay Point will decrease the employment level in the MIW Region by (on average) approximately 105 FTE.

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results. In contrast, most other tools used to assess economic impacts, including I-O multiplier analysis, do not place constraints on the availability of factors. Consequently, these tools tend to overestimate the impacts of a project or policy.

The total employment losses are projected to be greatest during the period where high siltation is expected to occur, which will be in the later years. There will be an offsetting amount of employment gain in the rest of Queensland and in the rest of Australia (mostly outside Queensland), as the economy adjusts to the impact of reduced exports from the MIW region e.g. the exchange rate will depreciate improving the competitiveness of industries in other States that compete with imports, and real wages will fall because of the weakened economy, resulting in increased employment in the other States.

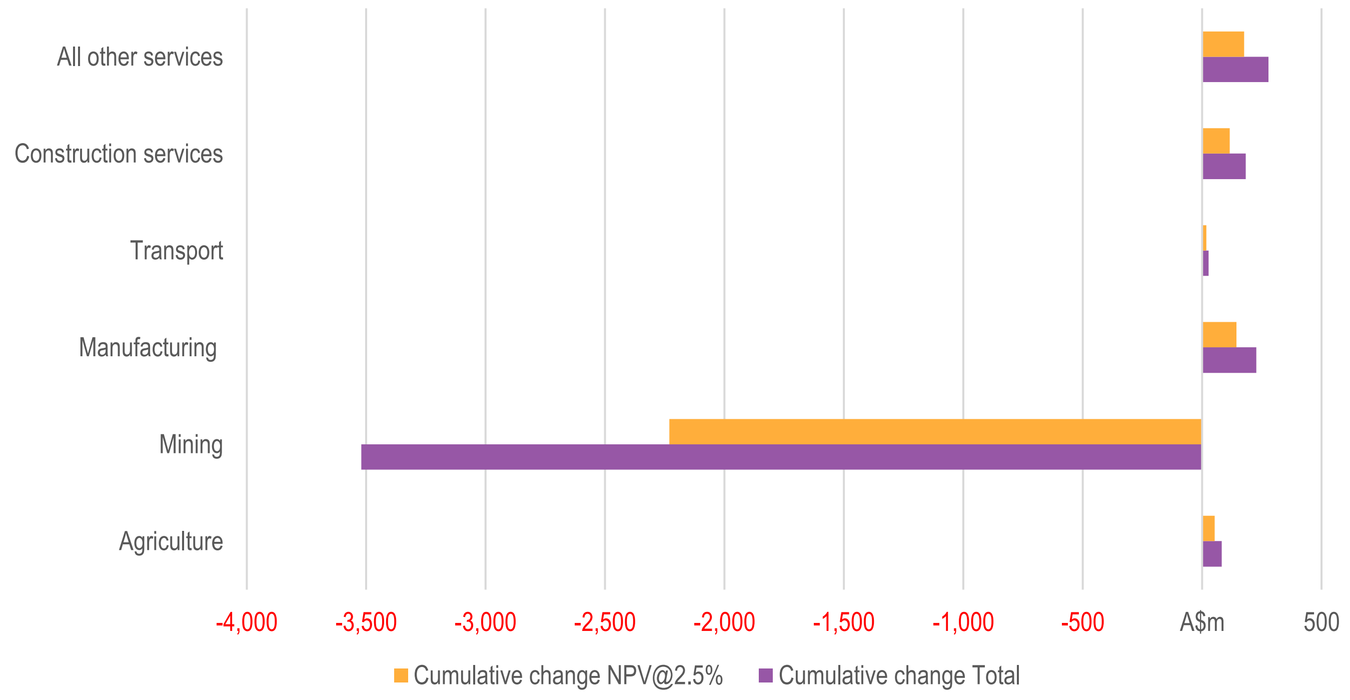
4.5 Industry impacts

Figure 4.4 presents the projected change in real output by industry following water depth losses at Port of Hay Point. Real output is a measure of an industry's sales, which can include sales to final users in the economy or sales to other industries (intermediate inputs). Real output by industry is different to the change in real economic output for the economy as a whole (i.e. GDP). Real output is measured as the change in production of an industry excluding any price changes. It is not valid to sum the changes in output in all industries to achieve the economy-wide change in output, as this would double count any sales by one business in the economy that are an input into other businesses.

As expected the mining industry in MIW region would experience a decline in output as a result of the reductions in coal export volumes. Not surprisingly, the biggest losses are concentrated in the mining sector.

The overall decrease in production in coal industry is mainly due to direct reductions export volumes, which lead to a reduction in profits. Some other industries will experience a small increase in their output, though not nearly enough to offset the decline in the mining industry. This will be due to the economy's adjustment mechanisms in response to the 'shock' from reduced coal exports e.g. the depreciation of the exchange rate, and the fall in real wages that will accompany a weakened labour market.

FIGURE 4.4 PROJECTED CHANGE IN INDUSTRY OUTPUT IN MIW REGION RELATIVE TO THE REFERENCE CASE, TOTAL CUMULATIVE 2017-18 AND 2032-33.

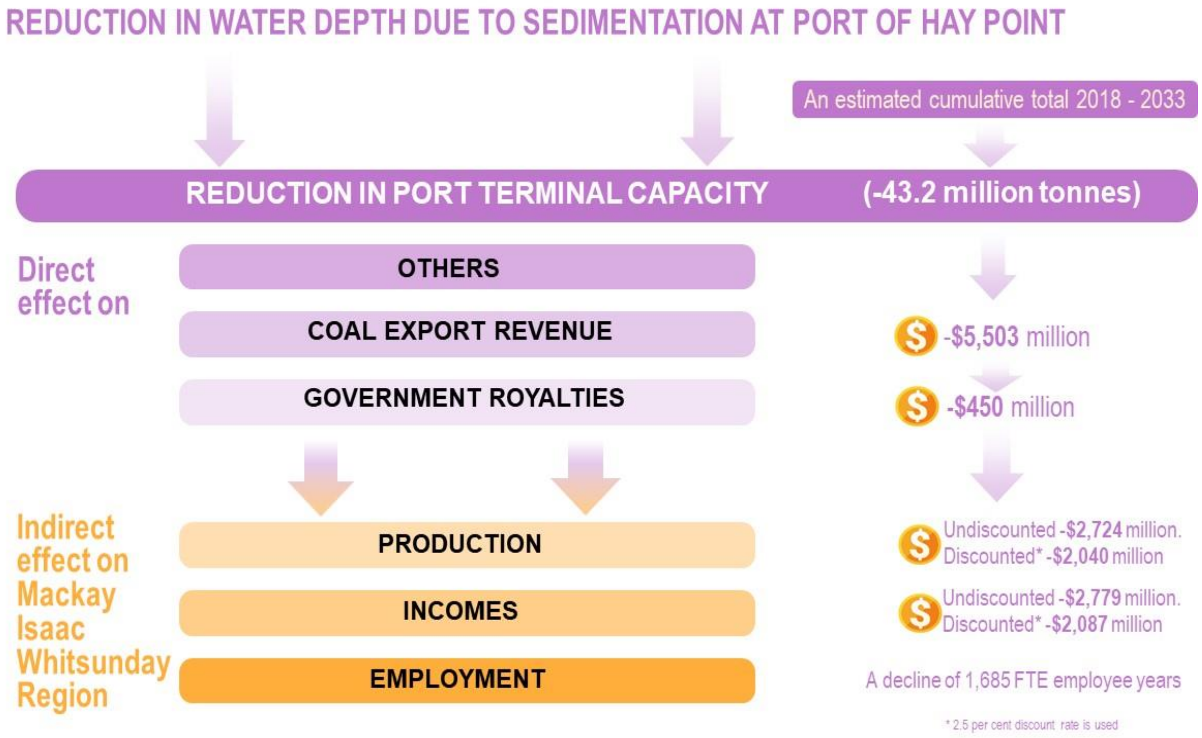


SOURCE: ACIL ALLEN CONSULTING MODELLING

4.6 Summary

A summary of potential economic impacts of no regular maintenance dredging at Port of Hay Point are provided in **Figure 4.5**.

FIGURE 4.5 POTENTIAL ECONOMIC IMPACTS OF NO REGULAR MAINTENANCE DREDGING AT PORT OF HAY POINT, 2018 TO 2033



SOURCE: ACIL ALLEN CONSULTING MODELLING

QUEENSLAND GOVERNMENT ROYALTIES

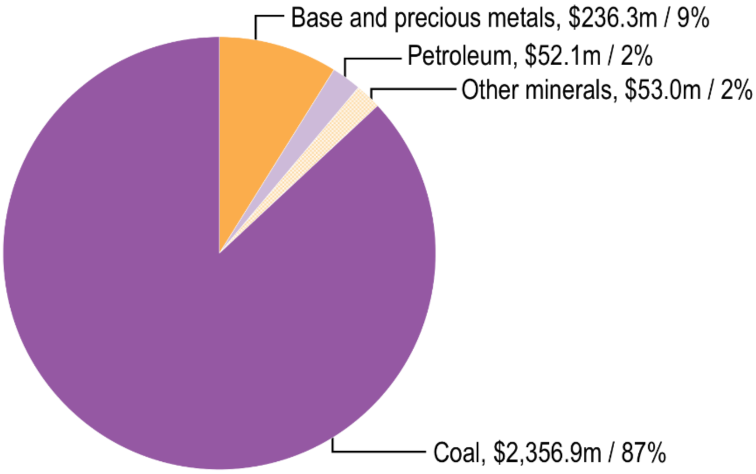
5

Loss of terminal capacity at Port of Hay Point will have two types of effects on the coal royalties received by the Queensland government. For a given price, the loss of coal volumes will decrease the government royalties. Since the demurrage fees are a deductible item, this will further reduce the royalties received by the Queensland Government.

5.1 Queensland royalty revenue

Queensland royalty revenue in 2015-16 are provided in **Figure 5.1**. Coal royalty revenue constitutes over 87 per cent of total royalty revenue in 2015-16 and it is the single largest royalty revenue source for the Queensland government.

FIGURE 5.1 QUEENSLAND ROYALTY REVENUE, 2015-16



SOURCE: HTTPS://PUBLICATIONS.QLD.GOV.AU/DATASET/ROYALTY-STATISTICS/RESOURCE/BB666798-73E0-4B6C-B935-6589DF17ECAE

5.2 Impact on coal royalty revenue

The coal royalty rate is calculated based on the weighted average price of metallurgical and thermal coal sold, disposed of or used in each year of the simulation in this economic assessment. Based on price and quantity assumptions reported in Chapter 3, it is estimated that average royalty rate for coal is A$10.4 per tonne.

The potential impact on royalty revenue of loss of port capacity as result of no maintenance dredging is provided in **Figure 5.2** and **Table 5.1**.

More specifically, over the period 2017-18 to 2032-33, not regularly dredged and maintained Port of Hay Point would project to decrease the coal royalty revenue by a cumulative total of A$450 million relative to the reference case (with a present value of A$337.9 million, using a 2.5 per cent real discount rate).

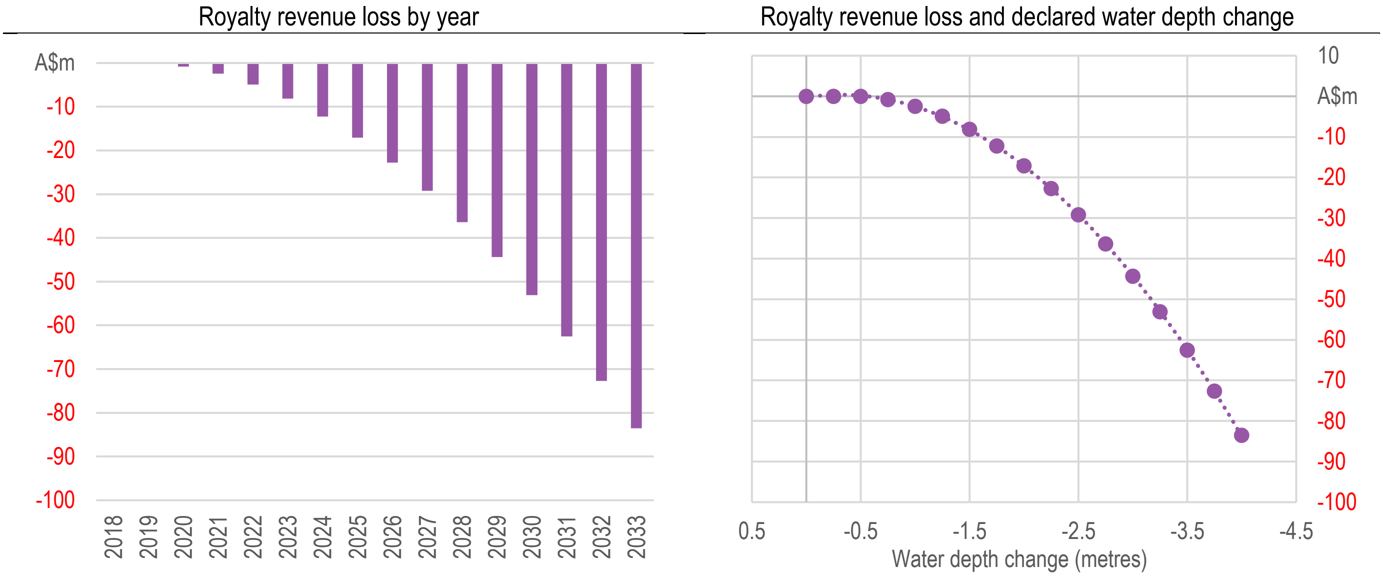
Though the DBCT has already lost 2 metres at its terminal berths, the analysis considers the average incremental loss at the Port of Hay Point (which includes HPCT) starting from 2018.

TABLE 5.1 COAL ROYALTY REVENUE LOSSES RELATIVE TO THE REFERENCE CASE

	Annual average	Cumulative change (2017-18 to 2032-33)	
		Total	PV (@ 2.5%)
	2016-17 A$m	*2016-17 A$m*	*2016-17 A$m*
A declared water depth loss scenario	-28.1	-450.3	-337.9

SOURCE: ACIL ALLEN CONSULTING

FIGURE 5.2 COAL ROYALTY REVENUE LOSS RELATIVE TO THE REFERENCE CASE, 2017-18 TO 2032-33



SOURCE: ACIL ALLEN CONSULTING MODELLING

ECONOMIC IMPACT ASSESSMENT METHODOLOGY

A

A.1 Coal industry and input-output relationships

An existing coal industry in MIW Region in Queensland calibrated into the CGE model based on the data collected for this project. Input-output tables (IO) are useful for not only estimating the direct economic contribution of the coal industry makes to the economy but also for estimating the indirect contribution. The indirect economic contribution recognises that in addition to the direct value added by a coal industry, there is also a significant amount of activity indirectly generated by its use of intermediate inputs as well as by the increased consumption demand generated by locals spending their incomes. The path to deriving credible IO tables accounting for all intra-industry linkages is not a simple. The IO tables are generally used to generate IO multipliers and used in the analysis of the economic footprint of the industry as well as form the basis for the database for the CGE modelling of the economic impacts.

A.2 Preventing double counting

A common misuse of multipliers is when they are used to individually estimate the indirect contribution of different parts of a production chain and then are simply added together to estimate the total contribution. To paraphrase Treasury criticisms 'if we added up the indirect contribution of every industry boasting how important they were because of such-and-such a multiplier they would be bigger than the entire economy'. A simple way to think of the issue is that each multiplier is an estimate of a particular industry's backward linkages throughout the economy.

A.3 CGE modelling of EIA of port operation and the effects of sedimentation

As discussed in **Box A.1**, while using IO multiplier analysis method is a rigorous method for understanding the economic footprint of an industry, it is generally not preferred for estimating the potential economic impacts of a significant change in export revenue losses associated with the loss of declared water levels due to sedimentation.

BOX A.1 ECONOMIC CONTRIBUTION VERSUS ECONOMIC IMPACT ANALYSIS

An economic **contribution** (or **footprint**) analysis differs from an analysis of **economic impact assessment** in that it does not purport to consider how the economy would respond to the closure, contraction or expansion of that industry. More specifically, a footprint analysis considers how much of the economy or how many people are *currently* affected by the activities of the new industry. In contrast, an economic impact analysis would consider how the overall economy would look before and after there has been a 'shock' as a new industry and consumers and other parts of the economy have adjusted. An impact analysis recognises that there are competing uses for scarce factors of production and therefore considers how, say, the IT services would change in response to, say, increased storage facilities available in Tasmania. While input-output multiplier analysis can (and are) used for economic impact analysis it is not the preferred methodology for assessing the impacts of major industry adjustments (particularly when applied at the state and national levels) and is generally poorly regarded by state and national government agencies as a credible tool for understanding the longer term impacts of policy decisions or major projects. The preferred approach for the analysis of economic impacts is Computable General Equilibrium (CGE) modelling. A key feature of CGE models is their ability to incorporate market constraints, particularly regarding the key factors of labour and capital. Therefore, we prefer to use CGE modelling to undertake the impact of no maintenance dredging at Port of Hay Point.

SOURCE: ACIL ALLEN CONSULTING

A.4 Overview of Tasman Global CGE model

Tasman Global is a dynamic, global computable general equilibrium (CGE) model that has been developed by ACIL Allen for the purpose of undertaking economic impact analysis at the regional, state, national and global level.

A CGE model captures the interlinkages between the markets of all commodities and factors, taking into account resource constraints, to find a simultaneous equilibrium in all markets. A global CGE model extends this interdependence of the markets across world regions and finds simultaneous equilibrium globally. A dynamic model adds onto this the interconnection of equilibrium economies across time periods. For example, investments made today are going to determine the capital stocks of tomorrow and hence future equilibrium outcomes depend on today's equilibrium outcome, and so on.

Thus a dynamic global CGE model, such as *Tasman Global*, has the capability of addressing the total, sectoral, spatial and temporal efficiency of resource allocation as it connects markets globally and over time. Being a recursively dynamic model, however, its ability to address temporal issues is limited. In particular, *Tasman Global* cannot typically address issues requiring partial or perfect foresight, however, as documented in Jakeman et al (2001), it is possible to introduce partial or perfect foresight in certain markets using algorithmic approaches. Notwithstanding this, the model does have the capability to project the economic impacts over time of given changes in policies, tastes and technologies in any region of the world economy on all sectors and agents of all regions of the world economy.

Tasman Global was developed out of the 2001 version of the Global Trade and Environment Model (GTEM) developed by ABARE (Pant 2001) and has been evolving ever since. In turn, GTEM was developed out of the MEGABARE model (ABARE 1996), which contained significant advancements over the GTAP model of that time (Hertel 1997).

A.4.1 A dynamic model

Tasman Global is a model that estimates relationships between variables at different points in time. This is in contrast to comparative static models, which compare two equilibriums (one before a policy change and one following). A dynamic model such as *Tasman Global* is beneficial when analysing issues where both the timing of and the adjustment path that economies follow are relevant in the analysis.

A.4.2 The database

A key advantage of *Tasman Global* is the level of detail in the database underpinning the model. The database used for this analysis is derived from the Global Trade Analysis Project (GTAP) database (version 8.1). This database is a fully documented, publicly available global data base which contains complete bilateral trade information, transport and protection linkages among regions for all GTAP commodities. It is the detailed database of its type in the world.

Tasman Global builds on the GTAP database by adding the following important features:

- a detailed population and labour market database
- detailed technology representation within key industries (such as electricity generation and iron and steel production)
- disaggregation of a range of major commodities including iron ore, bauxite, alumina, primary aluminium, brown coal, black coal and LNG
- the ability to repatriate labour and capital income
- explicit representation of the states and territories of Australia
- the capacity to explicitly represent multiple regions within states and territories of Australia.

Nominally, version 8.1 of the *Tasman Global* database divides the world economy into 141 regions (133 international regions plus the 8 states and territories of Australia) although in reality the regions are frequently disaggregated further. ACIL Allen regularly models Australian projects or policies at the regional level.

Table A.1 shows the industries that are contained in the model. The foundation of this information is the input-output tables that underpin the database. The input-output tables account for the distribution of industry production to satisfy industry and final demands. Industry demands, so-called intermediate usage, are the demands from each industry for inputs.

For example, electricity is an input into the production of communications. In other words, the communications industry uses electricity as an intermediate input. Final demands are those made by households, governments, investors and foreigners (export demand). These final demands, as the name suggests, represent the demand for finished goods and services. To continue the example, electricity is used by households – their consumption of electricity is a final demand.

Each sector in the economy is typically assumed to produce one commodity, although, in *Tasman Global*, the electricity, transport and iron and steel sectors are modelled using a 'technology bundle' approach. With this approach, different known production methods are used to generate a homogeneous output for the 'technology bundle' industry. For example, electricity can be generated using brown coal, black coal, petroleum, base load gas, peak load gas, nuclear, hydro, geothermal, biomass, wind, solar or other renewable based technologies – each of which has their own cost structure.

A.4.3 Model structure

Given its heritage, the structure of the *Tasman Global* model closely follows that of the GTAP and GTEM models and interested readers are encouraged to refer to the documentation of these models for more detail (namely Hertel 1997 and Pant 2001, respectively). In summary:

- The model divides the world into a variety of regions and international waters.
  - Each region is fully represented with its own 'bottom-up' social accounting matrix and could be a local community, an LGA, state, country or a group of countries. The number of regions in a given simulation depends on the database aggregation. Each region consists of households, a government with a tax system, production sectors, investors, traders and finance brokers.
  - 'International waters' are a hypothetical region where global traders operate and use international shipping services to ship goods from one region to the other. It also houses an international finance 'clearing house' that pools global savings and allocates the fund to investors located in every region.
  - Each region has a 'regional household'21 that collects all factor payments, taxes, net foreign borrowings, net repatriation of factor incomes due to foreign ownership and any net income from trading of emission permits.
- The income of the regional household is allocated across private consumption, government consumption and savings according to a Cobb-Douglas utility function, which, in practice, means that the share of income going to each component is assumed to remain constant in nominal terms.
- Private consumption of each commodity is determined by maximising utility subject to a Constant Difference of Elasticities (CDE) function which includes both price and income elasticities.
- Government consumption of each commodity is determined by maximising utility subject to a Cobb-Douglas utility function.
- Each region has *n* production sectors, each producing single products using various production functions where they aim to maximise profits (or minimise costs) and take all prices as given. The nature of the production functions chosen in the model means that producers exhibit constant returns to scale.

The other key feature of the database is that the cost structure of each industry is also represented in detail. Each industry purchases intermediate inputs (from domestic and imported sources) primary factors (labour, capital, land and natural resources) as well as paying taxes or receiving subsidies.

  - In general, each producer supplies consumption goods by combining an aggregate energy-primary factor bundle with other intermediate inputs and according to a Leontief production function (which in practice means that the quantity shares remain in fixed proportions). Within the aggregate energy-primary factor bundle, the individual energy commodities and primary factors are combined using a nested-CES (Constant Elasticity of Substitution) production function, in which energy and primary factor aggregates substitute according to a CES function with the individual energy commodities and individual primary factors substituting with their respective aggregates according to further CES production functions.
  - Exceptions to the above include the electricity generation, iron and steel and road transport sectors. These sectors employ the 'technology bundle' approach developed by ABARE (1996) in which non-homogenous technologies are employed to produce a homogenous output with the choice of technology governed by minimising costs according to a modified-CRESH production function. For example, electricity may be generated from a variety of technologies (including brown coal, black coal, gas, nuclear, hydro, solar etc.), iron and steel may be produced from a blast furnace or electric arc technologies while road transport services may be supplied using a range of different vehicle technologies. The 'modified-CRESH' function differs from the traditional CRESH function by also imposing the condition that the quantity units are homogenous.

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[21] The term "regional household" was devised for the GTAP model. In essence it is an agent that aggregates all incomes attributable to the residents of a given region before distributing the funds to the various types of regional consumption (including savings).

TABLE A.1 SECTORS IN THE *TASMAN GLOBAL* DATABASE

Sector		Sector	
1	Paddy rice	**37**	Wood products
2	Wheat	**38**	Paper products, publishing
3	Cereal grains nec	**39**	Diesel (incl. nonconventional diesel)
4	Vegetables, fruit, nuts	**40**	Other petroleum, coal products
5	Oil seeds	**41**	Chemical, rubber, plastic products
6	Sugar cane, sugar beef	**42**	Iron ore
7	Plant- based fibres	**43**	Bauxite
8	Crops nec	**44**	Mineral products nec
9	Bovine cattle, sheep, goats, horses	**45**	Ferrous metals
10	Pigs	**46**	Alumina
11	Animal products nec	**47**	Primary aluminium
12	Raw milk	**48**	Metals nec
13	Wool, silk worm cocoons	**49**	Metal products
14	Forestry	**50**	Motor vehicle and parts
15	Fishing	**51**	Transport equipment nec
16	Brown coal	**52**	Electronic equipment
17	Black coal	**53**	Machinery and equipment nec
18	Oil	**54**	Manufactures nec
19	Liquefied natural gas (LNG)	**55**	Electricity generation
20	Other natural gas	**56**	Electricity transmission and distribution
21	Minerals nec	**57**	Gas manufacture, distribution
22	Bovine meat products	**58**	Water
23	Pig meat products	**59**	Construction
24	Meat products nec	**60**	Trade
25	Vegetables oils and fats	**61**	Road transport
26	Dairy products	**62**	Rail and pipeline transport
27	Processed rice	**63**	Water transport
28	Sugar	**64**	Air transport
29	Food products nec	**65**	Transport nec
30	Wine	**66**	Communication
31	Beer	**67**	Financial services nec
32	Spirits and RTDs	**68**	Insurance
33	Other beverages and tobacco products	**69**	Business services nec
34	Textiles	**70**	Recreational and other services
35	Wearing apparel	**71**	Public Administration, Defence, Education, Health
36	Leather products	**72**	Dwellings

NOTE: NEC = NOT ELSEWHERE CLASSIFIED

— There are four primary factors (land, labour, mobile capital and fixed capital). While labour and mobile capital are used by all production sectors, the land is only used by agricultural sectors while the fixed capital is typically employed in industries with natural resources (such as fishing, forestry and mining) or in selected industries built by ACIL Allen.

- Land supply in each region is typically assumed to remain fixed through time with the allocation of land between sectors occurring to maximise returns subject to a Constant Elasticity of Transformation (CET) utility function.

  - Mobile capital accumulates as a result of the net investment. It is implicitly assumed in *Tasman Global* that it takes one year for capital to be installed. Hence, the supply of capital in the current period depends on the last year's capital stock and investments made during the previous year.
  - Labour supply in each year is determined by endogenous changes in population, given participation rates and a given unemployment rate. In policy scenarios, the supply of labour is positively influenced by movements in the real wage rate governed by the elasticity of supply. For countries where sub-regions have been specified (such as Australia), migration between regions is induced by changes in relative real wages with the constraint that net interregional migration equals zero. For regions where the labour market has been disaggregated to include occupations, there is limited substitution allowed between occupations by individuals supplying labour (according to a CET utility function) and by firms demanding labour (according to a CES production function) based on movements in relative real wages.
  - The supply of fixed capital is given for each sector in each region.

  The model has the option for these assumptions to be changed at the time of model application if alternative factor supply behaviours are considered more relevant.

- It is assumed that labour (by occupation) and mobile capital are fully mobile across production sectors implying that, in equilibrium, wage rates (by occupation) and rental rates on capital are equalised across all sectors within each region. To a lesser extent, labour and capital are mobile between regions through international financial investment and migration, but this sort of mobility is sluggish and does not equalise rates of return across regions.
- For most international regions, each consumer (private, government, industries and the local investment sector), consumption goods can be sourced either from domestic or imported sources. In any country which has disaggregated regions (such as Australian), consumption goods can also be sourced from other intrastate or interstate regions. In all cases, the source of non-domestically produced consumption goods is determined by minimising costs subject to a Constant Ratios of Elasticities of Substitution, Homothetic (CRESH) utility function. Like most other CGE models, a CES demand function is used to model the relative demand for domestically-produced commodities versus non-domestically produced commodities. The elasticities chose for the CES and CRESH demand functions mean that consumers in each region have a higher preference for domestically produced commodities than non-domestic and a higher preference for intrastate or interstate produced commodities versus foreign.
- The capital account in *Tasman Global* is open. Domestic savers in each region purchase 'bonds' in the global financial market through local 'brokers' while investors in each region sell bonds to the global financial market to raise investible funds. A flexible global interest rate clears the global financial market.
- It is assumed that regions may differ in their risk characteristics and policy configurations. As a result, rates of return on money invested in physical capital may differ between regions and therefore may be different from the global cost of funds. Any difference between the local rates of return on capital and the global cost of borrowing is treated as the result of the existence of a risk premium and policy imperfections in the international capital market. It is maintained that the equilibrium allocation of investment requires the equalisation of changes in (as opposed to the absolute levels of) rates of return over the base year rates of return.
- Any excess of investment over domestic savings in a given region causes an increase in the net debt of that region. It is assumed that debtors service the debt at the interest rate that clears the global financial market. Similarly, regions that are net savers give rise to interest receipts from the global financial market at the same interest rate.
- Investment in each region is used by the regional investor to purchase a suite of intermediate goods according to a Leontief production function to construct capital stock with the regional investor cost minimising by choosing between domestic, interstate and imported sources of each intermediate good via the CRESH production function. The regional cost of creating new capital stock versus the local rates of return on mobile capital is what determines the regional rate of return on new investment.
- In equilibrium, exports of a good from one region to the rest of world are equal to the import demand for that good in the remaining regions. Together with the merchandise trade balance, the net payments on foreign debt add up to the current account balance. *Tasman Global* does not require that the current account is in balance every year. It allows the capital account to move in a compensatory direction to maintain the balance of payments. The exchange rate provides the flexibility to keep the balance of payments in balance.
- Emissions of six anthropogenic greenhouse gases (namely, carbon dioxide, methane, nitrous oxide, HFCs, PFCs and SF_6) associated with the economic activity are tracked in the model. Almost all sources and sectors are represented; emissions from agricultural residues and land-use change and forestry activities are not explicitly modelled but can be accounted for externally. Prices can be applied to emissions which are converted to industry-specific production taxes or commodity-specific sales taxes that impact on demand. Abatement technologies similar to those adopted in Australian Government (2008) are available and emission quotas can be set globally or by region along with allocation schemes that enable emissions to be traded between regions.

More detail regarding specific elements of the model structure is discussed in the following sections.

A.4.4 Population growth and labour supply

Population growth is an important determinant of economic growth through the supply of labour and the demand for final goods and services. Population growth for each region represented in the *Tasman Global* database is projected using ACIL Allen's in-house demographic model. The demographic model projects how the population in each region grows and how age and gender composition changes over time and is an important tool for determining the changes in regional labour supply and total population over the projection period.

For each of region, the model projects the changes in age-specific birth, mortality and net migration rates by gender for 101 age cohorts (0-99 and 100+). The demographic model also projects changes in participation rates by gender by age for each region, and, when combined with the age and gender composition of the population, endogenously projects the future supply of labour in each region. Changes in life expectancy are a function of income per person as well as assumed technical progress on lowering mortality rates for a given income (for example, reducing malaria-related mortality through better medicines, education, governance etc.). Participation rates are a function of life expectancy as well as expected changes in higher education rates, fertility rates and changes in the work force as a share of the total population.

Labour supply is derived from the combination of the projected regional population by age by gender and the projected regional participation rates by age by gender. Over the projection period, labour supply in most developed economies is projected to grow slower than total population as a result of ageing population effects.

For the Australian states and territories, the projected aggregate labour supply from ACIL Allen's demographics module is used as the base level potential workforce for the detailed Australian labour market module, which is described in the next section.

A.4.5 The Australian labour market

Tasman Global has a detailed representation of the Australian labour market which has been designed to capture:

- different occupations
- changes to participation rates (or average hours worked) due to changes in real wages
- changes to unemployment rates due to changes in labour demand
- limited substitution between occupations by the firms demanding labour and by the individuals supplying labour, and
- limited labour mobility between states and regions within each state.

Tasman Global recognises 97 different occupations within Australia – although the exact number of occupations depends on the aggregation. The firms who hire labour are provided with some limited scope to change between these 97 labour types as the relative real wage between them changes. Similarly, the individuals supplying labour have a limited ability to change occupations in response to the changing relative real wage between occupations. Finally, as the real wage for a given occupation rises in one state relative to other states, workers are given some ability to respond by shifting their location.

The labour market structure of *Tasman Global* is thus designed to capture the reality of labour markets in Australia, where supply and demand at the occupational level do adjust, but within limits.

Labour supply in *Tasman Global* is presented as a three stage process:

1. labour makes itself available to the workforce based on movements in the real wage and the unemployment rate;
2. labour chooses between occupations in a state based on relative real wages within the state; and
3. labour of a given occupation chooses in which state to locate based on movements in the relative real wage for that occupation between states.

By default, *Tasman Global*, like all CGE models, assumes that markets clear. Therefore, overall, supply and demand for different occupations will equate (as is the case in other markets in the model).

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