Coastal Processes and Water Quality

13. COASTAL PROCESSES AND WATER QUALITY

13.1. Introduction

This Chapter provides a description of the existing marine water quality and coastal processes in the coastal zone adjacent to study area. The possible impacts on marine water quality and coastal processes associated with the construction, operation and decommissioning of the Project are assessed and recommendations regarding mitigation of these impacts are provided.

13.2. Policy Context and Legislative Framework

As impacts on the marine water quality and coastal processes are closely related to the environment, especially the marine ecological receptors, the policy context and legislative framework contained in **Chapter 14, Marine Ecology** are of relevance. Legislation specific to coastal management is described below.

13.2.1. National Water Quality Management Strategy

The National Water Quality Management Strategy (NWQMS) is a joint national approach to improving water quality in Australian and New Zealand waterways. It was originally endorsed by two Ministerial Councils - the former Agriculture and Resources Management Council of Australia and New Zealand (ARMCANZ) and the former Australian and New Zealand Environment and Conservation Council (ANZECC).

The NWQMS aims to protect the nation's water resources, by improving water quality while supporting the businesses, industry, environment and communities that depend on water for their continued development. As part of this strategy a number of guidelines for water quality have been published, including the *Australian and New Zealand guidelines for fresh and marine water quality – 2000 (ANZECC Guidelines) which are commonly used to provide guidance on appropriate water quality criteria for both fresh and marine waters.*

13.2.2. Coastal Protection Act 1972 (CP Act)

This Act deals with the protection of the coast in South Australia and the formation and roles of the Coastal Protection Boards. The CP Act divides South Australia into six Coast Protection Districts with the Project being located in the Eyre District. The functions of the CP Act include:

- Protect the coast from erosion, damage, deterioration, pollution and misuse
- Develop any part of the coast aesthetically, or to improve it for those who use and enjoy it
- Carry out, or be involved in, research into the protection, restoration or development of the coast.

13.3. Methodology and Assumptions

To understand potential impacts of the Project, an understanding of the existing conditions have been established for:

- Wave and current flow regime
- Sediment transport and geomorphological processes
- Water quality
- Shipping activities including ship movements and shipping routes.

As the proposed construction methodology avoids the need for dredging works and will utilise a low impact piling technique, no numerical modelling is considered necessary to understand impacts on marine water quality and coastal processes from construction and operation (shipping) activities.

In addressing potential hazards and spills during construction and operation, an approach that focuses on the implementation of best-practice environmental controls is proposed.

13.3.1. Methodology

An understanding of the existing conditions has been established through desktop review of the existing studies listed below, supplemented by collecting and testing sediment samples at the Project site to understand the sediment characteristics. The desktop study was reported by BMT WBM (2013) for the purpose of this study, appended to this report as **Appendix J.1**.

The following reports have been reviewed in order to provide this baseline description:

- Olympic Dam EIS: Appendix O11.2 (BHP Billiton (BHPB), 2009) Hydrodynamic and Water Quality Modelling in Spencer Gulf: Calibration Report
- Olympic Dam EIS: Appendix O11.3 (BHPB, 2009) Initial Modelling Assessments: Scenarios for a Desalination Plant in Spencer Gulf
  Olympic Dam Supplementary EIS: Appendix H5.2 (BHPB, 2011a) Hydrodynamic and Water Quality Modelling of Spencer Gulf: Model Validation Report
- Olympic Dam Supplementary EIS: Appendix H2.1 (BHPB, 2011a) Water Quality Field Sampling Report
- Olympic Dam Supplementary EIS: Appendix H2.1 (BHPB, 2011a) Water Quality Field Sampling Report
- Port Bonython Preliminary Wave Study report (BMT WBM, 2012).

The Marine Operation Manager of Flinders Port was consulted on vessel navigation and operations at the Project. A summary of these discussions on vessel navigation and operations is provided in this Chapter and is also contained as **Appendix J.2**.

Potential impacts on water quality and coastal processes have been assessed through a desktop qualitative assessment, which is considered sufficient for the purpose of this assessment, given the nature of the Project and the proposed design and construction methodology. **Chapter 14, Marine Ecology** considers the impacts a change in water quality or coastal processes have on fauna and flora of the Upper Spencer Gulf or their habitats.

13.3.2. Assumptions and Technical Limitations

This description of the existing environment and potential impacts is limited to information available in existing reports. The description of existing water quality and sediment transport is qualitative due to limited data, but it is sufficient for general characterisation of existing conditions. The wave model results presented here are taken from an uncalibrated model; however they do provide an indication of the likely wave climate. Overall, the data available is considered sufficient for the purposes of this assessment given that the Project does not involve dredging and that water quality and sediment transport impacts are expected to be minimal.

13.3.3. Description of Significance Criteria

The significance criteria shown in **Table 13.3a** have been developed specifically for this Project. The purpose of these criteria is to ensure there is a clear and consistent means of evaluating likely impacts on marine water quality and coastal processes from the construction and operation (shipping) activities.

Table 13.3a: Impact Significance

Impact Significance/ Consequence	Description of significance
Very high	Long term irreversible change in beach and nearshore profiles. Long term irreversible change in hydrodynamic regime and seabed profiles. Long term irreversible change in marine water quality.
High	Medium to long term irreversible/ significant change in beach and nearshore profiles. Medium to long term irreversible/ significant change in hydrodynamic regime and seabed profiles. Medium to long term irreversible/ significant change in water quality.
Moderate	Short to medium term moderate change in beach and nearshore profiles. Short to medium term moderate change in hydrodynamic regime and seabed profiles. Short to medium term moderate change in water quality.
Minor	Short term or temporary (during construction) change in beach and nearshore profiles. Short term or temporary (during construction) change in hydrodynamic regime and seabed profiles. Short term or temporary (during construction) change in water quality.
Negligible	No or negligible change in beach and nearshore profiles. No or negligible change in hydrodynamic regime and seabed profiles. No or negligible change in water quality.
Beneficial	An improvement in water quality

13.4. Existing Environment

13.4.1. Wave and Current Flow Regime

13.4.1.1. Wave Regime

The wave climate at the proposed Bulk Commodities Export Facility (BCEF) is principally defined by the waves generated from the winds prevailing over Spencer Gulf.

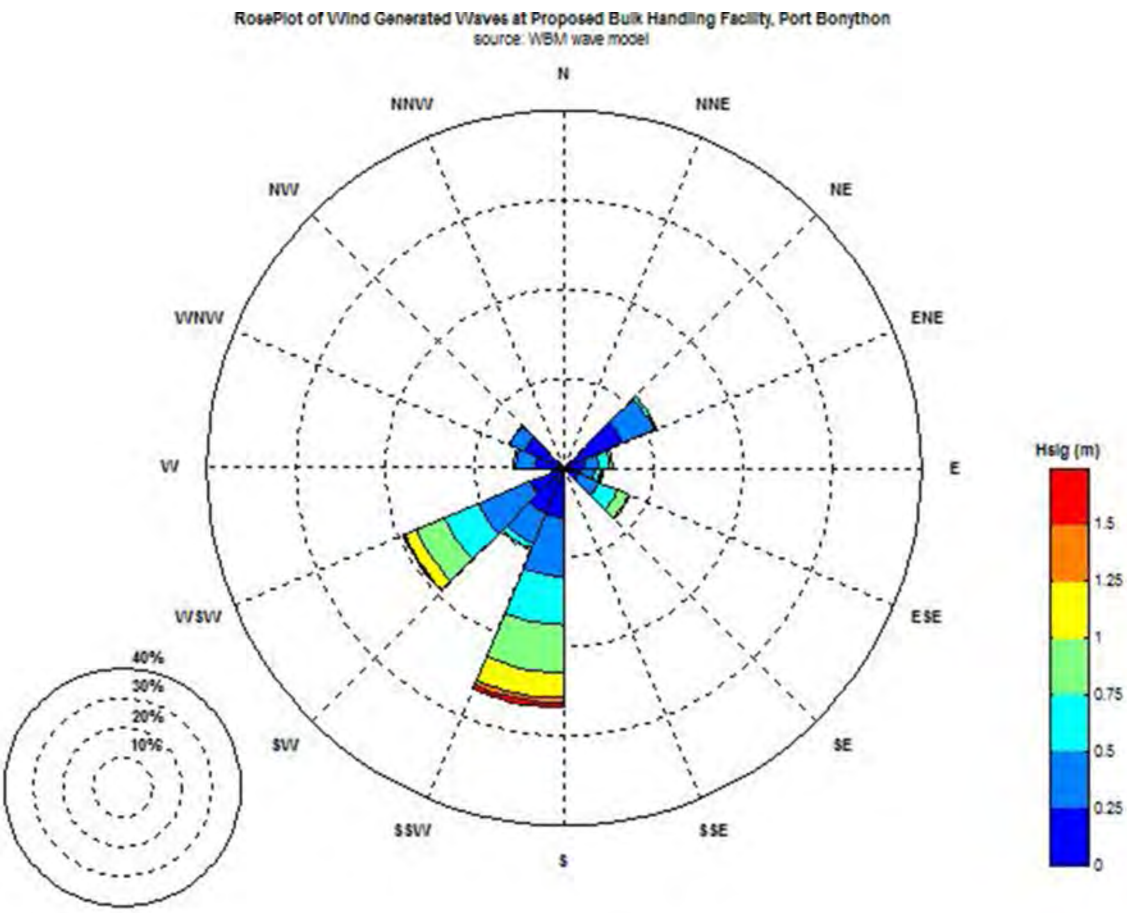
Wind generated waves are predicted to exceed one and a half metres significant wave height (significant wave height, Hsig) around 0.5 percent of the time at the proposed development with a peak period unlikely to exceed five seconds. As shown in **Figure 13.4a** the predominant wind generated wave directions are between south and west-southwest.

Appreciable seasonal variability in the wave conditions is evident with the larger events generally occurring in late winter to early spring. The influence of tidal currents and water levels could lead to increased wave heights.

The proposed BCEF is sheltered from the swell waves, generated far offshore in the Southern Ocean with peak periods of up to 20 seconds, by Thistle Island and those belonging to the Gambier and Neptune Island groups. Most of the swell wave energy is dissipated by the many shoals and banks before reaching the proposed development, where the significant wave heights of the swell waves are reduced to generally less than 0.25m.

The jetty structure of the proposed BCEF will be highly unlikely to cause changes in the wave regime, which if anything, will be very limited wave sheltering effects afforded by the steel piles.

Figure 13.4a: Rose Plot of Wind Generated Waves at the BCEF, Jan-09 to Nov-09 (extracted from BMT WBM (2013))



Current Flow Regime

The flow in the Spencer Gulf is tidally driven, with a tidal range of up to 2.7m in the northern part. Interaction between various tidal harmonic constituents leads to periods of weak neap tides. In the middle part of the Gulf the tidal regime is largely diurnal, while at the mouth and northern end of the Gulf is semi-diurnal (Easton, 1978).

The tides at Port Bonython are mixed, which means that both diurnal and semi-diurnal tide cycles occur. The tidal planes at Port Bonython are shown in **Table 13.4a**.

Table 13.4a: Tidal Planes at Port Bonython

Tidal Planes	Relative to LAT (m)	Relative to MSL (m)
Highest Astronomical Tide (HAT)	3.2	1.6
Mean Higher High Water (MHHW)	2.7	1.1
Mean Lower High Water (MLHW)	1.8	0.2
Mean Sea Level (MSL)	1.6	0
Mean Higher Low Water (MHLW)	1.4	-0.2
Mean Lower Low Water (MLLW)	0.5	-1.1
Lowest Astronomical Tide (LAT)	0	-1.6

Tides within the Gulf behave as standing waves driven by the tidal oscillation at the ocean boundary. Periodic amplification of the signal leads to large discharges through “the Rip”, which is the narrow passage adjacent to Point Lowly (Easton, 1978), to the east of the proposed BCEF. BMT WBM field measurements indicate that velocities through this section can reach over 1.5m/s (BHPB, 2009).

Tidal eddies occur in the lee sides of Point Lowly (Lewis & Noye, 1998, BHPB, 2009). During both ebb and flood tides, recirculation cells form to the south and north of Point Lowly. Measurements show the eddy formation south of the Point during ebb tides with a clockwise pattern producing an easterly alongshore flow. The magnitudes of these observed alongshore velocities are much smaller (< 10 percent) than the velocity magnitudes in “the Rip” (BHPB, 2009).

Current measurements were taken as part of BHPB (2009 and 2011a) in the vicinity of the proposed development site. The locations of the measurement points of the most relevance to this study are ‘1’, ‘C’ and ‘D’ as illustrated in **Figure 13.4b**

Current measurements at Point ‘1’ (July and August 2006) show the depth averaged current velocities of up to 1m/s were recorded during spring tide periods, with the predominant current directions being northeast (65°) during flood and southwest (245°) during ebb. Similar predominant current directions were observed in the measurements at Point D (April to June 2009), with similar magnitude of current velocities of up to 1m/s.

Measurement at Point C (April to June 2009) shows the effects of the tidal current eddy that forms in the lee of Point Lowly. At this location the current direction is predominantly easterly, up to 0.7m/s. **Figure 13.4c** shows the boat-mounted current measurements of the ebb current tidal eddy that forms in the lee of Point Lowly (BHPB, 2009), that even during a strong ebb tide the current flow in the vicinity of proposed site at Stony Point is eastwards.

13.4.2. Sediment Transport and Geomorphological Processes

13.4.2.1. Sediment Characteristics

Surface seabed sediment samples were collected on 5 March 2013 as part of this study at the locations shown in **Figure 13.4d** to better understand the characteristics of the seabed sediments.

Analysis of subsurface sediments (sedimentary profile) was not considered necessary for this study since there is no dredging work in the proposed development. Any project-related turbidity impacts will therefore be due to disturbance of surface sediments.

The field team noted that each site required a minimum of four casts of the grab sampler since the bed is well armoured at most locations by shell fragments, except at the tug berth where the sediment was sandier. Descriptions of the sediment and results of the Particle Size Distribution (PSD) analysis are given in **Tables 13.4b** and **13.4c** respectively. The results show that there is a high percentage of sand and gravel size material at most locations, limiting likely turbidity impacts.

Table 13.4b: Sediment sample descriptions taken on site

Time	Location	Echo Sounder Depth (m)	Sediment Description
10:30 AM	Approach 3	20	Muddy silty sand with shell fragments
11:00 AM	Approach 2	17	Coarse sand derived from shell grit
11:30 AM	Approach 1	13	Sandy shell grit with some mud
12:00 PM	Wharf	20-21	Muddy shelly grit
12:30 PM	Jetty 1	11	Shell material with some grit and mud
13:10 PM	Tug Berth	13	Muddy sand with some shell fragments
14:30 PM	Departing 1	21	Shell fragments mainly - little or no silt
14:45 PM	Departing 2	21	Shell fragments, coarse sand, no mud.

Figure 13.4b: Current measurement points (extracted from BMT WBM (2013))

Figure 13.4c: Measured surface velocities from ACDP transects during an ebb tide (extracted from WBM BMT (2013))

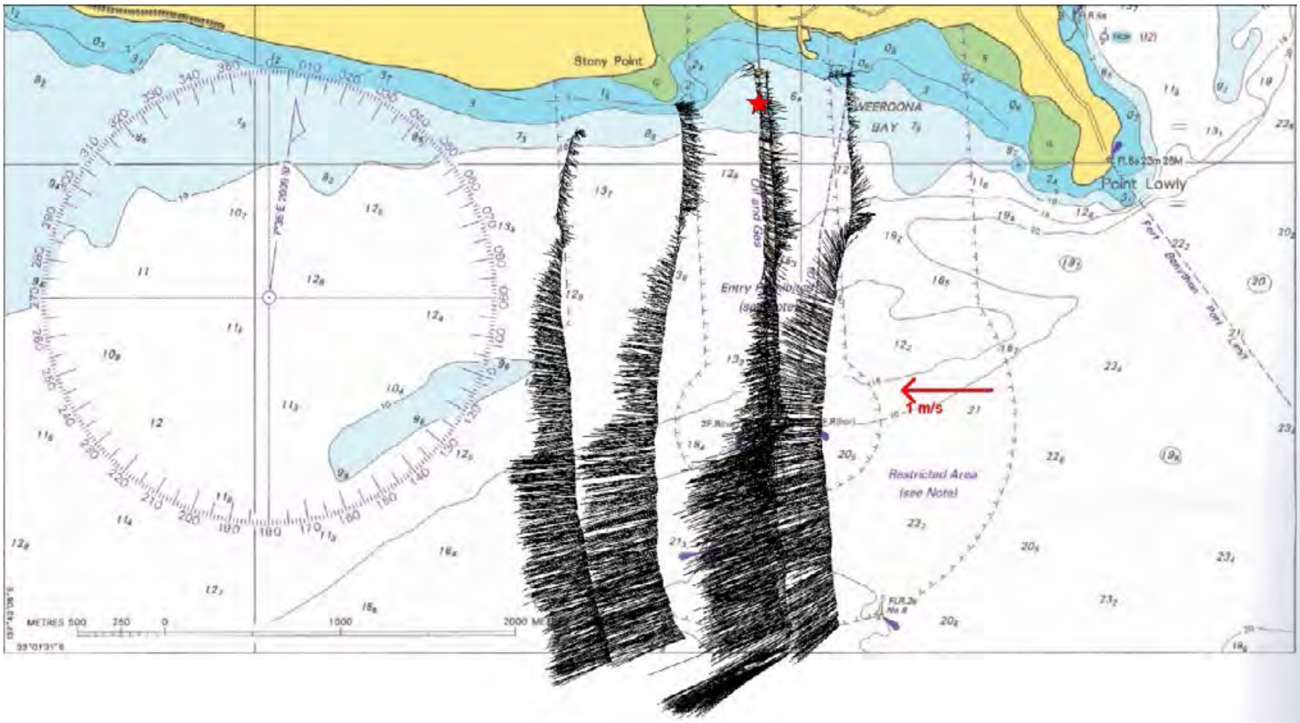


Figure 13.4d: Seabed sediment sampling locations

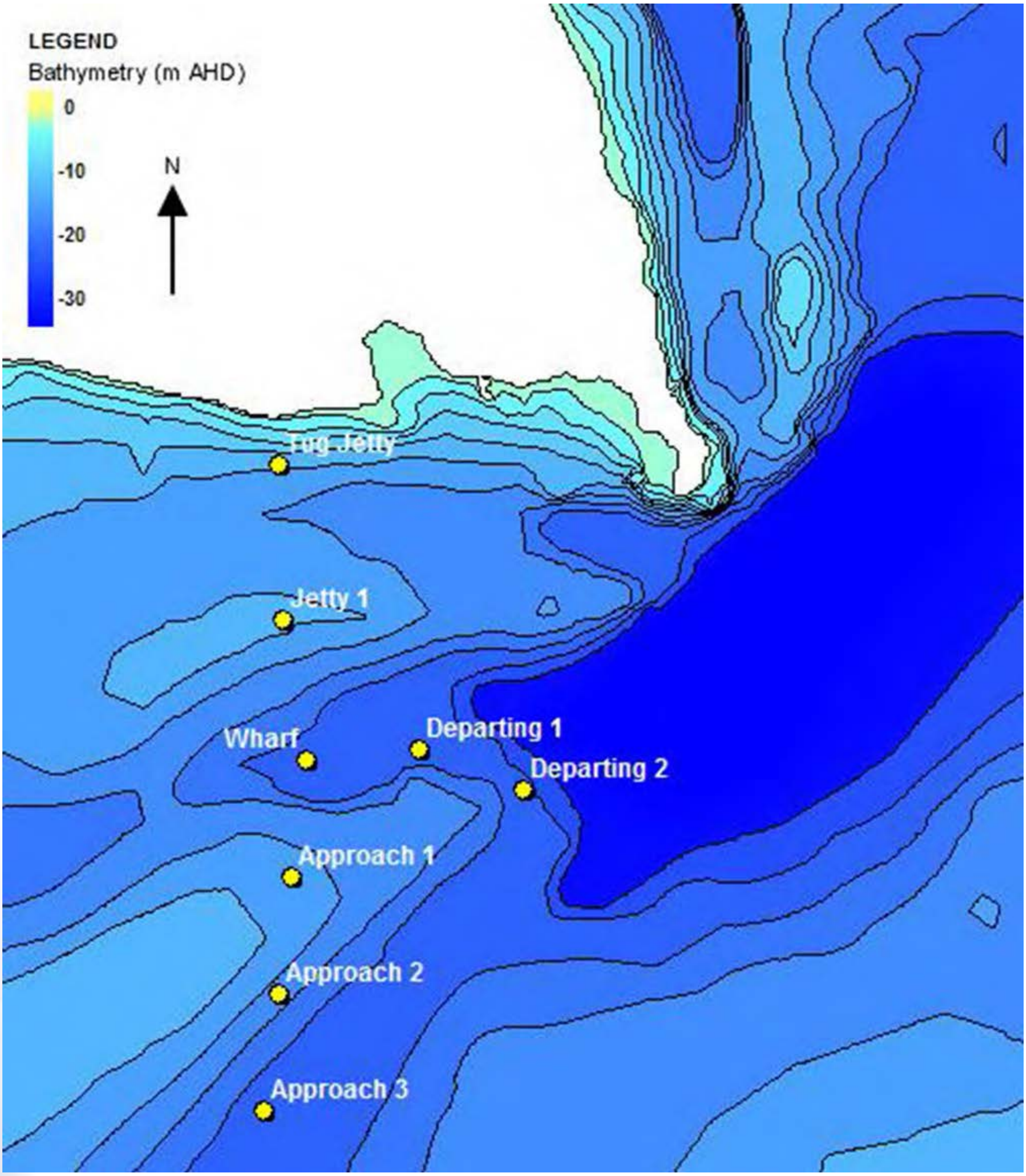


Table 13.4c: Sediment Sample PSD Results

Sample	% Silt/Clay *d* < 0.0625mm	% Sand 0.0625mm < *d* < 2mm	% Gravel (Shell) *d* > 2mm	d_{50}
Approach 3	22%	43%	35%	0.8mm
Approach 2	8%	75%	17%	0.5mm
Approach 1	8%	69%	23%	0.65mm
Wharf	13%	59%	28%	0.7mm
Jetty 1	8%	30%	62%	6.0mm
Tug Berth	20%	60%	20%	0.25mm
Departing 1	5%	27%	68%	4.7mm
Departing 2	6%	41%	53%	2.5mm
AVERAGE	11%	51%	38%	2.0mm

More detailed results of the sediment sampling and testing can be found in BMT WBM (2013) in **Appendix J.1**.

13.4.2.2. Coastal Protection

The rocky foreshore at the inner end of the proposed jetty does not have any existing man-made coastal protection, as illustrated by **Figure 13.4e**. The rocky nature of the coastline indicates that there is very limited sediment supply. Any sediment that is transported to the shoreline will tend to be subsequently transported by waves and currents around Stony Point and into the sandy embayment to the east (Weroona Bay) of the proposed BCEF site.

13.4.2.3. Sediment Transport

Based on the description of the wave and current flow regime in **Section 13.4.1.1**, the predominant littoral sand transport will be from west to east. The dominant incident wave directions are south-south-west to south and west-south-west to south-west, which will generate a longshore sediment transport potential at the shoreline which will tend to transport sediment to the east. The tidal currents near the shoreline predominantly flow toward the east, even during ebb tides.

Further offshore, the net sediment transport potential will depend on the relative magnitude of the ebb and flood tides at each location. Evidence from the previously described current measurements indicates that the current near the seabed at the end of the proposed jetty may exhibit a bias towards the ebb tide direction (approximately 245°, or westerly) which could generate a net sediment transport potential in this direction. An aerial photo of the site of the proposed jetty is shown in **Figure 13.4e**.

Figure 13.4e: Aerial Photo of the Site of the Proposed Jetty (Google Maps) (extracted from BMT WBM (2013))

13.4.2.4. Geomorphological Process

It is difficult to draw conclusions about ongoing geomorphological changes in the study area due to the lack of historical bathymetric data. The turbidity and Total Suspended Solids (TSS) data (refer to **Section 13.4.3.5**) indicate that there are active sediment transport processes occurring in the area, however it is not possible to quantify net fluxes or rates of bed level change. There is no evidence of recent or ongoing major change in either the shoreline alignment (which is rocky) or in the bed morphology along the proposed jetty alignment.

13.4.3. Marine Water Quality

13.4.3.1. Environmental Values

Appropriate ANZECC (2000) Environmental Values for the coastal waters between Black point-Point Lowly and around into Fitzgerald Bay are:

- The protection of aquatic ecosystems
- Amenity and recreation (passive and contact)
- Aquaculture
- Industrial Water Supply (because of BHPB desalination plant feed water).

13.4.3.2. General Water Quality Status

Main Water Quality Issues

The Upper Spencer Gulf region has supported major industry and urban areas for over 100 years, which has led to the discharge of effluents containing a range of pollutants. In Northern Spencer Gulf these occur principally at Whyalla (predominantly steelworks), Port Pirie (smelter) and Port Augusta (power stations). Because of the industries and the urban areas, the typical pollutants of major concern in relation to water quality are nutrients (nitrogen and phosphorus), suspended solids/turbidity and metals. At Point Lowly, there are minor sources of pollution to the marine environment from existing activities such stormwater runoff, potentially from roads, coastal home areas, stormwater runoff from the existing Santos jetty; these are of a small scale. There are no effluent discharges to the marine environment and no stormwater collection system. Major sources of nutrients from human development to the Gulf waters are provided in **Table 13.4d** and for metals in **Table 13.4e**.

As part of the investigations for the desalination plant as part of the proposed BHPB Olympic Dam Expansion, a water quality monitoring programme was undertaken to obtain baseline data. The program, reported in BHPB (2009) included the collection of samples at several locations at two depths (1m and 10m). The full results of the monitoring undertaken between August 2007 and November 2008, which included a wide range of analyses, and those of concern in this study are summarised in **Table 13.4f**, which also has the ANZECC (2000) trigger values.

BHPB (2009) indicated that the salinity range across all seasons was 40-42.5gram/Litre (g/L) with some credible evidence it may extend to 43g/L. This is significantly higher than seawater from the Southern Ocean at around 36g/L and is a result of factors such as high evaporation and low freshwater run-off creating a 'reverse estuary' with higher salinities at the head of the Gulf. Whilst annual variability is 3g/L, depth and daily variations can also exceed 1g/L (BHPB, 2009).

Table 13.4d: Current nutrient sources in Spencer Gulf - unless specified all data taken from 2009/12 National Pollutant Inventory (SEWPaC, 2013g)

Source	Location	Approx. Load (kg N/year)	Discharge type
Wastewater Treatment Plant	Port Lincoln	5400	Point source via outfall diffuser at Billy Lights Point
	Whyalla	12,000	Point source in tidal creek approximately 5km south of Whyalla
	Port Augusta (east)	21,000	Point source into ash ponds of Port Augusta Power Stations which discharges into tidal creek south of Port Augusta
	Port Pirie	15,000	Point source discharge into tidal Second Creek south of Port Pirie
Steel Manufacturing	Whyalla	220,000	Point Source discharge into tailings dam which is under tidal influence north of Whyalla
Tuna Aquaculture	Port Lincoln	1,946,000	Diffuse across the Boston Bay & Lincoln Offshore Zones
	Arno Bay	Not recorded	Diffuse discharges from farms offshore from Arno Bay
Kingfish Aquaculture	Port Lincoln	734,000	Diffuse discharges spread across a number of farms within Fitzgerald Bay, Port Neill, Arno Bay, Boston & Louth Bays.
	Arno Bay		
	Fitzgerald Bay		
	Port Neill		
Fish Processors	Proper Bay	Not recorded	Point source discharge in shallow water of Proper Bay
Power Station	Port Augusta (northern)	1700	Point source discharge at Port Augusta
Stormwater	Port Lincoln	3610	Drain outlets scattered around Boston & Proper Bays
	Whyalla	~1200	Drain outlets scattered around Whyalla
	Port Augusta	Unknown	Drain outlets scattered around Port Augusta
	Port Pirie	710	Drain outlets scattered around Port Pirie
Agriculture	Tod River	Estimated between 1000 – 10,000	Point source estuarine discharge at Louth Bay but infrequent discharge based on rainfall
	Broughton River	Unknown	Infrequent discharge based on rainfall but likely to be poor quality when flowing

Table 13.4e: Current metal sources in Spencer Gulf - unless specified all data from 2009/10 National Pollutant Inventory (SEWPaC, 2013g)

Industry	Facility	Location	Arsenic (kg As)	Cadmium (kg Cd)	Chronium (kg Cr total)	Copper (kg Cu)	Lead (kg Pb)	Manganese (kg Mn)	Mercury (kg Hg)	Nickel (kg Ni)	Zinc (kg Zn)
Steel Manufacturing	'Arrium' Wyhalla	Whyalla					5	240			950
		Arrium's liquid effluent is discharged into the tailings dam where diffusion through the slag walls and tidal mixing through the northern boundary disperses the effluent into the marine environment. Ammonia is also a significant pollutant from this facility but is covered in the section above.									
Lead & Zinc Smelter	Nyrstar	Port Pirie	250	310		320	3500	4700		350	19,000
		Nyrstar's liquid effluent is discharged into the small mangrove lined First creek. Tidal mixing then disperses the effluent into the marine environment.									
Power Stations	northern	Port Augusta	260	8	57	11		1	5	8	
	Playford	Port Augusta	100	3	22	4.4	4.4	68	2	3	
		The Alinta Power stations cooling water effluent is discharged into large ash ponds to the north of the facilities, The suspended material settles out and the effluent flows out through the small mangrove lined Hospital creek where tidal dispersion mixes the effluent with the marine environment.									
Stormwater	Multiple locations throughout Spencer Gulf	Metal loads in stormwater runoff are highly variable depending on the number of days between rainfall events, metal loads in source catchments and volume and intensity of individual rainfall events. For these reasons it is unwise to estimate metal loads based on very little data.									

Table 13.4f: Marine Water Quality data for the period September 2007-November 2008 (BHPB, 2009)

	Santos Jetty Fire Pump			A1		
	Min	Max	Avg	Min	Max	Med
Physicochemical						
pH	8.1	8.1	8.2	7.62	8.36	8.05
Conductivity (mS/cm)	58.6	60.6	59.8	56.3	64.7	61.21
Turbidity (NTU)	1	8	3	0.0	26.0	2.2
Suspended solids (mg?L)(1.2ug)	5.3	17.0	10.5	2.0	22.0	4.6
DO (mg/L)	-	-	-	3.81	10.75	8.6
DO (% sat)	-	-	-	86.5	140.9	120.4
Nutrients (mg/L)						
Ammonia as N	0.007	<0.005	0.01	<0.005	<0.1	<0.005
NOX as N	0.006	<0.005	0.008	<0.005	<0.1	<0.005
TKN as N	<0.05	0.62	0.239	0.08	<1.0	0.14
Total N as N	<0.06	0.62	0.247	0.10	<1.0	0.15
PTotal as P	0.011	0.023	0.017	0.007	0.015	0.011
Reactive P as P	<0.005	0.006	0.006	<0.005	0.0	<0.005
TOC	0.0	1.3	1.1	0.9	2.5	2.0
Chl a	0.77	1.5	1.1	0.3	2.0	0.8
Metals (ug/L)						
Iron Total	<5	6	6	<5	80	13
Iron dissolved	<5			<5	9.5	<5
Arsenic	,1	2	2	0.7	2.6	2.2
Cadmium	<5			<0.2	<0.2	<0.2
Chromium	7	7	7	<0.5	0.7	<0.5
Cr hexavalent	0.002			<0.002	<0.002	<0.002
Copper	<10	11	11	<1	12	3
Lead	<5			<0.2	5.3	0.4
Zinc	<30	32	30	<5	34.5	<4

Note:

Sample location A1 is at east of SANTOS jetty, west of Point Lowly, at 1m depth.

Sample location A10 is at east of SANTOS jetty, west of Point Lowly, 1m depth at 2-3m from seabed.

Sample location B1 is at Fitzgerald bay, north of Point Lowly, at 1m depth.

Sample location B10 is at Fitzgerald bay, north of Point Lowly, at 2-3m depth.

	A10			B1			B10			ANZECC (2000) trigger values
	Min	Max	Med	Min	Max	Med	Min	Max	Med	
	7.49	8.36	7.95	7.59	8.31	7.99	7.65	8.33	7.99	8-8.5
	56.4	64.82	62.03	56.7	65.3	62.65	56.8	65.2	62.65	
	0.0	23.0	2.6	0.0	20.4	2.4	0.0	27.0	2.38	0.5-10
	2.2	22.5	5.5	2.8	23.5	4.4	2.5	18.0	4.4	
	3.62	10.79	8.55	3.86	10.6	8.15	3.82	10.67	8.07	
	85.3	135.1	124	88.4	135	109.9	87	133	109.4	
	<0.005	<0.1	<0.005	<0.005	<0.1	<0.005	<0.005	<0.1	<0.005	50
	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	50
	0.09	<1.0	0.14	0.10	<1.0	0.13	0.1	<1.0	0.15	
	0.10	<1.0	0.15	<0.10	<1.0	0.13	<0.1	<1.0	0.15	1000
	<0.01	0.013	0.012	0.007	0.020	0.014	0.007	0.020	0.012	100s
	<0.005	0.0	<0.005	<0.005	0.0	<0.005	<0.005	0.0	<0.005	10s
	0.9	2.0	1.5	0.9	2.0	1.9	0.9	2.0	1.5	
	0.3	1.1	0.9	0.4	1.4	<1	0.5	1.4	<1	1s
	6	57.5	19.5	5.5	31.5	14	<5	28.5	15.5	ND
	<5	15.5	<5	<5	9	<5	<5	15	<5	ND
	0.8	2.8	2.2	0.8	2.8	2.2	0.6	2.9	2.05	ID
	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.7/5.5
	<0.5	1.7	<0.5	<0.5	0.9	<0.5	<0.5	<0.5	<0.5	7.7/27.4
	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.14/4.4
	<1	11	2	<1	8.5	2	1	11	2.5	0.3/1.3
	<0.2	2.9	0.4	<0.2	2.3	0.5	<0.2	2.8	0.6	2.2/4.4
	<5	15	<5	<5	14	<5	<5	20	5	7/15

13.4.3.3. Nutrients

Examining **Table 13.4d**, it is noted that all nutrient concentrations are below the ANZECC (2000) trigger values, particularly the soluble (bioavailable) fractions. Steer et al (2013) describe the waters of northern Spencer Gulf as being low in nutrients (oligotrophic), which is apparent in the concentrations in **Table 13.4d**

In the Adelaide metropolitan coastal waters nutrient discharges have been confirmed as a major cause of seagrass loss (Bryars et al, 2011). In False and Fitzgerald Bays there has been a loss or degradation of approximately 20 square kilometres of seagrass, largely attributed to the steelworks. It is also considered likely by Steer et al (2013) that nutrients from anthropogenic sources are reaching the Black Point to Lowly Point waters and may contribute to the filamentous *Hincksia sordid* blooms, which frequently occur and cause extensive growths on the subtidal inshore reef.

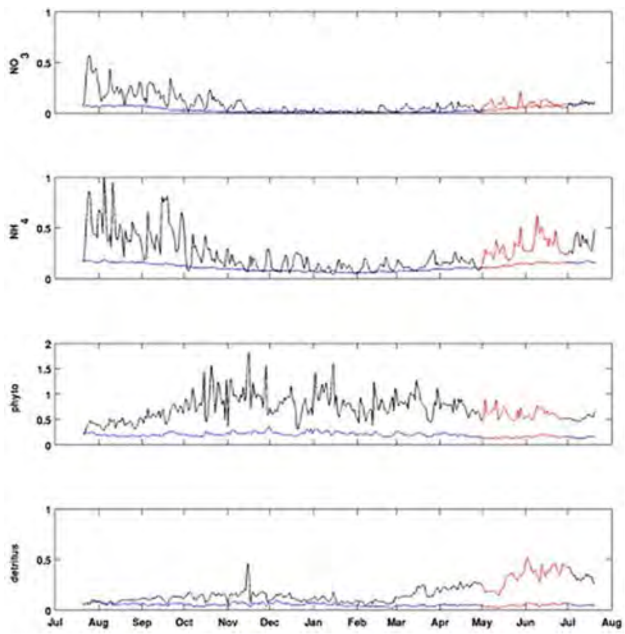
The nutrient data in **Table 13.4d** will not suggest any significant nutrient enrichment, which is not unexpected because of rapid uptake of available nutrients by plants, including opportunistic species such as *Hincksia sordid* and species such as *Ulva sp*. One of the mechanisms of seagrass decline is the prolific growth of epiphytic algae on the seagrass blades (Bryars et al 2011). It is suggested that in oligotrophic waters that total nitrogen will be a better indicator of nutrient status as it includes the organic fraction and some indication of phytoplanckton biomass in the water column as does measurements of chlorophyll ‘a’.

Steer et al. (2013), described the development by the South Australian Research Development Institute (SARDI) of a hydrodynamic-biogeochemical model for Spencer Gulf (refer Middleton et al. 2009). It has been used to investigate the connectivity of anthropogenic inputs into the Black Point- Point Lowly coastal area. It simulates the transfer of nitrate and ammonium through the lower trophic levels (phytoplankton, zooplankton and detritus); it also includes a benthic component that includes nitrification and denitrification, processes that are critical to nutrient cycling and ecosystem functioning in shallow waters. The results, shown in **Figure 13.4f**, indicate higher concentrations at Black Point and Point Lowly.

Overall, the current nutrient levels will meet the requirements for the protection of marine ecosystems, noting that the soft bottom and reef areas support diverse and healthy biological communities (Refer to **Chapter 14, Marine Ecology**).

Figure 13.4f Time series of modelled daily average, bottom concentrations of nitrate (NO3), ammonium (NH4), phytoplankton and large detritus predicted by the Spencer Gulf biogeochemical model for 2010/11 at Point Lowly. Blue and black lines represent the predicted concentrations for model scenario studies with nutrients supplied naturally from the model boundaries as well as anthropogenic sources, respectively. Red segments indicate months corresponding to the aggregation of cuttlefish at Point Lowly. All fields have common units of mmol N m-3 (Steer et al, 2013).

Figure 13.4f: Time series of modelled daily average



13.4.3.4. Metals

Studies undertaken of the environmental impact of metal discharges from Arrium (Whyalla) and the Port Pirie Smelter, the main sources reviewed by Steer et al (2013) indicate that the effects are confined to areas around Whyalla and Port Pirie. False and Fitzgerald Bays are unlikely to have been exposed to appreciable concentrations.

BHPB (2009) as part of the draft EIS for the Olympic Dam Expansion took sediment samples from 37 sites offshore of Point Lowly. No sample had contaminant levels above screening levels.

13.4.3.5. Turbidity

Measurements of turbidity and TSS were undertaken in the Port Bonython area as part of the Olympic Dam Expansion Project EIS (BHP Billiton, 2009). Two nephelometers recorded time series of turbidity at mid-depth at the two locations shown in **Figure 13.4g**. The turbidity measured during March 2008 showed a typical range of between 2 and 12 Nephelometric Turbidity Units (NTU), with peaks of up to 17 NTU during periods with stronger southerly winds. Turbidity measurements at the same offshore location during June 2008 showed lower turbidity levels less than 4 NTU. Turbidity measured at the inshore location during June 2008 varied from 0 to 20 NTU, with peaks during periods of strong southerly winds. TSS measurements were undertaken on 24 and 25 July 2008 along four transects (shown in **Figure 13.4g**). The TSS at all locations was less than 4 milligrams per litre (mg/L).

Figure 13.4g: TSS and Nephelometer Measurement Locations (from BHP Billiton 2009)

This data indicates that some sediment is mobilised and transported by spring tidal currents, since spring-neap variation in turbidity levels was apparent. It is also clear that wind generated waves cause entrainment of sediment during periods of southerly winds, particularly in nearshore areas. It is apparent that suspended sediment levels are generally higher in summer months than in winter.

Measurements of TSS were also undertaken as part of the Supplementary EIS for the Olympic Dam Expansion Project (BHP Billiton, 2011a) at a location approximately 700 metres west of Point Lowly. TSS levels of up to 25mg/L were recorded, however it was noted in the report that some of the measurements were affected by methodological issues and may not be accurate. Turbidity measurements were generally low (less than 10NTU).

13.4.3.6. Faecal Microorganisms

As indicated in the results of sample analysis from the Santos monitoring program (Refer to **Chapter 15, Marine Ecology**), all results for enterocci and E. coli, used as indicators of potential faecal contamination, were low with only a few or nil detected. This is not surprising as there are no effluent discharges or significant stormwater sources. In accordance with NHMRC (2006), this area will be considered as having a low risk.

13.4.3.7. Hydrocarbons

All of the analytical results for hydrocarbons were below the limits of detection. In 2009 groundwater contamination was reported at the Santos site (Steer et al, 2009), which had the possibility of intersecting with the intertidal zone. Subsequent monitoring of the intertidal zone found no evidence of hydrocarbons or ecological impact. The monitoring included the use of the Hairy mussel (*Trichomya hirsute*) and the translocated Mediterranean mussels (*Mytilus galloprovincialis*) as sentinel monitors.

13.4.3.8. Historical Oil Spills

As summarised by Gaylard (2011), in 1992 a ship to ship incident between the tanker 'ERA' and the tug boat 'Turmoil' occurred at the Santos jetty, resulting in the spillage of 300t of bunker oil. Strong north-west winds at the time pushed the spill to a front of approximately ten kilometres which impacted on the dense mangrove habitats south of Port Pirie between Fourth and Sixth Creek. Procedures in an oil spill contingency plan were followed in order to minimise impacts. Nevertheless the spill resulted in between 75-100 hectares (ha) of mangroves being oiled.

Approximately two to three hectares of heavily oiled areas were initially defoliated increasing to 3.2ha over the next three to four years. By 1996 there were no widespread signs of recovery (Wardrop et al 1996). It was estimated that approximately 60 tonnes of the oil had reached the mangroves (Pfennig, pers comm.). It is intended that the area be resurveyed in the near future, but examination of recent aerial photographs indicates that recovery is slow with most of the area remaining the same.

13.4.4. Existing Shipping Activities and Operations

13.4.4.1. Shipping Activities

Flinders Ports undertakes the management of shipping operations in Spencer Gulf including Upper Spencer Gulf, which includes Port of Whyalla, a Cape Transhipment Point (CTP), Port Pirie, Port Augusta and Port Bonython (Santos Jetty). Shipping routes to Port of Whyalla, Port Pirie, Port Bonython (Santos Jetty) and the CTP are shown in **Figure 13.4h**.

Figure 13.4i shows the annual vessel calls at the existing ports/CTP area. Currently Cape-size vessels up to 180,000 Dead Weight Tonnage (DWT) travel through Spencer Gulf to the boundary of the Port of Whyalla port limit and at the CTP area. In addition, gas tankers up to 110,000 DWT travel through Spencer Gulf to Port Bonython (Santos Jetty). Vessels calling at Port Pirie and Whyalla range in size considerably but are all significantly smaller than those calling at Port Bonython (Santos jetty).

The existing shipping channel as recommended by Australian Admiralty Chart 778 is along a route with water depth of 20m at Lowest Astronomical Tide (LAT) with the exception of the Yarraville Shoals where the water depth is slightly less than 20m (19.6m) at LAT, and on the vessel departure route (see Figure 13.4j) near Navigation Beacons 5 and 7 where the water depth is approximately 18.5m at LAT.

Figure 13.4h: Shipping (piloted and unpiloted) routes to these existing ports and CTP and the proposed shipping route for the proposed BCEF. (Flinders Ports, 2013)

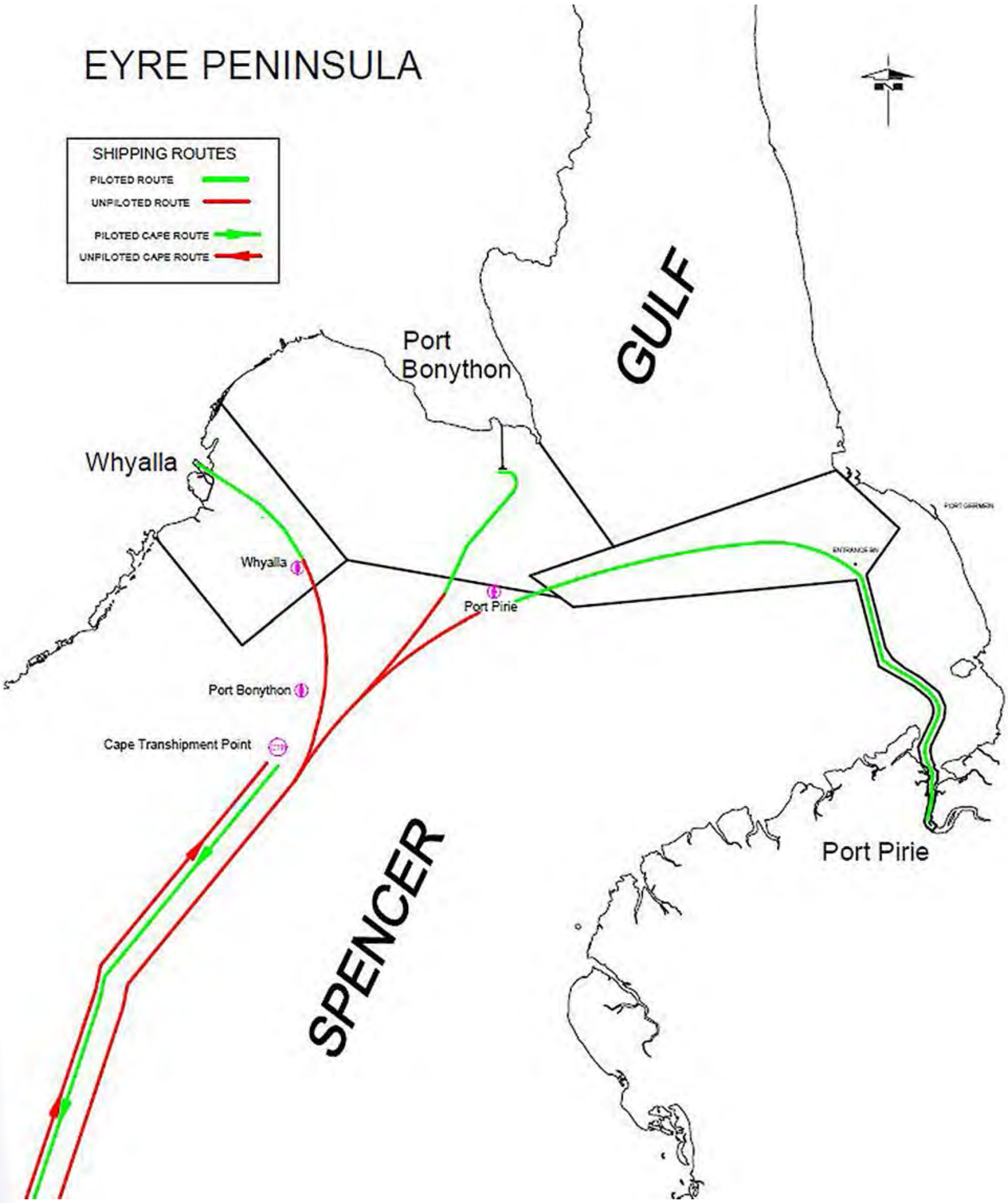
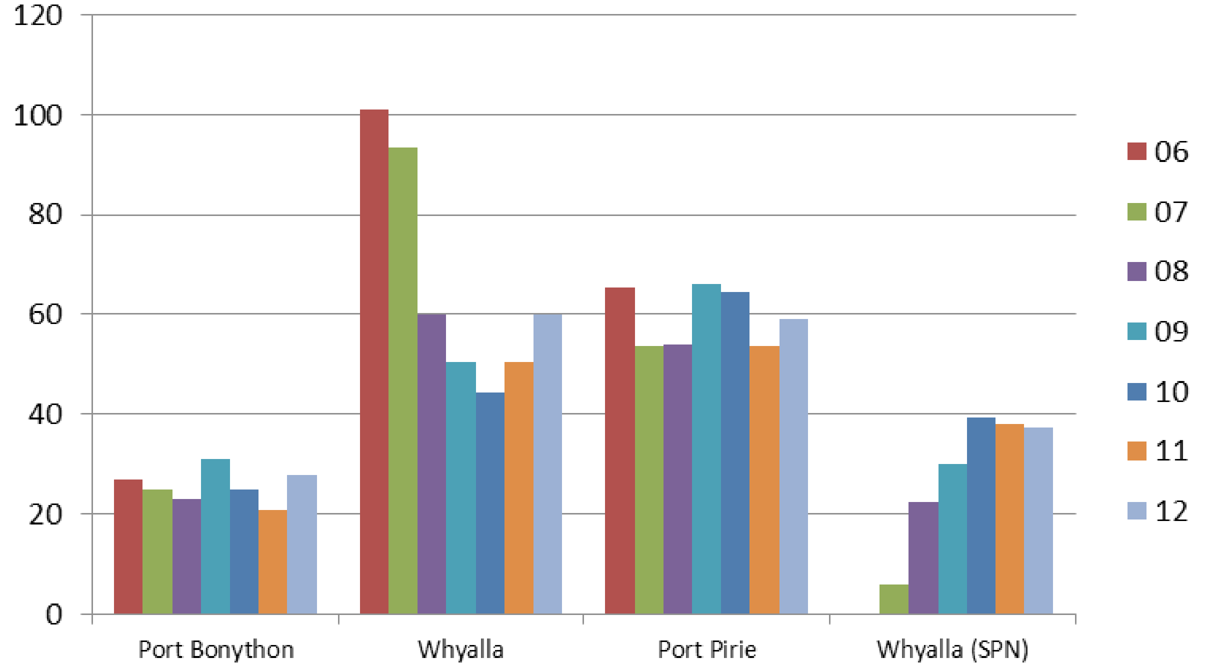


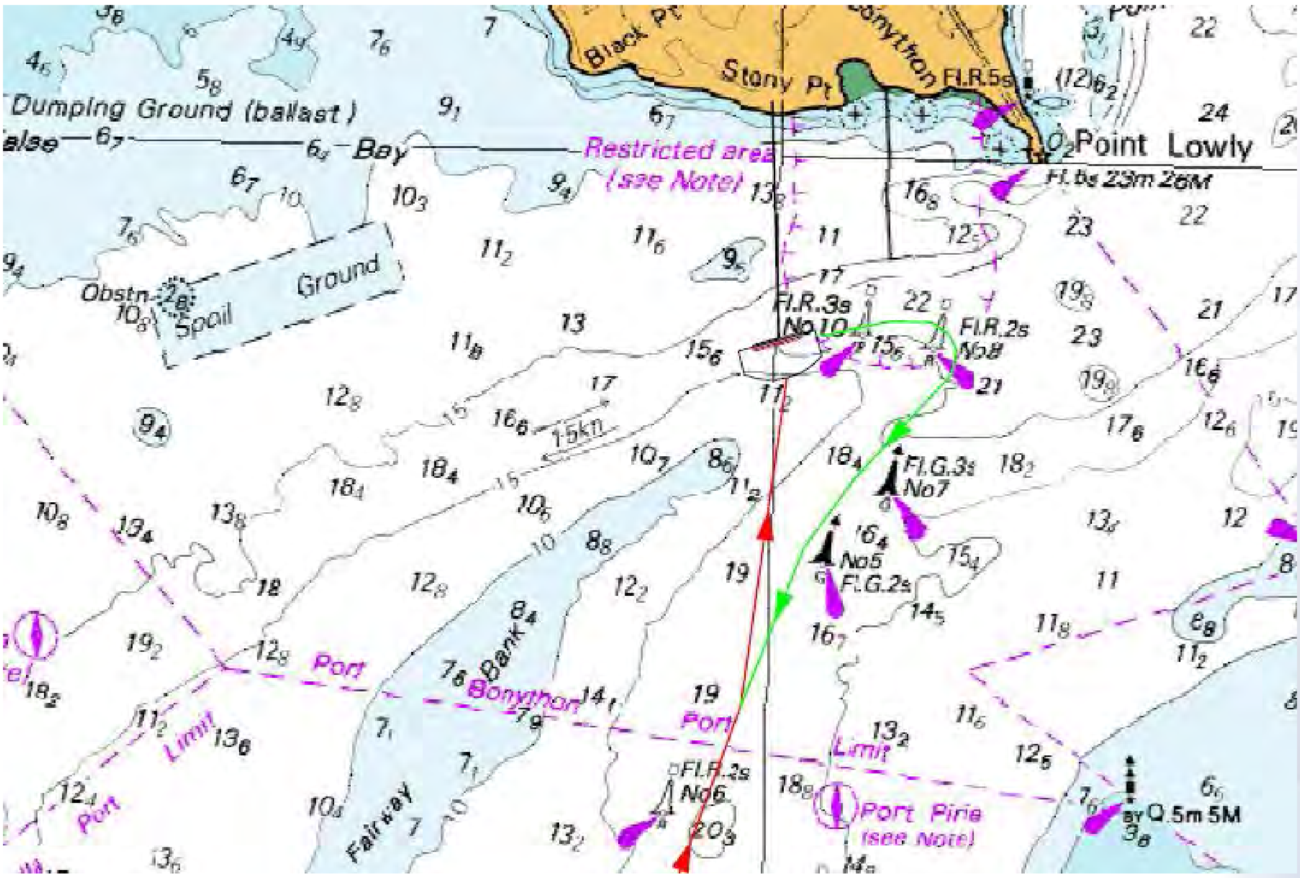
Figure 13.4i: Annual vessel calls (2006 to 2012 financial year) at existing ports/transhipment area provided by Flinders Ports.



13.4.4.2. Shipping Activities of the Proposed BCEF

The proposed development is expected to receive approximately 277 vessel calls per annum. This will be less if the full 50 Mega Tonnes Per Annum (Mtpa) capacity of iron ore handling is not delivered. The ships calling at the proposed BCEF will be largely using the existing shipping route, apart from at the approach and departure routes in the vicinity of the Project, as shown in **Figure 13.4j**.

Figure 13.4j: Proposed shipping routes in the vicinity of the proposed development



The maximum proposed design vessel is the Cape-size bulk carrier with the smaller Panamax bulk carrier also able to utilise the Port Gulf. Photos of unloaded and loaded Cape-size vessels are shown in **Figure 13.4k** and **13.4l**. Note the significant difference between unloaded and laden conditions.

Figure 13.4k: Capesize vessel laden

Figure 13.4l: Capesize vessel unloaded

The key design vessel details are presented in **Table 13.4g** showing the design vessel parameters/ dimensions.

Table 13.4g: Design vessel parameters/dimensions (From Flinders Port and Arup analysis)

Vessel Detail	Parameter	
Vessel Type	Cape-size Bulk Carrier	Panamax Bulk Carrier
Dead Weight Tonnage (DWT)	180, 000 T	80,000 T
Displacement	213,200T	98,800T
Length Overall (LOA)	290m	250m
Fully Laden Draft	18.3m	11.5m
Ballast Draft	11.5m (max.)	8.0m (max.)
Beam	48.5m	32.2m
Hatch Length	220m	195m

The berthing and de-berthing of the Cape-size bulk carriers will be assisted by tug boats of 70T bollard pull.

It is noted that during the construction of the jetty it is expected that there will be 20T bollard pull tug boats assisting the movement of barges during the construction. There are also other smaller marine crafts including crew boat and rescue boat.

The gross underkeel clearance for vessels manoeuvring in the Spencer Gulf is 0.9 m or 10 percent of the vessel draft (whichever is greater), as required by Flinders Ports. For the fully laden Cape-size vessel this corresponds to a required gross underkeel clearance of 1.8m and hence the Cape-size vessel requires a water depth of 20.1m when manoeuvring or underway. **Table 13.4h** presents the required water depths for the design Cape-size bulk carrier when entering Spencer Gulf, manoeuvring to and from the proposed berth at the BCEF and departing Spencer Gulf.

Table 13.4h: Cape-size vessel water depth requirements (Arup analysis)

Vessel draft situation	Unloaded	Fully laden
Description	Vessel entering Spencer Gulf and manoeuvring to berth	Vessel at/ leaving berth and manoeuvring out of Spencer Gulf
Vessel draft	11.5m	18.3m
10% gross underkeel clearance when manoeuvring	1.2m	1.8m
Required water depth when manoeuvring	12.7m	20.1m
Required water depth when manoeuvring at LAT	12.7m	20.1m
Required water depth when manoeuvring at MLLW	12.2m	19.6m
Required water depth when manoeuvring at MHLW	11.3m	18.7m
Required water depth when manoeuvring at MSL	11.1m	18.5m

The required water level for safe vessel manoeuvring increases with increase in sea bed level. It is noted that the existing operation procedures of Flinders Port require fully laden vessel to depart from the berth within two hours prior to high tides for safe navigation through the departure route and Yarraville Shoals.

13.5. Potential Impacts

13.5.1. Relevant Construction Elements/ Operational Activities

The key design elements, construction activities and operational activities that may have an impact on the marine water quality and coastal processes are:

- The jetty abutment, referred to as "groyne" in BMT WBM (2013)
- The steel piles (during construction and long term impacts)
- Construction waste management
- Waste management (during operation)
- Oil spills
- Ship movements.

13.5.2. Beach and Nearshore Profiles

13.5.2.1. Jetty Abutment

As indicated in **Section 13.4.2.2**, the rocky foreshore at the inshore end of the proposed jetty does not have any existing coastal protection. The rocky nature of the coastline indicates limited sediment supply. Any sediment that is transported to the shoreline will tend to be subsequently transported by waves and currents around Stony Point and into the sandy embayment to the east of the proposed development site.

Drawing 60051283-SK-021 Rev C in **Appendix E.1** has been used to assess potential impact of the embankment on the longshore transport. This drawing indicates that the structure will extend approximately 30m below the Mean Higher High Water (MHHW) contour. Assuming seaward slope of the embankment is the same as the landward slope of the embankment, it is likely that the toe will be located approximately 2m below MHHW or around Mean Lower Low Water (MLLW) (refer to **Table 13.4a**). In this case the embankment will be located completely within the tidal range and allow any significant sand transport to occur past the toe of the structure.

It is therefore considered that there will be negligible change in beach and nearshore profiles due to the jetty abutment. Armour protection to the jetty abutment will be designed against potential scouring due to wave and current flow.

13.5.3. Hydrodynamic Regime and Seabed Profiles

13.5.3.1. Steel Piles

Drawing 60051283-SK-029 Rev A in **Appendix E.1** has been used to assess potential impact to nearshore sediment transport. The drawing indicates that the jetty will be supported by one metre diameter steel piles in groups of two. The nearshore piles will be spaced at approximately 5m centres laterally and approximately 32m centres longitudinally for the first kilometre, beyond which at approximately 16m centres.

The depth averaged tidal currents measured at Point 1 in July and August 2006 range between 0.5m/s and 1m/s during spring tide periods, and the direction of the current was predominantly 65°N (flood) and 245°N (ebb). These currents will have the potential to transport sands and silts.

The diameter and spacing of the piles is such that the regional interference to tidal flow will be negligible. The magnitude of the flow velocity indicates that there may be local scour around the piles however this will not influence broader sediment transport processes.

It is therefore considered that there will be negligible change in the hydrodynamic regime and seabed profiles.

13.5.4. Water Quality

13.5.4.1. Jetty Abutment

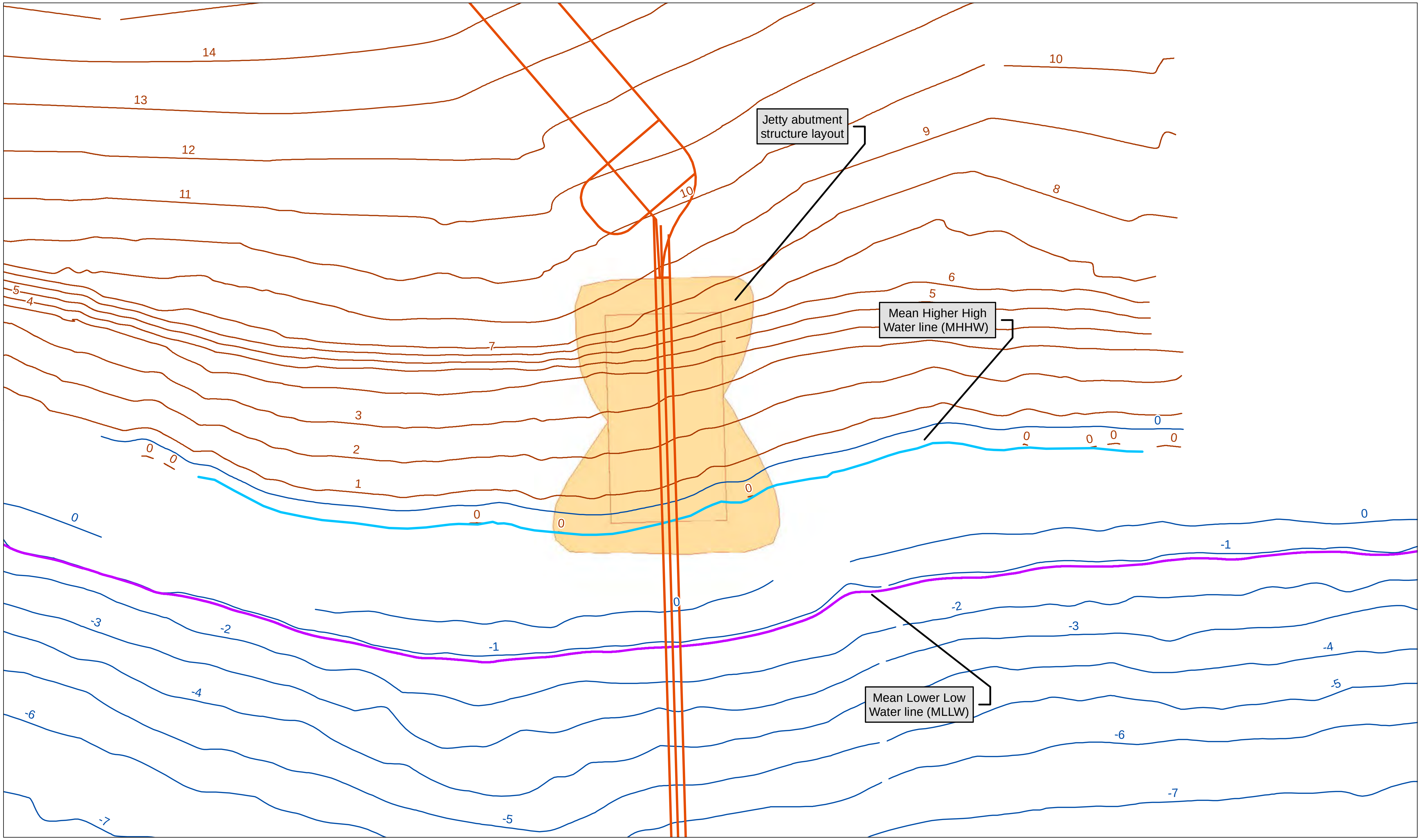
During the construction, in the inter-tidal zone, a rock bund will be constructed on the outer slope of the abutment together with geotextile filters to prevent loss of fill material. The construction of the jetty abutment has therefore negligible impact on turbidity.

The jetty abutment including the rock bund is approximately 100m wide and will extend approximately 15-30m into the upper inter-tidal zone. It will not extend into the sub-tidal zone.

The location of the jetty abutment and its interface with the inter-tidal zone is shown in **Figure 13.5a**.

Figure 13.5a: Jetty Coastal Interface

Figure 13.5a: Jetty Coastal Interface



Port Bonython EIS
Spencer Gulf Port Link

Figure 13.5a -
Jetty Coastal Interface

Legend

- Mean higher high water line
- Mean lower low water line
- Terrain contours
- Bathymetry contours

Due to inconsistenacies in the land-based and marine-based terrain data, these tidal lines are only indicative at this stage. They will be refined at a later stage once the terrain data has been reviewed.

ARUP

Spencer Gulf Port Link

1:1,500 (at A3)

0 25 50 100
Meters

Map Projection: Transverse Mercator
Horizontal Datum: Geographic Datum of Australia
Grid: Map Grid of Australia 1994, Zone 53

13.5.4.2. Steel Piles

Installation of steel piles could have an impact on turbidity, but it is expected that the effects will be localised and transitory. It is difficult to quantify the effects without physical measurement of the sediment release from pile driving as there is very limited data.

Compared to dredging, it is an activity that has minimal effect. A monitoring study was undertaken for the Columbia River bridge project (Evans and Associates, 2011) to examine effects of piles installation, with both hammer and vibrational piling. The monitoring found that at 10m and 200m from the piles turbidity increases were low, between 2-3 NTU, which was less than the natural variation for the monitoring period (Evans and Associates, 2011). Even though it was in more estuarine conditions, it nevertheless illustrates the fact that there was only a small transient effect.

The current proposal indicates that open ended (hollow) pile of approximately 1 – 1.2m diameter (pending final design) will be driven into the seabed. It has considerably less disturbance to sediment compared to solid piles. Considering the use of hollow piles and outcome of the Columbia River monitoring study, impacts of the piles installation are considered negligible.

The installed steel piles there will have negligible impact on hydrodynamic regime and hence will not be expected to increase the amount of suspended sediment.

13.5.4.3. Construction Waste

The construction of the jetty abutment on the foreshore and jetty structures above water may generate construction waste. As described in **Chapter 19, Environmental Management Plan,** the contractor is required to prepare a Construction Waste Plan to ensure that measures are in place including storage of waste on barges or in skips high enough from wave actions, and temporary works to prevent waste falling into the sea.

There will therefore be very low risk of construction waste affecting water quality.

13.5.4.4. Oil Spills

In Australia there are multiple layers of precautions taken to avoid oil spill impacts. The National Plan to Combat Pollution of the Sea by Oil, Noxious and Hazardous Substances requires each state and the Northern Territory to prepare contingency plans in the event of oil, noxious or hazardous spills in their jurisdictions. In response South Australia has prepared the South Australian Marine Spill Contingency Action Plan (SAMSCAP).

Oil spills are classified according to the amount of oil lost, as follows:

- Tier one – up to ten tonnes – small spill, local response
- Tier two - ten to 1000 tonnes – medium sill, regional and interstate response
- Tier three – above 1000 tonnes – large spill, national and possibly international assistance.

Flinders Ports has the equipment for a Tier one response. There is also a Spill Contingency Plan for Port Bonython (AGC, 1988a,b), which compliments the SAMSCAP and National Plan. The Spill Contingency Plan outlines site specific response strategies for various coastal types (rock platform, shingle, sandy beach, seagrass, mangroves etc.) and their ecological sensitivities, based on a coastal sensitivity map and priority ranking prepared by Manning (1984).

Regular training sessions and exercises are held at a number of ports on an annual basis. Oil Majors along with assistance from Australian Maritime Safety Authority (AMSA) also have a major stockpile of oil spill equipment and dispersants in Australian Maritime Oil Spill Centre (AMOS) in Geelong.

Fuelling of some of the construction vessels may occur at the tug wharf. This will be by road tanker and will involve diesel fuel oil. There will be no storage of fuel for vessels on the construction site. This avoids the need for storage tanks and fuel pipelines with all the associated risks of breakages or leaks.

There will be no Cape-size or Panamax vessel refuelling for vessels utilising the BCEF hence there is no risk arising from refuelling activities.

There could however be oil spill from a collision of ship with the jetty structure or other ship, or grounding incident. The impact of an oil spill will depend on:

- The type of oil involved, e.g. distillates, bunker (foreign or Australian), crude oil, etc.
- The volume of oil spilled
- The weather conditions at the time of the spill
- Location of the spill.

The new jetty development will operate under Port Bonython's existing oil spill contingency plan. Although a ship collision or grounding is unlikely, as the impact could be very high, it would have a high risk rating.

13.5.4.5. Operation Waste

The Project will not provide waste disposal facilities for the ships and hence all waste material produced during marine operational activities will be kept on the ships and disposed of or recycled as appropriate offsite.

There will be a self-contained toilet located on the jetty for use during loading activities for operational staff. This will be a typical self-contained unit with discharge treated to AMSA requirements. Similarly there will be no discharges from ablution facilities located on the land to the marine environment. On land, a permanent facility will be constructed well removed from any watercourse. It will include a treatment system that uses treated waste water for local irrigation.

The risk of waste material affecting marine water quality is expected to be low.

13.5.4.6. Stormwater Runoff

As there are no proposed discharges in to the sea it is considered the project will not contribute to the increase in pollutants (e.g. nutrients, metals) described in **Section 13.4.3.**

However there is a small risk that these pollutants will be carried by stormwater runoff discharged to the water-courses then to the sea. This risk is assessed in **Chapter 4, Water Resources** as being low with measures to mitigate release of Project specific polluting substances (fuels, oil, metals, litter, herbicides, etc.) resulting from spillages and leaks.

During construction, such measures will be detailed in the construction Environmental Management Plan processes and Erosion and Sediment Control Plan (ESCP). When the Project is in operation, the stormwater runoff is to be contained and treated before discharge to the natural water courses.

The risk of stormwater runoff on marine water quality affecting the nutrients, metals, chemical and oil level is therefore considered to be low. As this is dealt with extensively in **Chapter 4, Water Resources**, it is not further described in this Chapter.

13.5.4.7. Ship Movements

Impact of ship movements on turbidity has been assessed based on the Cape-size vessel, as the Panamax vessel has significantly less draft than a Cape-size vessel. The impact assessment also considered the use of tug boats of 70T, which are bigger than the 20T bollard pull tug boats and other smaller marine crafts to be used during the construction phase as the worst case.

As mentioned in **Section 13.4.2.1**, seabed sediments were collected and analysed for their particle size distribution at the wharf and approach and departure routes in the vicinity of the proposed development. The main navigation route is following the existing navigation route being used by vessels calling at the Santos jetty. These analyses were undertaken to inform an assessment of propeller wash induced turbidity at the proposed development by tugs and design vessels. A preliminary assessment of propeller wash induced turbidity at the proposed BCEF was undertaken using empirical formulae to calculate sediment re-suspension threshold velocities and particle settling velocities. This assessment is based on data relating to bed sediments, tug and ship manoeuvring scenarios including the influence of adverse tides.

Section 13.4.3.5 indicates that some sediment is mobilised and transported by spring tidal currents, which range up to 1m/s. Satellite imagery and a water quality sampling study conducted in 2008 (BHP Billiton, 2009) also revealed high levels of background turbidity around Point Lowly and the proposed development site.

The preliminary results of the propeller wash assessment are summarised in **Table 13.5a** (refer to **Figure 13.5a** for distances in metres from the proposed jetty) and indicate that propeller induced velocities are sufficient to mobilise a high percentage of sediments from the seabed. Between 28 percent and 100 percent of sediments could be suspended along the length of the departure channel with 63 percent being resuspended at the wharf. The highest settling time was found to occur at the wharf with an estimated 12-24 hours required for the suspended material (depending on the assumption of the depth of water column involved), to settle out of the water column.

A lower percentage (roughly 48 percent) of sea bed material is resuspended at the channel bend by propeller wash velocities. This is due to the relatively coarse material present at this location with an average D_{50} of 4mm. Although initially directed to north the expected settling time is 0.1 to 0.2 hour.

Settling times in the remainder of the departure channel are relatively low with 90 percent of suspended material estimated to settle out of the channel in one hour.

The following points in relation to the calculations should be taken into account:

- The low settling time calculated at the wharf is considered to be a conservative estimate as it was assumed that the total mass of sediment is suspended well into the water column. In reality, the sediment particles may suspend to various depths within the water column and may therefore require less time to settle out of the channel
- The study does not take into account possible "armouring" of the seabed after disturbance of the finer sediments. As demonstrated in **Table 13.5a**, propeller wash induced velocities are sufficient to mobilise even coarse sediment fractions into suspension. These particles rapidly settle back onto the seabed, with the finer sediments being carried away, and may create a layer of coarse sediments trapping the finer material below, effectively armouring the seabed. This may result in lower re-suspension and lower residence times over time.

The primary receptor of the potential impact of the increased turbidity is the subtidal habitat 2.5km to the northwest of the ship berthing area which provides habitat for the Australian Giant Cuttlefish. Considering the predominant tidal current directions being northeast during flood and southwest during ebb tides, suspended sediment carried by the propeller-induced current, even if exerting in a northwest direction, is unlikely to reach the subtidal habitat.

As such, in addition to conservatism of the settling time assumption and the potential armouring effect following initial ship movements, it is considered that impacts on the subtidal habitat are unlikely, although a further assessment will be undertaken during detailed design to confirm this assessment.

In terms of Impact Significance Criteria shown in **Table 13.3a**, the impact is expected to be "moderate" on water quality, although the impact on the habitat is expected to be minor or negligible.

Figure 13.5b: Distances from the jetty along the navigation channel

Table 13.5a: Preliminary Propeller Wash Results

Chainage (m)	Channel Section	Average Depth (mCD)	Engine Power	Tug Power	Max Propellor Wash Induced Velocity (m/s)	Max Particle Grain Size Suspended (mm)	% Particles Re-suspended	D10 Settling Time (hrs)	D10 Settling Time -Half Water Column (hrs)
0 - 500	Wharf	20.0	Dead Slow Ahead	Max Power	0.7	1.2	63	24.1	12.1
500 - 1000	Approach to wharf	21.0	Dead Slow Ahead/Slow	None	0.6	0.9	28	0.2	0.1
1000 - 1500	End of approach	21.0	Dead Slow Ahead/Slow	None	0.6	0.9	28	0.2	0.1
1500 - 3000	Channel Bend	21.0	Slow/Half Ahead	None	0.9	2.1	48	0.2	0.1
3000 - 5000	Channel Straight (shallow area)	18.5	Half Ahead	None	3.7	45.0	100	1.0	0.5
5000 - 12000	Channel Straight	19.5	Full Ahead	None	3.4	35.0	100	N/A	N/A
12000 - 14500	Channel Bend	20.6	Full Ahead	None	2.3	12.5	100	N/A	N/A
14500 - 18500	Channel Straight	20.8	Full ahead	None	2.1	9.5	82	N/A	N/A
15500 - 19500	Channel Straight*	22.0	Full ahead	None	1.5	4.5	72	N/A	N/A

Note: N/A in the Settling Times columns indicates that no sediment data was available.

13.6. Mitigation Measures

As the jetty abutment and steel piles have negligible impacts there are no requirements to identify possible mitigation measures.

For the ship movements, at this stage only preliminary assessments have been made regarding possible propeller wash sediment re-suspension and no numerical modelling has been undertaken to confirm its fate once in the water column and subjected to tidal influences.

It should be noted that the primary receptor of the potential impact is the subtidal habitat to the northwest of the ship berthing area. Further assessment will be undertaken during detailed design to confirm the risk of sediment suspended by propeller induced currents travelling to the subtidal habitat, although qualitatively it is considered unlikely based on the known current data.

A summary of the mitigation measures identified are given in **Table 13.6a**.

Table 13.6a: Summary of proposed mitigation measures

Activity	Potential Impact	Significance	Likelihood	Risk Rating
Impact Assessment - Beach and Near-Shore profiles				
Operation Phase				
Jetty abutment	Risk of interrupting sediment transport	Minor	Unlikely	Low
Impact Assessment - Hydrodynamic regime and seabed profiles				
Operation Phase				
Jetty piles	Risk of changing hydrodynamic, sediment transport regime leading to changes in seabed profiles	Negligible	Unlikely	Low
Impact Assessment – Water quality				
Construction Phase				
Jetty abutment	Risk of release of fill material during construction increase turbidity	Minor	Possible	Medium
Jetty piles	Risk of release of fine sediment during the installation of piles	Negligible	Unlikely	Low
Construction waste	Risk of waste arising from construction activities affecting the marine water quality	Minor	Unlikely	Low
Operation Phase				
Oil spills	Risk of oil spills as a result of ship collision (with other ship or structure) or refuelling activities	Very High	Unlikely	High
Operation waste	Risk of waste and pollutants arising from operation activities affecting the marine water quality	Minor	Possible	Medium
Stormwater runoff	Risk of stormwater runoff carrying pollutants fuels, oil, metals, litter, herbicides, etc discharges to the sea	Minor	Possible	Medium
Ship movements	Risk of increased turbidity due to propeller wash	Moderate	Possible	Medium

Mitigation	Significance	Likelihood	Risk Rating
Design of the footprint of the abutment to be within the tidal zone.	Negligible	Unlikely	Low
Ensure the proposed piled jetty design is carried forward for construction instead of a gravity structure for the wharf.	Negligible	Unlikely	Low
During construction that fill material is only placed following the construction of the rock bund and geotextile filter to contain fill material.	Negligible	Unlikely	Low
Ensure proposed hollow steel piles are used.	Negligible	Unlikely	Low
Construction Environmental Management Plan and Construction Waste Plan.	Negligible	Unlikely	Low
No fuelling facilities for the Cape-size or Panamax Size vessels. No storage of fuel for vessels on the construction site. Operate under Port Bonython's Spill Contingency Plan.	Very High	Unlikely	High
All marine operational waste will be kept on the ships and disposed of or recycled as appropriate offsite. No waste disposal from the ships allowed at the jetty. There will be a self-contained toilet located on the jetty for use during loading activities. No discharges from ablution facilities located on the land to the marine environment. On land, a permanent facility will be constructed well removed from any watercourse. It will include a treatment system that uses treated waste water for local irrigation.	Negligible	Unlikely	Low
Storage of hazardous substances in bunded areas. Treatment of stormwater prior to discharge to waterways via buffer strips, vegetated swales, etc. Regular water quality monitoring at discharge point.	Minor	Unlikely	Low
Sediment modelling to confirm if the sediment suspended by the propeller-induced currents will travel to the subtidal reef to the northwest of the ship berthing area.	Moderate	Possible	Medium