PORT OF **WEIPA**

APPENDIX J

Economic impact of no maintenance dredging at the Port of Weipa

ACIL ALLEN CONSULTING

REPORT TO
NORTH QUEENSLAND BULK PORTS CORPORATION
9 OCTOBER 2019

ECONOMIC IMPACT OF NO MAINTENANCE DREDGING AT THE PORT OF WEIPA

FINAL REPORT
E18/31038

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C O N T E N T S

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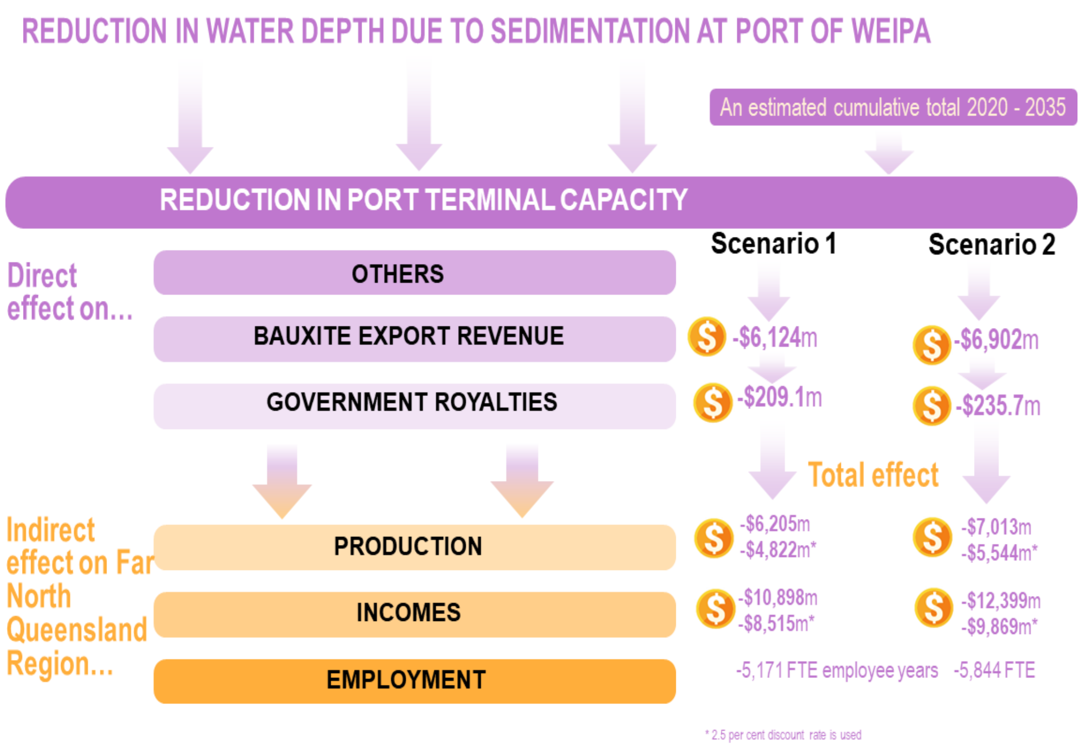
EXECUTIVE SUMMARY

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 – 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 Channels and Berth Pockets, if maintenance dredging of the Port is not carried out.

NQBP has commissioned ACIL Allen Consulting (ACIL Allen) to provide an independent report on the potential economic impacts which result from the accumulation of marine sediments in the existing port navigational infrastructure at the Port of Weipa 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 NQBP. 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 Far North Queensland Region of Queensland, rest of Queensland, rest of Australia and rest of the World.

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

FIGURE ES 1 POTENTIAL ECONOMIC IMPACTS OF NO REGULAR MAINTENANCE DREDGING AT PORT OF WEIPA, 2019-20 TO 2034-35



SOURCE: ACIL ALLEN CONSULTING MODELLING

Key modelling inputs

The model assumes a vessel can access the deepest berth pockets at Lorim Point (-12.3m LAT) 100 per cent of the time based on the assumption that scheduling is fully optimised, in order to mitigate the impact of depth loss on capacity throughput. At the Port of Weipa, it is mainly the declared depth of the South Channel which restricts vessel movements. Typical maintenance dredging volume estimate, declared depth, design depth and footprint for the dredged areas at the Port of Weipa are provided in **Table ES 1**. Dredging the South Channel is important to access various Wharves at the Port of Weipa.

TABLE ES 1 TYPICAL MAINTENANCE DREDGING AT THE PORT OF WEIPA

Port Area	Volume Estimate	Declared Depth	Design Depth [a]	Footprint
	m^3	(m below LAT)	(m below LAT)	(ha)
South Channel	465,000	11.7*	12.1 to 14.1	256
Approach Channel	24,000	7.3	7.3	272.5
Departure Channel	12,000	11.1	11.1 to 11.8	138.3
Evans Landing	500	9.4	9.4	0.50
Humbug	500	9.5	9.5	0.86
Lorim Point	500	12.3	12.3	2.45
Tug Berth	500	9.0	9.0	2.12

[a] In some areas the design depth is variable due to natural variability in the sedimentation which occurs. The design depths are shown in Figure 3.3. Although the design depth at the Lorim Point Tug Berths is -9 m LAT it has not been dredged to that depth (currently around -5 m LAT) and due to the existing depths the TSHD Brisbane is not able to dredge the area and so bed levelling has been used to maintain the depths to -5 m LAT.

SOURCE: NQBP 2018, PORT OF WEIPA: SUSTAINABLE SEDIMENT MANAGEMENT ASSESSMENT, BATHYMETRIC ANALYSIS, REPORT NO. P007_R01F1. PREPARED BY PORTS & COASTAL SOLUTIONS PTY LTD, JULY 2018

NQBP scenarios

The NQBP has provided two probable predictive sedimentation model scenarios with various year types — normal, cyclonic and worst year. The worst year defined as where 2.4M m^3 of sedimentation would occur, which happened in the 2018-19 season. In both scenarios, the declared depth of South Channel is reduced by 5.2m to -6.5m by year 9 of the 16-year period assessment. Minus 6.5m is typically the depth of adjacent seabed to mid South Channel at which point no further reduction in declared depth would occur. The current declared depth is -11.7m at the South Channel. Details of NQBP two scenarios are provided in **Table ES 2**.

TABLE ES 2 KEY FEATURES OF TWO SCENARIOS MODELLED

	Scenario 1			Scenario 2		
Year	Year type	Sediment accumulation (m3)	Declared depth (m)	Year type	Sediment accumulation (m3)	Declared depth (m)
0			(11.70)			(11.70)
1	normal	409,393	(12.13)	normal	409,393	(12.13)
2	cyclone	1,267,211	(11.84)	cyclone	1,267,211	(11.84)
3	normal	1,676,604	(11.56)	Worst (2.5Mm3)	3,638,018	(10.05)
4	cyclone	2,534,422	(10.87)	normal	4,046,664	(9.76)
5	normal	2,943,815	(10.39)	cyclone	4,839,652	(8.80)
6	cyclone	3,801,633	(9.37)	normal	5,218,548	(8.32)
7	normal	4,211,026	(8.89)	cyclone	5,870,971	(7.31)
8	Worst (2.5Mm3)	6,141,071	(6.82)	normal	6,141,071	(6.82)
9	normal	6,343,070	(6.50)	Worst (2.5Mm3)	6,664,993	(6.50)
10	cyclone	6,438,163	(6.50)	normal	6,725,765	(6.50)
11	normal	6,498,934	(6.50)	cyclone	6,820,858	(6.50)

Year	Scenario 1 Year type	Scenario 1 Sediment accumulation (m3)	Scenario 1 Declared depth (m)	Scenario 2 Year type	Scenario 2 Sediment accumulation (m3)	Scenario 2 Declared depth (m)
12	cyclone	6,594,027	(6.50)	normal	6,881,629	(6.50)
13	normal	6,654,799	(6.50)	cyclone	6,976,722	(6.50)
14	cyclone	6,749,892	(6.50)	normal	7,037,494	(6.50)
15	normal	6,810,664	(6.50)	cyclone	7,132,587	(6.50)
16	cyclone	6,905,757	(6.50)	normal	7,193,359	(6.50)

SOURCE: NQBP

Scenarios modelled

— **Reference case scenario —** in this scenario, there will be a regular maintenance dredging at the Port of Weipa for next 16 years.

Two scenarios modelled in this study are based on predictive sedimentation model developed by NQBP. They are:

— **A change in current water depth scenario (loss scenario 1) —** port capacity losses over 16 years that potentially would occur when there is a loss of declared water depth level of up to 5.2 metres after year 9 due to sedimentation at the South Channel which mainly restricts vessel movements into and out of the Port of Weipa. In this scenario, there will be at least one worst year in terms of sediment accumulation in next 16 years.

— **A change in current water depth scenario (loss scenario 2) —** This is similar to **Scenario 1**, however, there will be least two worst years in terms of sediment accumulation in next 16 years

Economic model inputs

To annualise the declared water depth losses over 16 years, consistent with the predictive sedimentation model, the declared depths at South Channel reported in **Table ES 2** are used in this study.

The analysis shows that a maximum reduced declared depth loss of 5.2m to -6.5m after 9 years of 16-year assessment would leads to a loss of 120.7 million tonnes of export volumes in Scenario 1 and a loss of 136.1 million tonnes in Scenario 2, over 16 years.

An average bauxite price of US$35 per tonne and exchange rate of A$0.69/US$ are assumed in this study to translate the export volume losses into revenue losses. The estimated cumulative revenue losses over 16 years will be around A$6,124 million in Scenario 1 and A$6,902 million in Scenario 2. The key economic modelling inputs are summarised in **Table ES 3**.

TABLE ES 3 KEY ECONOMIC MODELLING INPUTS

	Cumulative total reduction in declared water depth in year 9 in next 16-year assessment	Cumulative total reduction in bauxite export volumes in next 16 years	Cumulative total reduction in bauxite export revenue in next 16 years
	metres	Million tonnes	A$m
Scenario 1	-5.2	-120.7	-6,124
Scenario 2	-5.2	-136.1	-6,902

SOURCE: ACIL ALLEN CONSULTING BASED ON NQBP DATA

Key economic impacts

If maintenance dredging does not occur at the Weipa Port, there will be several economic impacts.

The capacity of the 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 bauxite supply chain industries. The indirect impacts will also flow through to the broader 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 total macroeconomic impacts of loss of declared water depth at Port of Weipa have been estimated over the period to 2034-35 using ACIL Allen's *Tasman Global* computable general equilibrium (CGE) model.

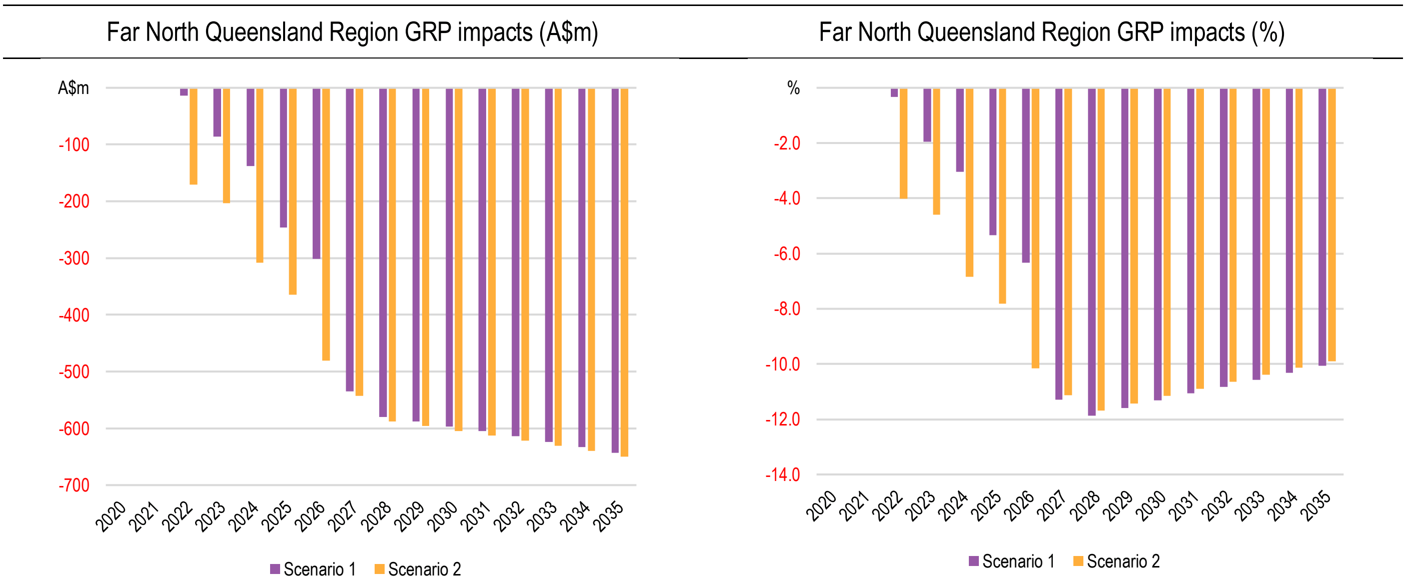
The estimated impacts point to significant output losses as shown in **Figure ES 2** and **Table ES 4**.

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 2019-20 to 2034-35 in **Scenario 1**, no maintenance dredging would project to decrease the real economic output of the Region (i.e. real GRP) by a cumulative total of $6,205 million over the period of 16 years (with a present value of $4,822 million, using a 2.5 per cent real discount rate), or around $388 million per year on average.

— Over the period 2019-20 to 2034-35 in **Scenario 2**, no maintenance dredging would project to decrease the real economic output of the Region (i.e. real GRP) by a cumulative total of $7,013 million over the period of 16 years (with a present value of $5,544 million, using a 2.5 per cent real discount rate), or around $438 million per year on average.

FIGURE ES 2 PROJECTED CHANGE IN REAL ECONOMIC OUTPUT AS A RESULT OF NO REGULAR MAINTENANCE DREDGING AT THE PORT OF WEIPA, RELATIVE TO A REFERENCE CASE



SOURCE: ACIL ALLEN CONSULTING MODELLING

TABLE ES 4 REAL OUTPUT IMPACTS RELATIVE TO A REFERENCE CASE, 2019-20 AND 2034-35

	Cumulative change (2018-19 to 2034-35)					
	Average annual		Total		PV (@ 2.5%)	
Regions	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2
	2017-18 A$m	*2017-18 A$m*	*2017-18 A$m*	*2017-18 A$m*	*2017-18 A$m*	*2017-18 A$m*
Far North Queensland Region (GRP)	($388)	($438)	($6,205)	($7,013)	($4,822)	($5,544)
Queensland (GSP)	($50)	($56)	($797)	($890)	($516)	($559)
Australia (GDP)	($100)	($114)	($1,592)	($1,825)	($1,126)	($1,284)

SOURCE: ACIL ALLEN CONSULTING MODELLING

Real income

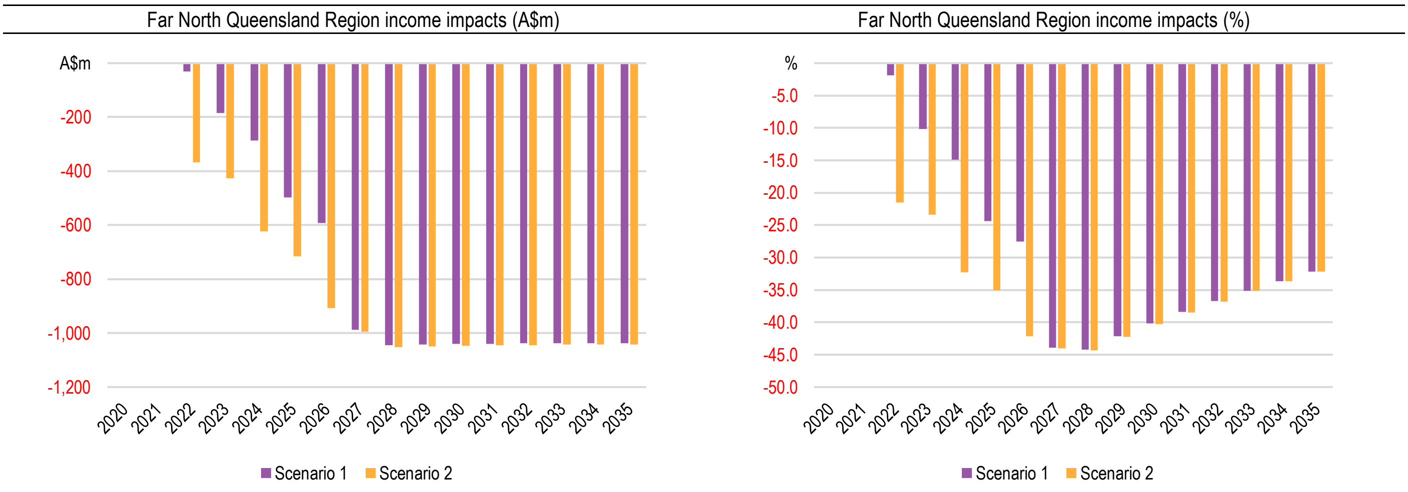
An alternative macroeconomic measure of the economic loss associated with the water depth loss and port capacity losses is provided by the change in real income.

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 3** and **Table ES 5**.

— Over the period 2019-20 to 2034-35 in **Scenario 1**, no maintenance dredging at the South Channel would project to decrease the real income of Far North Queensland Region residents by a cumulative total of $10,898 million loss relative to a reference case (with a present value of $8,515 million, using a 2.5 per cent real discount rate).

— Over the period 2019-20 to 2034-35 in **Scenario 2**, no maintenance dredging at the South Channel would project to decrease the real income of Far North Queensland Region residents by a cumulative total of $12,399 million loss relative to a reference case (with a present value of $9,869 million, using a 2.5 per cent real discount rate).

FIGURE ES 3 PROJECTED CHANGE IN REAL INCOME AS A RESULT OF NO REGULAR MAINTENANCE DREDGING AT THE PORT OF WEIPA, RELATIVE TO A REFERENCE CASE



SOURCE: ACIL ALLEN CONSULTING MODELLING

TABLE ES 5 REAL INCOME IMPACTS RELATIVE TO A REFERENCE CASE, 2019-20 AND 2034-35

			Cumulative change (2018-19 to 2034-35)			
	Average annual		Total		PV (@ 2.5%)	
Regions	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2
	2017-18 A$m	*2017-18 A$m*	*2017-18 A$m*	*2017-18 A$m*	*2017-18 A$m*	*2017-18 A$m*
Far North Queensland Region (GRP)	($681.1)	($774.9)	($10,898)	($12,399)	($8,515)	($9,869)
Queensland (GSP)	($235.4)	($276.3)	($3,766)	($4,420)	($2,831)	($3,362)
Australia (GDP)	($384.9)	($443.5)	($6,159)	($7,096)	($4,677)	($5,453)

SOURCE: ACIL ALLEN CONSULTING MODELLING

The average annual cost of maintenance dredging at the Port of Weipa was around $2 million.[1] This is purely a dredging cost and does not include costs associated with mobilisation, demobilisation, standby, environmental monitoring, project management and permit approval processes. By including these costs increases the total average annual cost of dredging at the Port of Weipa by 50 per cent. It is estimated that the total annual cost of dredging would be around $3.1 million. Thus, for an annual expense of around $3 million per year by the Port of Brisbane, the Far North Queensland region would avoid (average) annual output losses between $388 million and $438 million.

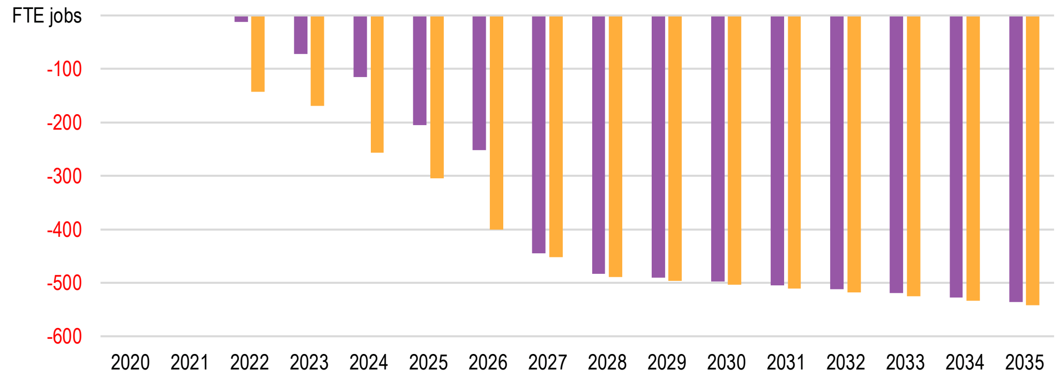
Employment

Over the assessed life of 16 years when the port infrastructure loses 5.2 metres of declared water depth from current existing levels, it is projected that Far North Queensland Region in total (both direct and indirect) will lose between 5,171 in Scenario 1 and

[1] Unpublished dredging cost data provided on 10 December 2018 by NQBP for this study.

5,844 in Scenario 2 additional employee years of full time equivalent (**Figure ES 4**). More specifically, it is projected that the change in water depth levels at Port of Weipa will decrease the employment level in the Region (on average) between 323 and 365 FTE. The total employment loss in the 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 the impact of reduced exports from the 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 4 EMPLOYMENT IMPACTS IN THE FAR NORTH QUEENSLAND REGION

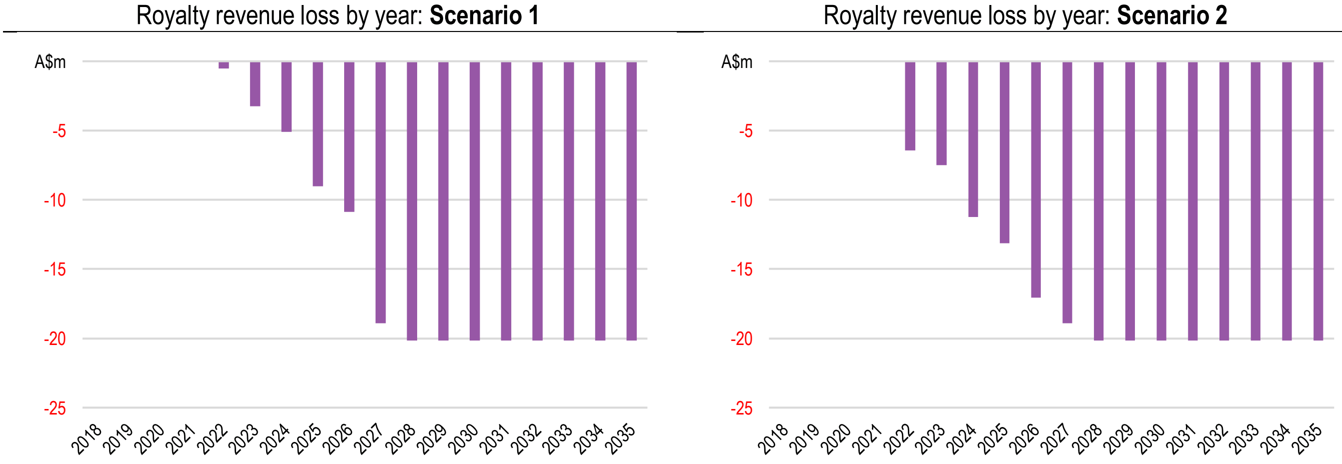


SOURCE: ACIL ALLEN CONSULTING MODELLING

Royalty revenue

Bauxite is not the major royalty revenue source for Queensland Government. However, over the period 2019-20 to 2034-35, if no maintenance dredging occurs at the Port of Weipa, bauxite royalty revenue is projected to fall by a cumulative total of $209.1 million in Scenario 1 and $235.7 million in Scenario 2 relative to the reference case as shown in **Figure ES 5**. The estimated bauxite royalty revenue losses are broadly equivalent to an annual average decline of $12.3 million in current prices or 25 per cent of Queensland Government bauxite royalties in Scenario 1.

FIGURE ES 5 BAUXITE ROYALTY REVENUE LOSS RELATIVE TO THE REFERENCE CASE, 2019-20 TO 2034-35



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

SOURCE: ACIL ALLEN CONSULTING MODELLING

GLOSSARY

API	Aluminium Price Index
CGE	Computable General Equilibrium Modelling
cms	Centimetres
Demurrage	Refers to the charges that the shipowners pay to the charter for its delayed operations of loading and unloading
DWT	Dead Weight Tonnes
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).
LAT	Lowest Astronomical Tide
LME	London Metal Exchange
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.
RORO	roll-on/roll-off
RTA	Rio Tinto Alcan
SA4	Statistical Area Level 4 of the Australian Bureau of Statistics.
SSM	Sustainable Sediment Management

INTRODUCTION 1

The maintenance of safe navigational depths at ports is essential for a an island 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 its major ports — 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 and Channels, if maintenance dredging of the Port is not carried out.

NQBP has engaged 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 Weipa in Queensland.

The potential economic and employment impacts are assessed at:

- The Far North Queensland local region, where the Port of Weipa is located
- The Gladstone region, where bauxite is purified to produce alumina
- The rest of Queensland

This report develops scenarios based on the NQBP data and information and some data contained in the SSM Bathymetric Analysis Report Port of Weipa.[2]

The scenarios were 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 Weipa and the Gladstone Region of Queensland, rest of Queensland, rest of Australia and rest of the World.

1.1 The Port of Weipa

The Port of Weipa is one of the largest bauxite export ports in the world and is located 200 kilometres from the tip of Australia.

There has been considerable private and public sector investment in port infrastructure at the Port of Weipa to support the importing and exporting needs of the Northern region of Australia. The Port is accessible by a shipping channel (South Channel) with a maximum declared depth of 11.7 metres Lowest Astronomical Tide (LAT).[3]

Located on the North-West coast of Cape York Peninsula, the Port of Weipa's main activity is the export of bauxite (aluminium ore) from the Rio Tinto Alcan (RTA) mine. There are four berths located at the Port of Weipa:

- Lorim Point East Wharf — managed by RTA for bauxite export. It has 365 metres length and 60 metres width berth pocket. It has the capacity of maximum 90,000 Dead Weight Tonnes (DWT)
- Lorim Point West Wharf — managed by RTA for bauxite export. It has 325 metres length and 60 metres width berth pocket. It has the capacity of maximum 90,000 DWT
- Evans Landing Wharf — managed by NQBP for the importing of fuel and oil (roll-on/roll-off (RORO) available). It has 165 metres length and 30 metres width berth pocket. It has the capacity of maximum 40,000 DWT
- Humbug Point Wharf — managed for RTA by Sea Swift Pty Ltd for the importing of general cargo (roll-on/roll-off (RORO) available). It has 195 metres length and 35 metres width berth pocket. It has the capacity of maximum 25,000 DWT

Both Lorim Point East and Lorim Point West Wharves average loading capacity is 5,000 tonnes/per hour.

[2] NQBP 2018, Port of Weipa: Sustainable Sediment Management Assessment, Bathymetric Analysis, Report No. P007_R01F1. Prepared by Ports & Coastal Solutions Pty Ltd, July 2018.
[3] Queensland Government 2019, Weipa approach channel and harbor — amended port navigation depths. https://publications.qld.gov.au/dataset/weipa-notices-to-mariners/resource/79167e46-9776-4401-9cbd-53f3cc8dbfa0

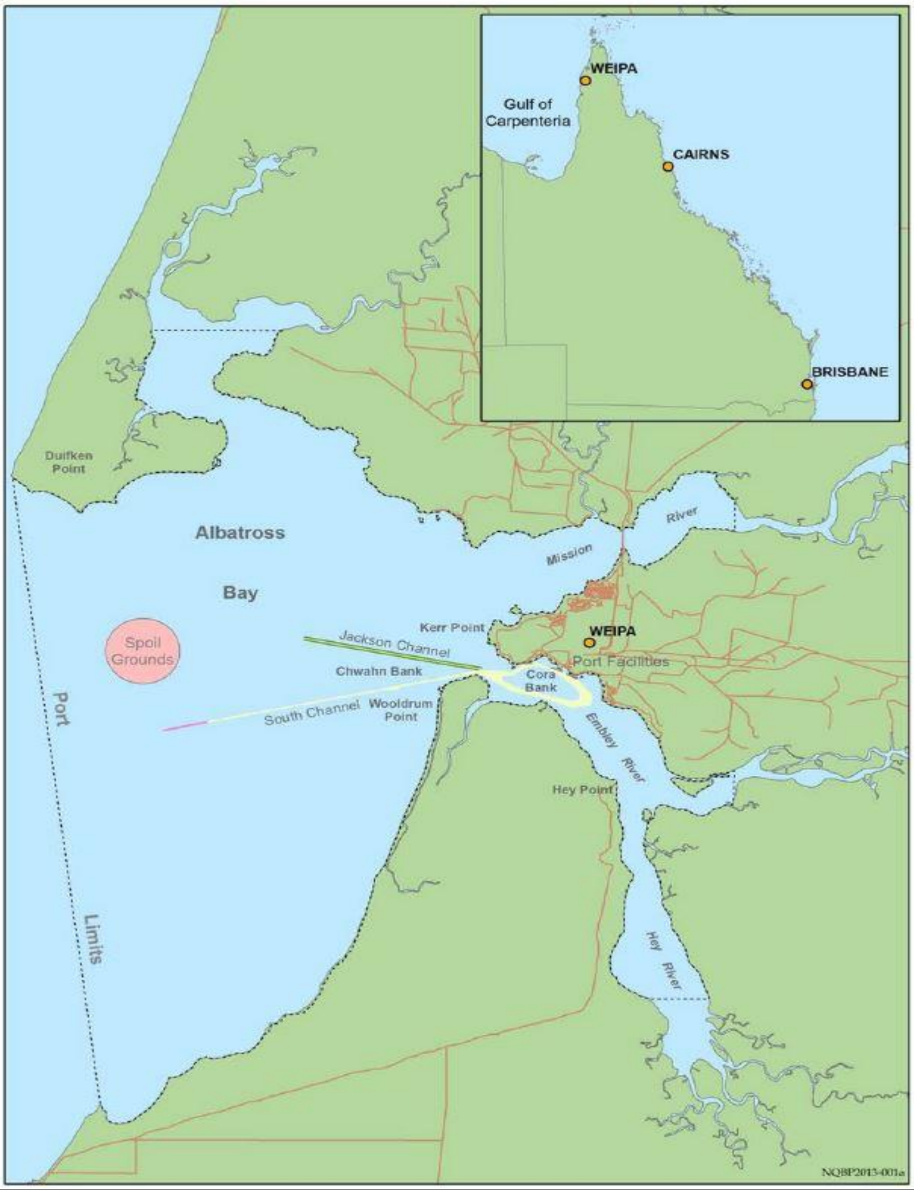
Ports North provides pilotage[4] and NQBP undertakes regular maintenance dredging of the shipping channels and berths at the Port of Weipa to ensure there is sufficient depth for vessels to safety travel to and from the berths. The sediment has historically been removed by maintenance dredging has been relocated to an offshore dredge material placement area (DMPA) located in Albatross Bay (**Figure 1.1**).

NQBP has State and Commonwealth approvals to support maintenance dredging and at sea placement of the dredged sediment at the Port of Weipa. The current 10-year permit was issued in 2010 and it will expire in June 2020.

The Port of Weipa provides for a range of ancillary port facilities that support operational needs. The Port also accommodates municipal facilities including a community centre, public boat ramp and sewage treatment plant. Whilst not core port activities, these facilities are located on Strategic Port Land and provide important services to the Port and community.

The geographic location of Port of Weipa is shown in **Figure 1.1**. The Port is located within Albatross Bay in the Gulf of Carpentaria, on the North West coast of Cape York Peninsula in Queensland.

FIGURE 1.1 LOCATION OF PORT OF WEIPA



SOURCE: NQBP 2013, PORT OF WEIPA — LONG TERM ENVIRONMENTAL MANAGEMENT (LTDMP), MAINTENANCE DREDGING, E11/39354 (PACE REF 2011003 — 003 REV 2), 25 SEPTEMBER 2013

4 Pilotage is navigating using fixed points of reference on the sea or on land, usually with reference to a nautical chart or topographic map to obtain a fix of the position of the vessel with respect to a desired course or location.

The Port of Weipa consists of a main shipping channel in Albatross Bay (South Channel) and an Inner Harbour. The Inner Harbour consists of four shipping berths as outlined above plus an inner Approach Channel and an inner Departure Channel. The three wharves — Lorim Point Wharf, Humbug Wharf and Evans Landing Wharf — provide four shipping berths. Lorim Point Wharf has two berths, which are dredged to 12.3m below LAT, while Humbug and Evan's Landing Wharves each have one berth and are dredged to depths of 9.5m and 9.4m below LAT respectively. In addition to the shipping berths, there is a tug berth behind the Lorim Point Wharf. The South Channel is located in the centre of Albatross Bay and is the access channel for ships using the Port of Weipa. The channel was first dredged in the early 1960s, with additional capital dredging in the 1970s, 2006 and 2012. The South Channel is currently maintained to a length of approximately 17 km, a width of 105.5 m and a declared depth of a maximum of 11.7m LAT (design depth for departure channel is 11.1m LAT). The South Channel terminates at the junction with Jackson Channel, which is located within the natural harbour formed by the Embley-Hey estuary (Inner Harbour). Within the Inner Harbour there is a natural swing basin surrounding Cora Bank. Depths in the Inner Harbour range from 0 – 2 m at the centre of Cora Bank to 8 – 20 m in the surrounding swing basin.[5]

The need for maintenance dredging arises periodically due to sedimentation of existing channels, berths and basins within the Port. Declared operational depths are determined for various facilities, and routinely monitored via hydrographic surveys. Prevailing coastal processes lead to the continued accumulation of fine sediments within the channel, swing basin and berth pockets of the Port of Weipa. To maintain navigable depths, and discharge its requirements, these accumulations require removal via dredging. Under the present dredging regime, the dredge 'Brisbane' services the Port every year. The majority of annual maintenance dredging is undertaken in the South Channel, with approximately 80 per cent of dredging occurring towards the western end of the channel and approximately 10 per cent of dredging occurring at the Bellmouth.

1.2 The Far North Queensland regional economy

The Port of Weipa has located in the Far North Queensland region. The largest sector of the Far North Queensland economy, on all measures, is mining (specifically, bauxite mining) as shown in **Table 1.1**. The bauxite mining sector plays an important role in the region.

TABLE 1.1 FAR NORTH QUEENSLAND REGIONAL PROFILE, 2015-16

Industry	Employment		Output		Value-add	
	No	%	A$m	%	A$m	%
Mining	6,959	50%	1,930	54%	671	46%
Retail Trade	2,300	16%	304	8%	131	9%
Construction	880	6%	256	7%	74	5%
Manufacturing	312	2%	121	3%	38	3%
All others	3,575	25%	983	27%	529	37%
Total	**14,027**	**100%**	**3,593**	**100%**	**1,444**	**100%**

SOURCE: ACIL ALLEN ESTIMATES BASED ABS DATA SOURCES

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 Weipa as result of the accumulation of marine sediments in the existing port navigational infrastructure, mainly at South Channel. 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 Weipa for next 16 years.

[5] NQBP 2013, Port of Weipa — Long Term Environmental Management (LTDMP), Maintenance Dredging, E11/39354 (PaCE Ref 2011003 — 003 Rev 2), 25 September 2013.

- **A change in current water depth scenario (loss scenario 1)** — port capacity losses over 16 years that potentially would occur when there is a loss of declared water depth level of up to 5.2 metres after Year 9 due to sedimentation at the South Channel which mainly restricts vessel movements into and out of the Port of Weipa. In this scenario, there will be at least one worst year in terms of sediment accumulation in next 16 years.
- **A change in current water depth scenario (loss scenario 2)** — This is similar to scenario 1, however, there will be least two worst years in terms of sediment accumulation in next 16 years

The hypothetical scenarios illustrate the potential economic losses associated with various degrees of siltation and sedimentation at the Port of Weipa 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 Weipa on the economies of

- Far North Queensland Region (SA3) [6]
- Rest of Queensland
- Rest of Australia.

1.5 Report structure

The structure of this report is as follows:

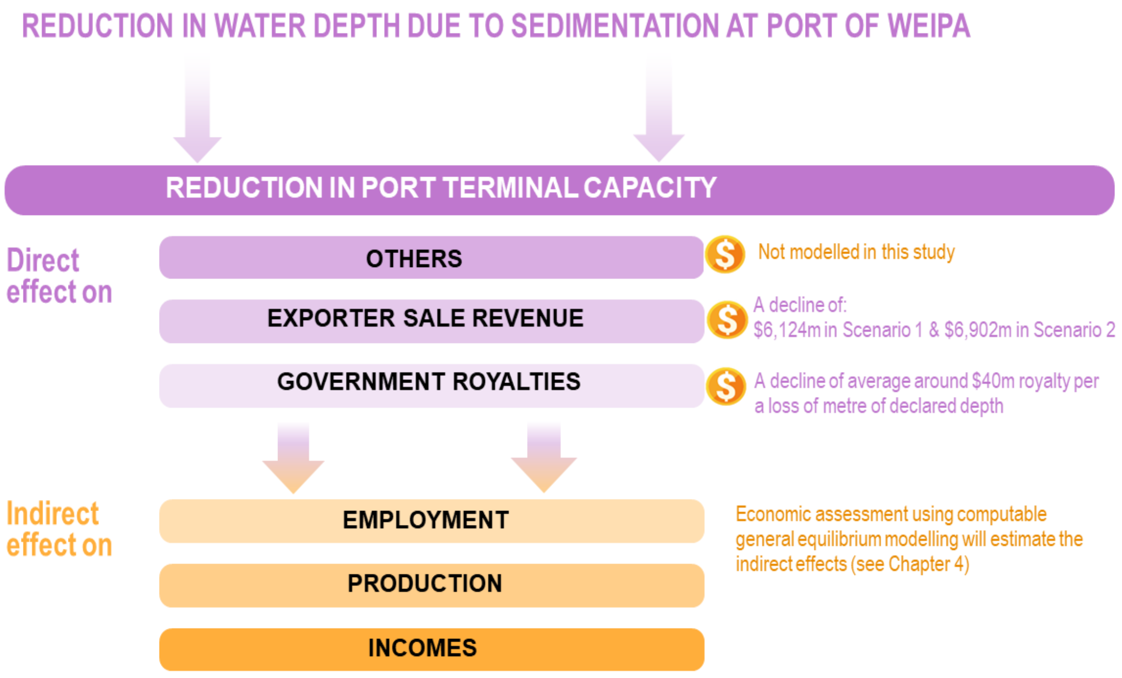
- Chapter 2 provides a framework for assessing the impact of the reduction in declared water depth due to sedimentation. This framework provides measurable direct economic impacts of various degrees of sedimentation at ports.
- Chapter 3 provides data sources and assumptions used to estimate the direct and indirect impacts of sedimentation. This chapter includes annual loss of declared water depth at the main channel, expected bauxite, alumina and aluminium 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 bauxite royalty revenue losses to the Queensland Government due to the loss of port capacity

[6] Statistical Area Level 3 (SA3) sub-state geographic areas of the Australian Bureau of Statistics.

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 THE PORT OF WEIPA'S MAIN CHANNEL



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 a decline in government 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, increasing 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.

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.

Exporters 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. Therefore, 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 the expected sedimentation at the Port of Weipa. Key considerations included in the economic assessment are:

— Bauxite prices
— Bauxite volumes
— Dredging volumes
— Dredging costs
— Royalty revenue.

3.1 Bauxite prices

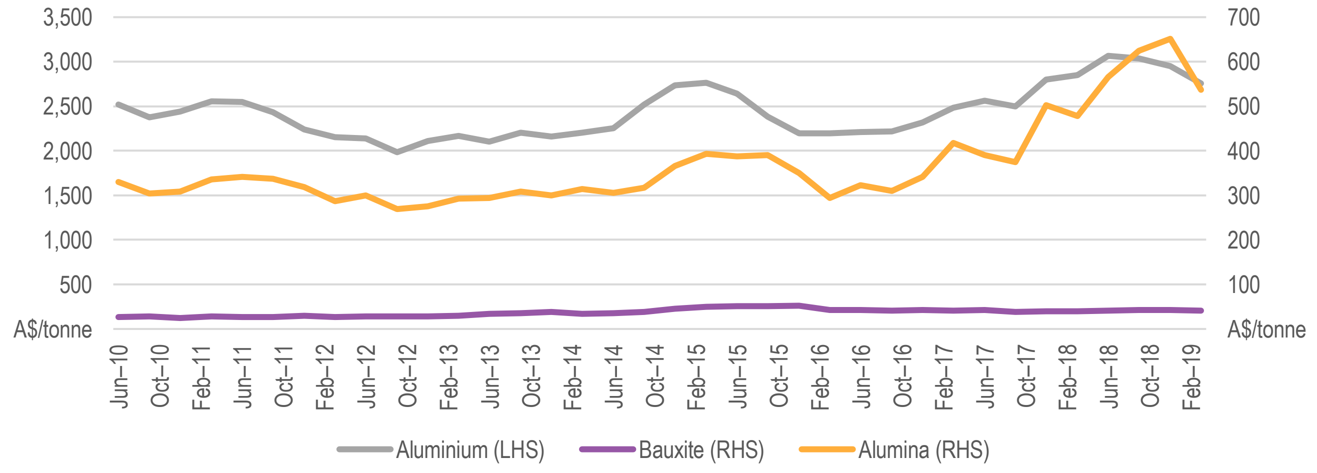
Historical bauxite, alumina and aluminium prices in Australia are provided in **Figure 3.1**.

Bauxite prices (along with alumina and aluminium) move together due to their short and long-run production relationships. Over the past eight years, on average prices grew for:

- Bauxite by 5.6 per cent per annum
- Alumina by 6.9 per cent per annum
- Aluminium by 2.5 per cent per annum

Alumina is a key input in aluminium's production and as a result the changes in alumina prices influence the aluminium prices. However, Alumina doesn't have a very liquid market and that makes the pricing difficult. Aluminium on the other hand is trade metal on the London Metal Exchange (LME). As a result, most producers of alumina, price the alumina as a percentage of aluminium price index (API). Recently, it appears that alumina producers are moving away from this percentage approach. As shown in **Figure 3.1**, the alumina and aluminium prices are diverging. Alumina prices through API are less dependent on aluminium prices and help in independent price discovery of alumina. Nonetheless, alumina prices can't be totally independent of aluminium prices and they are highly correlated.

FIGURE 3.1 BAUXITE, ALUMINA AND ALUMINIUM PRICES



Note: Average unit export value

SOURCE: OFFICE OF THE CHIEF ECONOMIST (2018), RESOURCES AND ENERGY QUATERLY, MARCH 2019.

Export revenues are based on tonnes loaded to the vessel and the price of bauxite or alumina or aluminium — average unit export value. To calculate export revenue and bauxite royalties related to expected loss in declared water depth at Port of Weipa, average bauxite price of A$50.7/tonne was used in this study. Queensland aluminium value chain begins with the mining bauxite at Weipa. Because of bauxite's many impurities, it must be refined to produce alumina. This refining takes place in Gladstone and alumina is then processed to produce raw or primary aluminium. This will be either used in Australia or exported.

3.2 Export volumes

Historical trade volumes from the Port of Weipa are provided in **Table 3.1**. Bauxite is the major commodity that is exported from the Port of Weipa. Weipa deposits have close to 50 percent available alumina and are amongst the world's highest-grade deposits. However, the Western Australian deposits in the Darling Range and the undeveloped Mitchell Plateau are relatively low grade, at around 30 percent available alumina. Most Australian deposits have the disadvantage of being relatively high in silica, which requires the use of higher amounts of caustic soda, raising alumina refining costs. However, the Australian deposits are shallow and relatively easy to mine.[7]

TABLE 3.1 TRADE VOLUMES FROM THE PORT OF WEIPA, 2012-13 TO 2016-17, MILLION TONNES

	2012-13	2013-14	2014-15	2015-16	2016-17
EXPORTS					
Bauxite	28.92	30.39	31.73	32.28	35.54
– *To Gladstone for alumina refinery*	*16.32*	*16.61*	*17.13*	*18.79*	*19.01*
– *International exports*	*12.60*	*13.78*	*14.60*	*13.49*	*16.52*
General Cargo	0.01	0.01	0.01	0.01	0.01
Livestock	0.00	0.00	0.00	0.00	0.00
Total exports	**28.92**	**30.40**	**31.74**	**32.29**	**35.55**
IMPORTS					
Fuel	0.08	0.07	0.08	0.07	0.10
General Cargo	0.04	0.04	0.04	0.04	0.04
Total imports	**0.12**	**0.11**	**0.11**	**0.11**	**0.14**

SOURCE: QUEENSLAND GOVERNMENT 2018, TRADE STATISTICS FOR QUEENSLAND PORTS.

More than 50 per cent of Weipa bauxite goes to Gladstone (Queensland Alumina Ltd, (QAL), which is owned by RTA and Rusal) for further refining. Around 45 per cent is exported to other countries. Delays in shipments due to the sedimentation caused by no maintenance dredging directly affect the international exports from Port of Weipa but also its supply chain in Queensland. It is important to consider both effects in the economic impact assessment. Alumina and aluminium production, domestic use and international exports from the Port of Gladstone are provided in **Table 3.2**. Boynes Smelters Limited (BSL) in Gladstone which is 60 per cent owned by RTA has the capability to produce of 570,000 tonnes of aluminum per year.[8]

TABLE 3.2 ALUMINA AND ALUMINIUM TRADE VOLUMES FROM THE PORT OF GLADSTONE, 2012-13 TO 2016-17, MILLION TONNES

	2012-13	2013-14	2014-15	2015-16
Alumina production	5.17	5.26	5.43	5.95
Alumina and Alumina Hydrate international exports	4.89	5.08	5.47	6.21
Alumina domestic use in smelters	0.28	0.18	0.07	0.07
Aluminium international exports	0.33	0.39	0.41	0.42

Note: Approximately four tonnes of bauxite produce one tonne of alumina and approximately two tonnes of alumina are required to produce one tonne of aluminium

SOURCE: TRADE STATISTICS FOR QUEENSLAND PORTS

A 5.2 metre loss in average declared water depth over 16 years would result in a total loss of 120.7 million tonnes of bauxite exports in Scenario 1 and 136.1 million tonnes in Scenario 2 at the Port of Weipa (**Table 3.3**).

[7] http://aluminium.org.au/australian-industry/
[8] http://www.boynesmelters.com.au/

RTA has provided inputs to the calculation of impacts on export volumes of losses in declared water depth at South Channel. RTA has suggested that for every 0.1m loss of depth would impact the export volumes by 800 tonnes per vessel. Nearly 5.4 ships per week or 280 ships per year operate at the Port of Weipa to load bauxite. In annual terms, it is estimated that for every 0.1m loss of depth would impact the export volumes by 224,000 tonnes (280 multiplied with 800).

It is estimated that a cumulative export revenue loss at the Port of Weipa over the next 16 years will be A$6,124 million in Scenario 1 and A$6,902 million in Scenario 2. The cumulative export revenue loss represents a 15 per cent in Scenario 1 and 17 per cent in Scenario 2 relative to the reference case in the Region.

TABLE 3.3 DIRECT BAUXITE EXPORT IMPACTS

	Scenario 1		Scenario 2	
Year	Impact on export volumes (tonnes)	Loss of export revenue (A$m)	Impact on export volumes (tonnes)	Loss of export revenue (A$m)
0				
1				
2				
3	-309,753	-16	-3,706,410	-188
4	-1,866,697	-95	-4,340,042	-220
5	-2,945,154	-149	-6,500,591	-330
6	-5,208,045	-264	-7,579,048	-384
7	-6,286,503	-319	-9,841,940	-499
8	-10,920,397	-554	-10,920,397	-554
9	-11,648,000	-591	-11,648,000	-591
10	-11,648,000	-591	-11,648,000	-591
11	-11,648,000	-591	-11,648,000	-591
12	-11,648,000	-591	-11,648,000	-591
13	-11,648,000	-591	-11,648,000	-591
14	-11,648,000	-591	-11,648,000	-591
15	-11,648,000	-591	-11,648,000	-591
16	-11,648,000	-591	-11,648,000	-591
TOTAL	**-120,720,549**	**-6,124**	**-136,072,428**	**-6,902**

SOURCE: NQBP

3.3 Dredging volumes

Several capital dredging has been undertaken at the Port of Weipa since the 1960s, with the most recent capital works undertaken in 2012:[9]

- 1961–63: The South Channel was first dredged across the inner half of Albatross Bay with the natural South Channel being deepened to a depth of 8.2m below Low Water Datum which is approximately equivalent to LAT
- 1980s: The South Channel was deepened and extended to a length of 14.5 km
- 2006: The South Channel was deepened and widened. Due to the variable sedimentation within the South Channel the design depth was increased from the uniform depth of -12.2m LAT and due to the deepening, the channel also had to be widened to ensure the batter slopes were stable
- 2012: The South Channel was extended by 2.4 km with a design depth of -12.2m LAT.

The Port has approximately 655 hectares of channels, swing basins and berths where depths are maintained by maintenance dredging. A summary of historical dredging works is provided in **Table 3.4**. The fact that the Port requires annual maintenance

[9] NQBP 2018, Port of Weipa: Sustainable Sediment Management Assessment, Bathymetric Analysis, Report No. P007_R01F1. Prepared by Ports & Coastal Solutions Pty Ltd, July 2018.

dredging indicates that regular sedimentation occurs. In addition to the regular sedimentation, it has also been observed that extreme events such as tropical cyclones can result in significant increases in the sedimentation and therefore increased maintenance dreading requirements the Port. The maintenance dredging generally scheduled immediately after the wet season at the Port of Weipa. In 2019, over 2.4M m3 of material was removed by maintenance dredging due to sediment infill over wet season which consisted of three cyclones and a low monsoonal weather event and considered as a worst year.

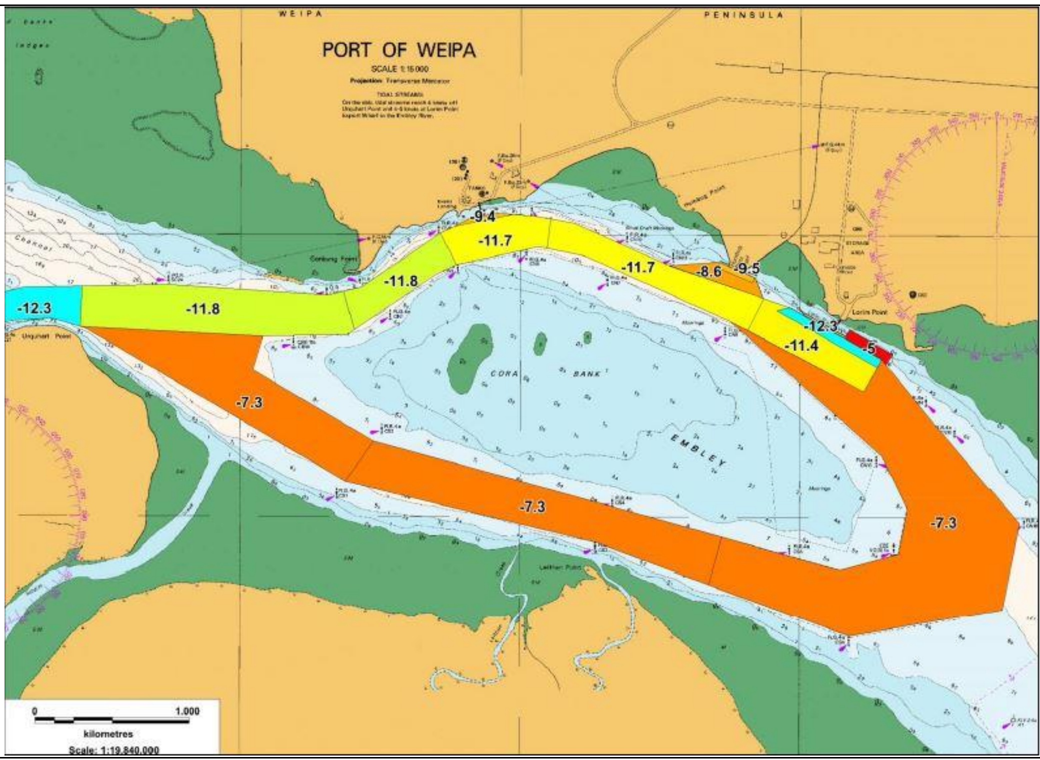
TABLE 3.4 HISTORICAL DREDGING AT THE PORT OF WEIPA

Year	Type of dredging	Volume of in-situ Material removed (m3)
2002	Maintenance	976,585
2003	Maintenance	463,513
2004	Maintenance	621,650
2005	Maintenance	803,098
2006	Capital and Maintenance	2,976,868
2007	Maintenance	711,000
2008	Maintenance	774,100
2009	Maintenance	553,457
2010	Maintenance	832,779
2011	Maintenance	470,820
2012	Capital and Maintenance	927,057
2013	Maintenance	644,525
2014	Maintenance	394,523
2015	Maintenance	368,384
2016	Maintenance	504,071
2017	Maintenance	297,301
2018	Maintenance	591,875

SOURCE: NQBP 2018, PORT OF WEIPA: SUSTAINABLE SEDIMENT MANAGEMENT ASSESSMENT, BATHYMETRIC ANALYSIS, REPORT NO. P007_R01F1. PREPARED BY PORTS & COASTAL SOLUTIONS PTY LTD, JULY 2018

The design depths have been adjusted over time based on the variable sedimentation which occurs in the Port as shown in **Figure 3.2**. In addition, the Dynamic Under Keel Clearance (DUKC) system is in operation at the Port of Weipa to ensure safe vessel navigation and to help optimise port operations.

FIGURE 3.2 VARIABLE DESIGN DEPTHS (METRE LAT) IN THE PORT OF WEIPA INNER HARBOUR



SOURCE: NQBP 2018, PORT OF WEIPA: SUSTAINABLE SEDIMENT MANAGEMENT ASSESSMENT, BATHYMETRIC ANALYSIS, REPORT NO. P007_R01F1. PREPARED BY PORTS & COASTAL SOLUTIONS PTY LTD, JULY 2018

Typical maintenance dredging volume estimate, declared depth, design depth and foot print for the dredged areas at the Port of Weipa are provided in **Table 3.5**. Dredging the South Channel is important to access various Wharves at the Port of Weipa.

Two predictive sedimentation models were used to estimate loss of declared depth during a 16-year period. Both models had a maximum loss of 5.2m resulting in a reduced declared depth of -6.5m after Year 9

TABLE 3.5 TYPICAL MAINTENANCE DREDGING AT THE PORT OF WEIPA

Port Area	Volume Estimate	Declared Depth	Design Depth [a]	Footprint
	m^3	(m below LAT)	(m below LAT)	(ha)
South Channel	465,000	11.7*	12.1 to 14.1	256
Approach Channel	24,000	7.3	7.3	272.5
Departure Channel	12,000	11.1	11.1 to 11.8	138.3
Evans Landing	500	9.4	9.4	0.50
Humbug	500	9.5	9.5	0.86
Lorim Point	500	12.3	12.3	2.45
Tug Berth	500	9.0	9.0	2.12

[a] In some areas the design depth is variable due to natural variability in the sedimentation which occurs. The design depths are shown in Figure 3.3. Although the design depth at the Lorim Point Tug Berths is -9 m LAT it has not been dredged to that depth (currently around -5 m LAT) and due to the existing depths the TSHD Brisbane is not able to dredge the area and so bed levelling has been used to maintain the depths to -5 m LAT.

SOURCE: NQBP 2018, PORT OF WEIPA: SUSTAINABLE SEDIMENT MANAGEMENT ASSESSMENT, BATHYMETRIC ANALYSIS, REPORT NO. P007_R01F1. PREPARED BY PORTS & COASTAL SOLUTIONS PTY LTD, JULY 2018

The NQBP has provided two probable predictive sedimentation model scenarios with various year types — normal, cyclonic and worst year (Table 3.5) for this study. The worst year defined as where 2.4M m^3 of sedimentation would occur, which was happened in 2018-19 season. In both scenarios, the declared depth of South Channel is reduced by 5.2m to -6.5m by year 9 of the 16-year period assessment. Minus 6.5m is typically the depth adjacent seabed to channel at which point no further reduction in declared depth would occur. The current declared depth is -11.7m at the South Channel.

TABLE 3.6 KEY FEATURES OF SCENARIOS

	Scenario 1			Scenario 2		
Year	Year type	Sediment accumulation	Declared depth (m)	Year type	Sediment accumulation	Declared depth (m)
0			(11.70)			(11.70)
1	normal	409,393	(12.13)	normal	409,393	(12.13)
2	cyclone	1,267,211	(11.84)	cyclone	1,267,211	(11.84)
3	normal	1,676,604	(11.56)	Worst year (2.5Mm3)	3,638,018	(10.05)
4	cyclone	2,534,422	(10.87)	normal	4,046,664	(9.76)
5	normal	2,943,815	(10.39)	cyclone	4,839,652	(8.80)
6	cyclone	3,801,633	(9.37)	normal	5,218,548	(8.32)
7	normal	4,211,026	(8.89)	cyclone	5,870,971	(7.31)
8	Worst year (2.5Mm3)	6,141,071	(6.82)	normal	6,141,071	(6.82)
9	normal	6,343,070	(6.50)	Worst year (2.5Mm3)	6,664,993	(6.50)
10	cyclone	6,438,163	(6.50)	normal	6,725,765	(6.50)
11	normal	6,498,934	(6.50)	cyclone	6,820,858	(6.50)
12	cyclone	6,594,027	(6.50)	normal	6,881,629	(6.50)
13	normal	6,654,799	(6.50)	cyclone	6,976,722	(6.50)
14	cyclone	6,749,892	(6.50)	normal	7,037,494	(6.50)
15	normal	6,810,664	(6.50)	cyclone	7,132,587	(6.50)
16	cyclone	6,905,757	(6.50)	normal	7,193,359	(6.50)

SOURCE: NQBP

3.4 Dredging costs

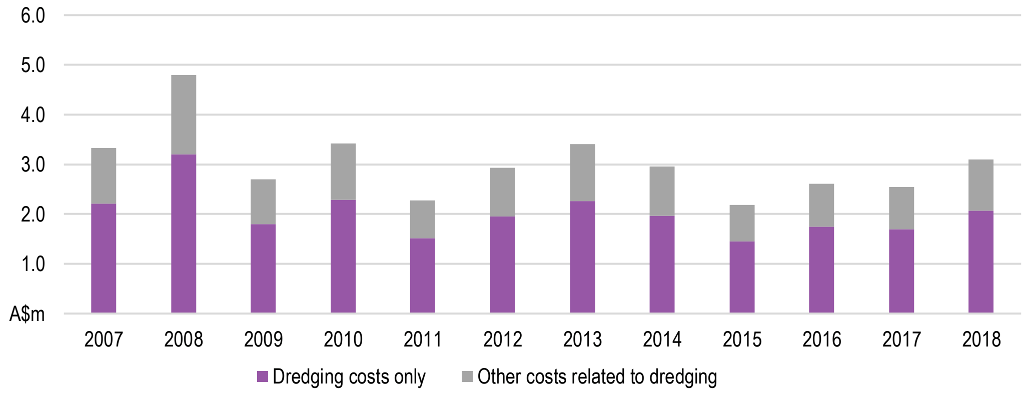
Maintenance dredging works are an integral part of the port's operations. NQBP manages the annual maintenance dredging program at the Port of Weipa — a program that has run for more than 50 years. Regular maintenance dredging ensures safe, navigable shipping depths for port users.

As noted in 2017-18 NQBP's Annual Report,[10] NQBP continues to work closely with Rio Tinto, Weipa Town Authority and other local representatives to enhance port capability, diversify trade, boost local employment and foster economic development within the Western Cape region. In 2017-18, NQBP supported the construction of Rio Tinto's Amrun project, facilitating project and break-bulk cargo in and out of the port. In line with its operational priorities to ensure effective and efficient shipping, NQBP conducted its annual maintenance dredging at the Port of Weipa. For the first time, NQBP also extended dredging to Amrun, on behalf of Rio Tinto. Sustainable sediment management assessment also began for the Port of Weipa and Amrun to inform the beyond 2020 long-term maintenance dredging approvals application.

All costs in current prices associated with the dredging including mobilisation/demobilisation, standby, environmental monitoring, project management and permit/approvals processes are summarised in **Figure 3.3**. On average, dredging costs only at the port of Weipa was around $2 million. Total dredging program costs were around $3 million. A 50 per cent of total dredging program costs include dredge mobilisation, demobilisation, bed levelling, survey, project management, environmental monitoring and compliance.

[10] NQBP 2018, 2017-18 Annual Report, https://nqbp.com.au/__data/assets/pdf_file/0020/31088/North-Queensland-Bulk-Ports-Annual-Report-2017-18.pdf

FIGURE 3.3 HISTORICAL TOTAL DREDGING COSTS AT PORT OF WEIPA



Note: Other costs include dredge mobilisation, demobilisation, bed levelling, survey, project management, environmental monitoring and compliance.
SOURCE: UNPUBLISHED DATA FROM NQBP

3.5 Port charges

Port charges are a cost to the export industry and change when the volume of export that is shipped being changes. Port charges at Weipa are provided in **Table 3.7**.

TABLE 3.7 PORT CHARGES AT PORT OF WEIPA

Vessels	$ (excl.GST)	$ (incl.GST)
Vessel loading or unloading cargo that has a gross tonnage of more than 3,000 GRT (per ton of GRT)	Price on Application	
For ships with a gross tonnage of less than or equal to 3,000 GRT and loading or unloading cargo that weighs more than 3,000 tonnes, for each 48-hour period or part of the period (per tonne of cargo).	$0.307	$0.338
For ships with a gross tonnage of less than or equal to 3,000 GRT and loading or unloading cargo that weighs less than or equal to 3,000 tonnes, for each 48 period or part of the period (per tonne of cargo).	$0.175	$0.193
All other vessels	Price on Application	

Note: All charges are effective as at 1 July 2018.
SOURCE: HTTPS://NQBP.COM.AU/TRADE/FEES-AND-CHARGES

3.6 Royalty rates

Mineral Royalty payments are calculated according to Schedule 3 of the Mineral Resources Regulation (2013) in Queensland.[11] 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. The royalty rate for bauxite is calculated:

- separately for each mining operation for which the producer is liable to pay royalty
- separately for bauxite sold, disposed of or used inside Queensland (domestic bauxite) and bauxite sold, disposed of or used outside Queensland (export bauxite)[12] sourced from each mining operation
  - For export, the higher of 10 per cent value or $2 per tonne
  - For domestic, where bauxite has also been sold, disposed or used outside Queensland during the period, the higher of 75 per cent of the rate per tonne for export bauxite or $1.50 per tonne. Otherwise, $1.50 per tonne.
- where the producer is paid on the basis of the number of dry metric tonnes sold (rather than the actual number of tonnes physically sold)—with reference to the number of dry metric tonnes sold.

[11] https://www.legislation.qld.gov.au/LEGISLTN/CURRENT/M/MineralReR13.pdf
[12] Schedule 3, section 4 of the Regulation.

ECONOMIC ASSESSMENT 4

This chapter uses quantitative analysis to assess the potential progressive economic impacts of loss of declared water depth at Port of Weipa 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 Weipa in particular. Economic impacts at the Port of Weipa, as a result of the accumulation of marine sediments in the South Channel which mainly restricts vessel movements into and out of the Port of Weipa, 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 scenarios have been analysed using Tasman Global Model.

— **Reference case scenario** — in this scenario, there will be a regular maintenance dredging at the Port of Weipa for next 16 years.

Two loss scenarios modelled in this study are based on predictive sedimentation model developed by NQBP. They are:

— **A change in current water depth scenario (loss Scenario 1)** — port capacity losses over 16 years that potentially would occur when there is a loss of declared water depth level of up to 5.2 metres after Year 9 due to sedimentation at the South Channel which mainly restricts vessel movements into and out of the Port of Weipa. In this scenario, there will be at least one worst year in terms of sediment accumulation in next 16 years.

— **A change in current water depth scenario (loss Scenario 2)** — This is similar to Scenario 1, however, there will be at least two worst years in terms of sediment accumulation in next 16 years

The analysis shows that a maximum reduced declared depth loss of 5.2m to -6.5m after 9 years of 16-year assessment would leads to a loss of 120.7 million tonnes of export volumes in Scenario 1 and a loss of 136.1 million tonnes in Scenario 2.

An average bauxite price of US$35 per tonne and exchange rate of A$0.69/US$ are assumed in this study to translate the export volume losses into export revenue losses. The estimated cumulative revenue losses over 16 years will be around A$6,124 million in Scenario 1 and A$6,902 million in Scenario 2

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 year 9 in next 16-year assessment	Cumulative total reduction in bauxite export volumes in next 16 years	Cumulative total reduction in bauxite export revenue in next 16 years
	metres	Million tonnes	A$m
Scenario 1	-5.2	-120.7	-6,124
Scenario 2	-5.2	-136.1	-6,902

SOURCE: ACIL ALLEN CONSULTING

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

As mentioned above, the analysis of scenarios 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 (e.g. the economic impact of no maintenance dredging at the Port of Hay Point, the proposed Carmichael coal mine in the Galilee Basin). 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 Far North Queensland 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 at the Port of Weipa. Each of the scenarios was modelled for a sixteen-year period from 2019-20 to 2034-35. All of the reported economic impacts represent changes relative to a reference case. The economic impacts are shown in 2017-18 dollars. All present value (PV) calculations use a 2.5 per cent real discount rate.

4.2 Real economic output

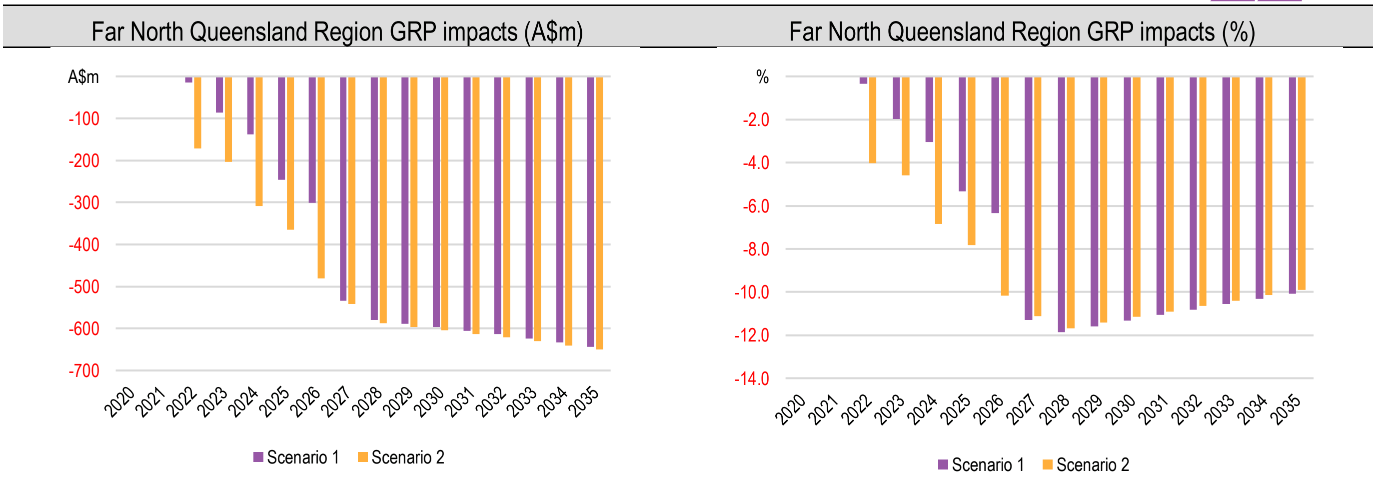
Gross Domestic Product (GDP) is one of the primary indicators used to gauge the health of an economy. It measures the amount of economic activity happening in the country and represents the total dollar value of all goods and services produced over a specific time period. It can be thought of as the 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 Far North Queensland 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 South Channel of Port of Weipa. **Table 4.2** shows the total impacts of no maintenance dredging at the Port of Weipa for next 16 years.

— Over the period 2019-20 to 2034-35 in **Scenario 1**, no maintenance dredging would project to decrease the real economic output of the Region (i.e. real GRP) by a cumulative total of $6,205 million over the period of 16 years (with a present value of $4,822 million, using a 2.5 per cent real discount rate), or around $388 million per year on average.

— Over the period 2019-20 to 2034-35 in **Scenario 2**, no maintenance dredging would project to decrease the real economic output of the Region (i.e. real GRP) by a cumulative total of $7,013 million over the period of 16 years (with a present value of $5,544 million, using a 2.5 per cent real discount rate), or around $438 million per year on average.

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 Weipa would be between $388 million and $438 million, on average, this is equivalent to a loss of 12.2 per cent and 13.8 per cent, respectively of Far North Queensland Region's current GRP. [13] The average annual cost of maintenance dredging at the Port of Weipa was around $2 million.[14] This is purely a dredging cost and does not include costs associated with mobilisation, demobilisation, standby, environmental monitoring, project management and permit approval processes. By including these costs increase the total average annual cost of dredging at the Port of Weipa by 50 per cent. It is estimated that the total annual cost of dredging would be around $3 million. Thus, for an annual expense of around $3 million per year by NQBP, the Far North Queensland region would avoid (average) annual output losses between $388 million and $438 million.

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



Note: Real economic output for Far North Queensland region is equivalent to real GRP while real economic output at the Queensland level is equal to real GSP. All dollars are in 2017-18 terms.
SOURCE: ACIL ALLEN CONSULTING MODELLING

[13] Based on the estimated Far North Queensland Region GRP in 2017-18 of $3,173 million.
[14] Unpublished dredging cost data provided on 10 December 2018 by NQBP for this study.

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

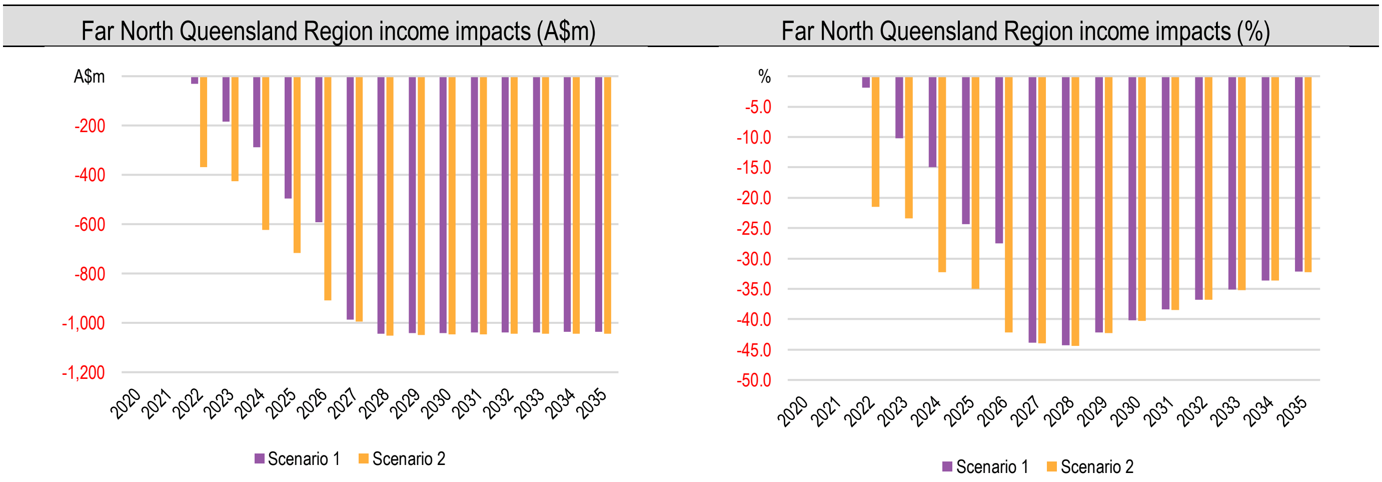
	Cumulative change (2018-19 to 2034-35)					
	Average annual		Total		PV (@ 2.5%)	
Regions	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2
	2017-18 A$m	*2017-18 A$m*	*2017-18 A$m*	*2017-18 A$m*	*2017-18 A$m*	*2017-18 A$m*
Far North Queensland Region (GRP)	($388)	($438)	($6,205)	($7,013)	($4,822)	($5,544)
Queensland (GSP)	($50)	($56)	($797)	($890)	($516)	($559)
Australia (GDP)	($100)	($114)	($1,592)	($1,825)	($1,126)	($1,284)

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 of the residents of the 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 Weipa. Given (by assumption) that a high proportion of the employees of the Port live in the Region, a significant amount of the additional personal incomes that are generated by the Port of Weipa are estimated to stay in the Far North Queensland 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 Region. The Queensland Government will receive fewer royalties from the export of bauxite 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 WEIPA, 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 Weipa for next 16 years.

TABLE 4.3 REAL INCOME IMPACTS RELATIVE TO A REFERENCE CASE, 2019-20 AND 2034-35

			Cumulative change (2018-19 to 2034-35)			
	Average annual		Total		PV (@ 2.5%)	
Regions	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2
	2017-18 A$m	*2017-18 A$m*	*2017-18 A$m*	*2017-18 A$m*	*2017-18 A$m*	*2017-18 A$m*
Far North Queensland Region (GRP)	($681.1)	($774.9)	($10,898)	($12,399)	($8,515)	($9,869)
Queensland (GSP)	($235.4)	($276.3)	($3,766)	($4,420)	($2,831)	($3,362)
Australia (GDP)	($384.9)	($443.5)	($6,159)	($7,096)	($4,677)	($5,453)

SOURCE: ACIL ALLEN CONSULTING MODELLING

— Over the period 2019-20 to 2034-35 in **Scenario 1**, no maintenance dredging at the South Channel would project to decrease the real income of Far North Queensland Region residents by a cumulative total of $10,898 million loss relative to a reference case (with a present value of $8,515 million, using a 2.5 per cent real discount rate).

— Over the period 2019-20 to 2034-35 in **Scenario 2**, no maintenance dredging at the South Channel would project to decrease the real income of Far North Queensland Region residents by a cumulative total of $12,399 million loss relative to a reference case (with a present value of $9,869 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 Far North Queensland Region between $20,640 and $23,480 per person or annual decrease in income between $1,300 and $1,500. This is a noticeable decrease in well-being of Region residents.[15]

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 into 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 the Region. Negative net international trade contributions are directly related to the export revenue losses associated with port capacity losses.

TABLE 4.4 REAL GNI DECOMPOSITION, CUMULATIVE TOTAL AT MACRO LEVEL

Real income components	Far North Queensland		Rest of Queensland		Rest of Australia		Total Australia	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2
	2017-18 A$m	*2017-18 A$m*	*2017-18 A$m*	*2017-18 A$m*	*2017-18 A$m*	*2017-18 A$m*	*2017-18 A$m*	*2017-18 A$m*
Consumption	-8,659	-9,793	4,315	4,843	-6,125	-6,958	-10,470	-11,907
Investment	-2,459	-2,793	51	58	-2,184	-2,491	-4,592	-5,226
Net foreign trade	4,913	5,573	1,043	1,222	6,717	7,623	12,673	14,418
Real exports	-320	-342	7,143	7,946	6,930	7,697	13,753	15,301
Real imports	5,233	5,915	-6,100	-6,724	-213	-72	-1,080	-881
Real economic output	**-6,205**	**-7,013**	5,408	6,123	-1,592	-1,825	-2,389	-2,715
Price deflator effect	-1,615	-1,918	524	590	-1,091	-1,327	-2,182	-2,655
Terms of trade	-2,659	-2,929	908	929	-1,751	-1,999	-3,503	-3,999
Net income transfers	-419	-540	292	336	-127	-200	-254	-404
Real income	**-10,898**	**-12,399**	7,132	7,978	-4,562	-5,352	-8,327	-9,772

SOURCE: ACIL ALLEN CONSULTING MODELLING

[15] Median household weekly income in the region is $1,184, according to the ABS 2016 Census.

4.4 Labour market

A key issue when estimating the impact of a policy or project is determining how the labour market will respond.[16] Typically there are two extreme choices:

— 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 Weipa on employment is shown in **Figure 4.3**. As shown in this figure, lower bauxite exports as a result of no regular maintenance dredging at the Port of Weipa would result in increased unemployment in the Region. Potential decrease in bauxite exports would decrease domestic demand of goods and services through reduced efficiency in the bauxite 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 the Region when the port is not fully operational can have an impact on the labour market though three mechanisms:

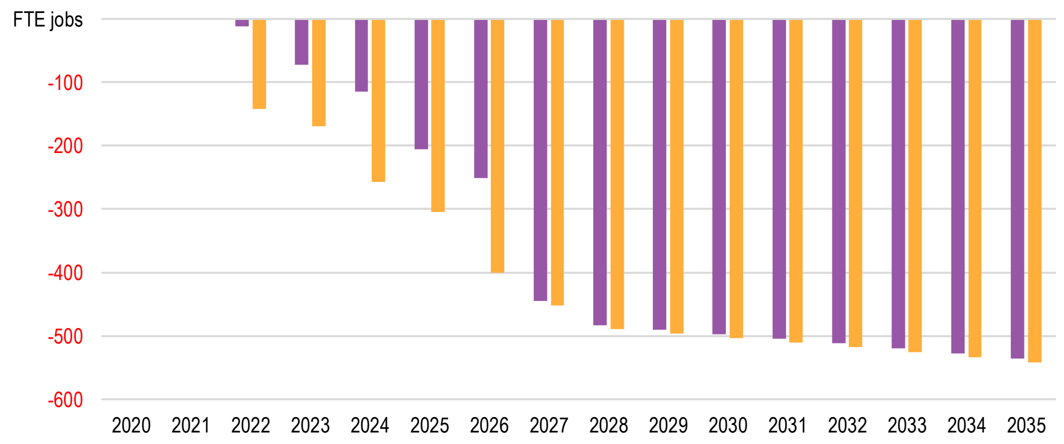
— Decreasing migration from the rest of Queensland and rest of Australia

— 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 the 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

[16] 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 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.

Over the assessed life of 16 years when the port infrastructure loses 5.2 metres of declared water depth from current existing levels, it is projected that Far North Queensland Region in total (both direct and indirect) will lose between 5,171 in Scenario 1 and 5,844 in Scenario 2 additional employee years of full time equivalent. More specifically, it is projected that the change in water depth levels at Port of Weipa will decrease the employment level in the Region (on average) between 323 and 365 FTE.

The total employment losses are projected to be greatest during the period where high siltation is expected to occur, which will be around Year 9. 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 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..

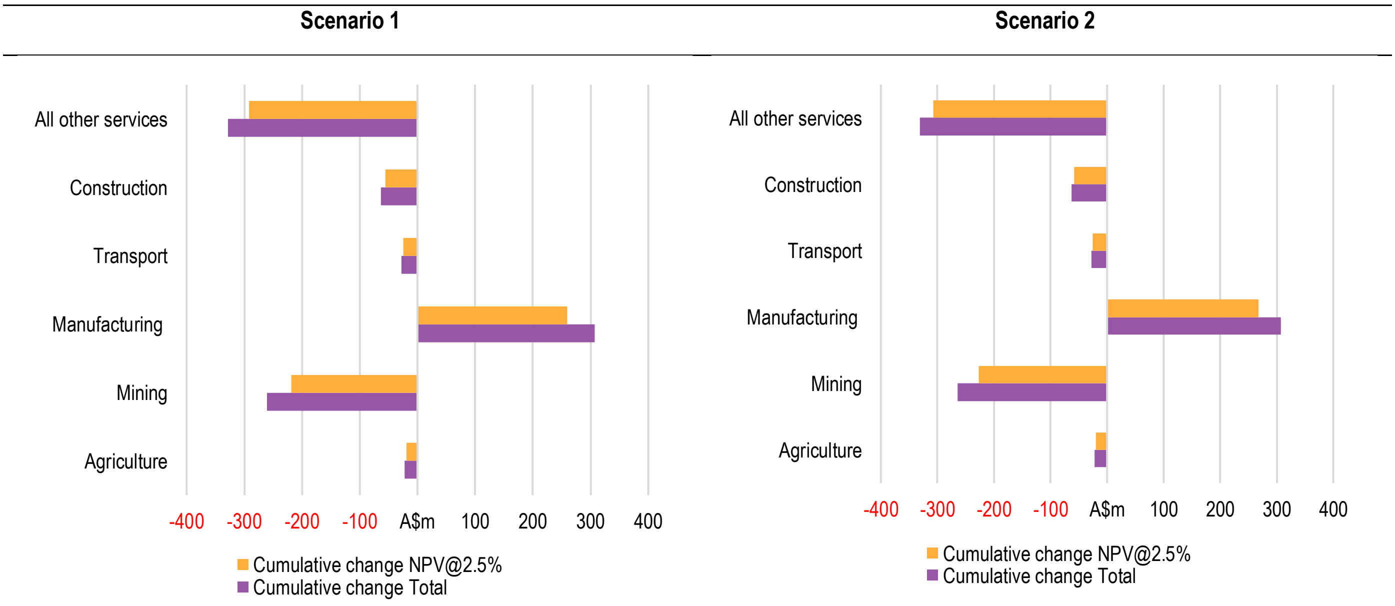
4.5 Industry impacts

Figure 4.4 presents the projected change in real output by industry following water depth losses at Port of Weipa. 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 the Region would experience a decline in output as a result of the reductions in bauxite export volumes. Not surprisingly, the biggest losses are concentrated in the mining sector.

The overall decrease in production as a result of reduction in exports, which lead to a reduction in profits. Some other manufacturing 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 bauxite 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 FAR NORTH QUEENSLAND REGION RELATIVE TO THE REFERENCE CASE, TOTAL CUMULATIVE 2019-20 AND 2034-35.

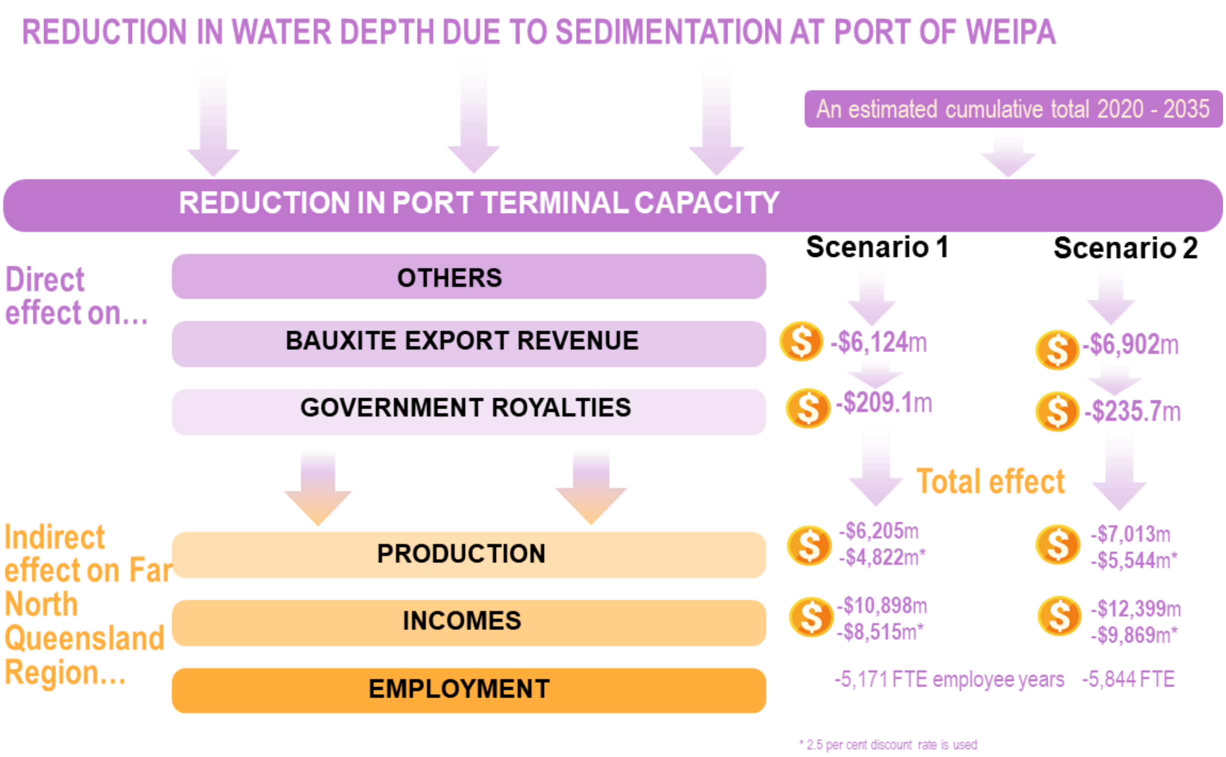


SOURCE: ACIL ALLEN CONSULTING MODELLING

4.6 Summary

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

FIGURE 4.5 ECONOMIC IMPACTS OF NO REGULAR MAINTENANCE DREDGING AT PORT OF WEIPA, 2019-20 TO 2034-35



SOURCE: ACIL ALLEN CONSULTING MODELLING

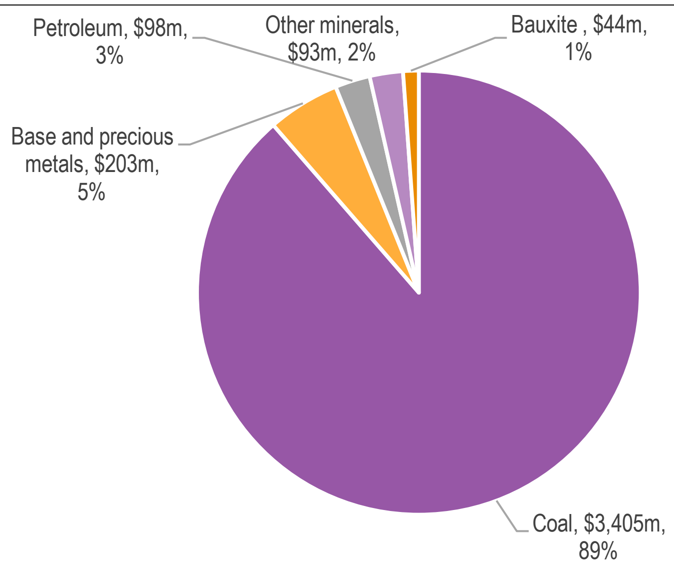
QUEENSLAND GOVERNMENT ROYALTIES 5

Loss of bauxite export revenue will have two types of effects on the bauxite royalties received by the Queensland government. For a given price, the loss of bauxite 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 2016-17 are provided in **Figure 5.1**. Coal royalty revenue constitutes over 89 per cent of total royalty revenue in 2016-17 and it is the single largest royalty revenue source for the Queensland Government. It is estimated that the Queensland Government received nearly $44 million of royalty revenue from the bauxite production in Weipa.

FIGURE 5.1 QUEENSLAND ROYALTY REVENUE, 2016-17



SOURCE: QUEENSLAND GOVERNMENT

5.2 Impact on bauxite royalty revenue

The bauxite royalty rate is calculated based on the price of bauxite 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 bauxite is A$1.4 per tonne.

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

In scenario 1, over the period 2019-20 to 2034-35, a not regularly dredged and maintained Port of Weipa would project to decrease bauxite royalty revenue by a cumulative total of A$209.1 million relative to the reference case (with a present value of A$155.1 million, using a 2.5 per cent real discount rate). This is equivalent to annual average royalty revenue loss of around A$12.3 million or around 25 per cent of bauxite royalty revenue.

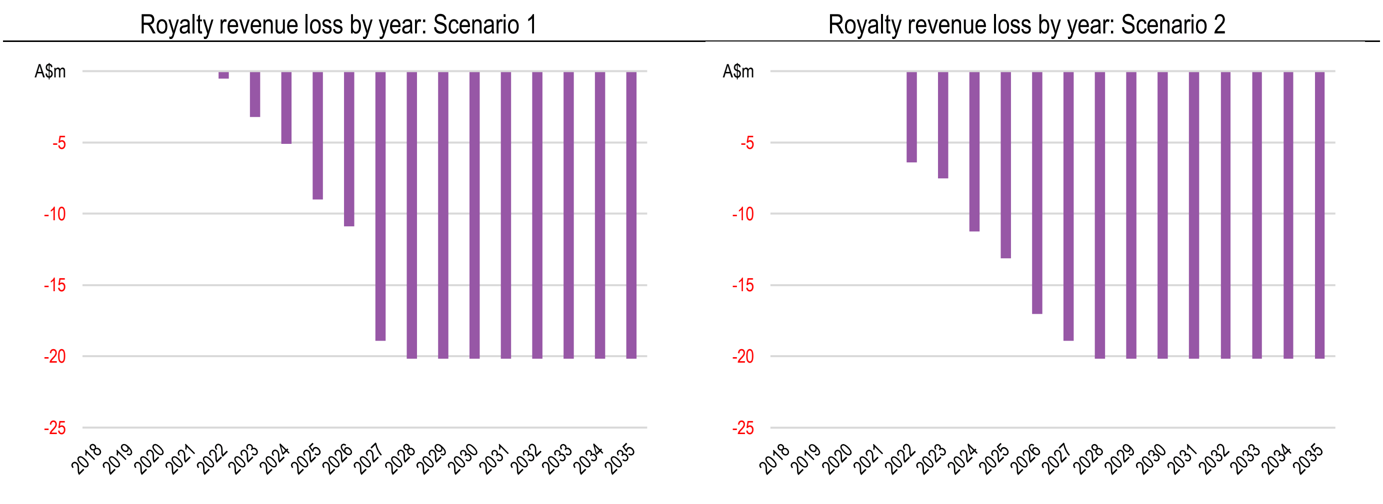
In scenario 2, over the period 2019-20 to 2034-35, a not regularly dredged and maintained Port of Weipa would project to decrease bauxite royalty revenue by a cumulative total of A$235.7 million relative to the reference case (with a present value of A$178.2 million, using a 2.5 per cent real discount rate). This is equivalent to annual average royalty revenue loss of around A$13.9 million or around 28 per cent of bauxite royalty revenue.

TABLE 5.1 BAUXITE ROYALTY REVENUE LOSSES RELATIVE TO THE REFERENCE CASE

	Annual average	Cumulative change (2017-18 to 2034-35)	
		Total	PV (@ 2.5%)
	2017-18 A$m	*2017-18 A$m*	*2017-18 A$m*
Scenario 1	-12.3	-209.1	-155.2
Scenario 2	-13.9	-235.7	-178.2

SOURCE: ACIL ALLEN CONSULTING

FIGURE 5.2 BAUXITE ROYALTY REVENUE LOSS RELATIVE TO THE REFERENCE CASE, 2019-20 TO 2034-35



SOURCE: ACIL ALLEN CONSULTING

ECONOMIC IMPACT ASSESSMENT METHODOLOGY

A

A.1 Bauxite industry and input-output relationships

An existing bauxite mining industry in Weipa 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 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 Bauxite industry in the Weipa region, 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 Weipa.

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'[17] 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.

[17] 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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