14. COASTAL PROCESSES

This chapter describes the supplementary coastal processes study undertaken to address changes made to the project description, to take account of additional information, and to respond to specific comments made in submissions on the Arrow LNG Plant EIS (Coffey Environments, 2012).

The chapter presents the findings of the supplementary coastal processes study completed by BMT WBM Pty Ltd (BMT WBM) (Appendix 7, Coastal Processes and Marine Water Quality Technical Study).

Further information on marine sediments and marine water quality can be found in Chapter 12, Sediment Characterisation and Chapter 13, Marine Water Quality, respectively.

14.1 Studies and Assessments Completed for the EIS

This section provides an overview of the study and assessment completed for the Arrow LNG Plant EIS and the main conclusions from that assessment.

BMT WBM was engaged to conduct the coastal processes, marine water quality, hydrodynamics and legislation study and assessment. Chapter 15 of the EIS outlines the findings of this study relevant to coastal processes and hydrodynamics, and the technical study is appended to the EIS as Appendix 8.

The coastal processes study and assessment:

- Collated and reviewed available data on coastal processes and hydrodynamics in Port Curtis, in and around the area of the project sites, including thorough site inspection.
- Described the existing wave climate and modelled wave conditions with project marine facilities in place.
- Established extreme storm tide water levels at project sites.
- Assessed the implications of the project structures and dredging on sediment transport processes within Port Curtis.
- Assessed the potential impacts on coastal processes in general and in particular along the shoreline associated with project marine works.
- Identified mitigation measures to reduce impacts on coastal processes from project activities.

Cumulative coastal and hydrodynamic impacts associated with the WBDD Project and wider development of the port were also assessed, and the findings are provided in detail in Chapter 32 of the EIS.

The study showed that the activities with the greatest influences on coastal processes would be the dredging of access channels and the construction of marine infrastructure.

Computer modelling simulations concluded that the significance of impacts to coastal processes in the study area ranged from negligible to moderate (see Table 15.6 in Chapter 15 of the EIS). Impacts of significance included:

- Changes in water levels in the Calliope River by up to 0.8 m during spring tides.

- Changes in currents in the Calliope River by up to 0.7 m/s during spring tides.
- Localised silt deposition at Hamilton and Boatshed Point infrastructure.
- Increased sediment transport from Hamilton Point to the southeast.
- Increased sediment transport and deposition at the mouth of the Calliope River.

The detailed design of the marine infrastructure and development of the dredge management plan will incorporate several measures to mitigate impacts to coastal and hydrodynamic processes.

EIS commitments designed to reduce potential impacts are repeated in Table 14.1.

Table 14.1 Coastal processes EIS commitments

No.	Commitment
C15.01	Stabilise the shoreline, where required, at the high tide level where marine infrastructure is installed.
C15.02	Develop a dredge management plan that considers the appropriate water and sediment monitoring data (e.g., current WBDD Project data) and will include:
C15.03	• Requirements for monitoring of water quality.
C15.04	• Actions to be taken to minimise impacts of dredging on sensitive areas should water quality monitoring data show performance criteria are exceeded. Finalise specific actions in the dredge management plan.
C15.05	Implement management measures from the dredge management plan to address impacts from maintenance dredging.
C15.06	Decommission the LNG jetty and loading facilities in a similar fashion to the LNG plant. Dismantle the LNG jetty and cut the piles off at the seafloor. Remove the structure and piles as scrap. Remove debris from the concrete deck and building foundations for disposal on land.
C15.07	Leave the MOF and shore protection works at the LNG jetty (local benthic habitat and associated flora and fauna will have adapted to its presence over the operational life of the project).
C15.08	Only demolish the mainland launch site if another use is not identified.

14.2 Study Purpose

The supplementary coastal processes study addressed changes to the project description that have arisen as a result of front-end engineering design and further refinement of project options completed after finalisation and exhibition of the EIS. The study also provides additional information and responds to specific issues raised in the submissions on the EIS.

14.2.1 Project Description Changes

Project description changes relevant to impacts on coastal processes are described below.

Dredging Footprint and Volumes

The footprint of the proposed dredging locations at the LNG jetty and at the Boatshed Point materials offloading facility (MOF) and integrated personnel jetty have been revised from those presented in the EIS. The revised dredging volumes, depths and methods are provided in Table 6.1 of Chapter 6, Project Description: Dredging.

No changes are proposed to the volume of material to be dredged in the Calliope River or at launch site 4N. The volume of material to be dredged at the LNG jetty has increased (by 11,000 m^3). The main changes to dredging volumes relate to the addition of an access channel from the Targinie Channel to the Boatshed Point MOF and a swing basin and enlarged access area around the MOF. The inclusion of these additional sites has increased the dredging volume from 50,000 m^3 to approximately 313,000 m^3 at Boatshed Point (see Figure 6.4).

Marine Infrastructure

The layout of launch site 1 and Boatshed Point MOF and integrated personnel jetty have been revised. Boatshed Point remains the preferred site for the MOF and integrated personnel jetty, and the alternate site at Hamilton Point South has been discontinued. Launch site 1 remains Arrow Energy's preferred option with launch site 4N retained as an option. Changes to Boatshed Point and the mainland launch site infrastructure are shown in Figures 4.4 and 4.5 respectively.

14.2.2 Additional Information

Additional information relevant to the assessment of impacts on coastal processes has become available since the EIS was finalised and is described below.

Sediment Characterisation

A sediment sampling campaign consistent with the National Assessment Guidelines for Dredging (NAGD) (DEWHA, 2009a) was undertaken by Arrow Energy as part of the geotechnical program for the project to inform water quality, coastal processes and marine and estuarine ecology investigations. Samples taken in the vicinity of Boatshed Point and in the Calliope River were analysed for particle size and composition, acid sulfate soils and contamination. Data from the Western Basin Dredging and Disposal Project, for a limited number of sampling sites at the LNG jetty, was also used (GHD, 2009a). Particle size data was reviewed against existing data sets used by BMT WBM in the modelling to identify any changes to baseline conditions. Further details on the characterisation of sediment at project sites are contained in Chapter 12, Sediment Characterisation.

Light Detection and Ranging

Detailed light detection and ranging (LIDAR) topographic data was obtained for the project area and was used by BMT WBM in its hydrodynamic modelling.

Bathymetric Data

Further bathymetric data was collected during a hydrographic survey undertaken at the LNG jetty, Calliope River and Boatshed Point study areas in August 2012. The survey provided bathymetric data for the area of disturbance with results from the MOF and Calliope River study areas used by BMT WBM in its hydrodynamic modelling.

14.2.3 Submissions

Several submissions on the EIS raised issues relating to coastal processes. The full details of these submissions can be seen in the issues register table in Part B of the SREIS, together with responses to specific issues raised.

14.3 Study Method

This section describes the study method adopted by BMT WBM for the supplementary coastal processes study. The study method is described in detail in Appendix 9, Coastal Processes and Marine Water Quality Technical Study.

14.3.1 Baseline Data Collation and Modelling

Data on existing water quality and coastal processes in the vicinity of project sites was collated and reviewed to identify any changes to the existing environment in the project area as described in the EIS. The review considered changes to the project description and new information. Potential project impacts were identified that require remodelling and review.

The review concluded that the following scenarios should be remodelled:

- Changes to coastal processes and hydrodynamics in the vicinity of Boatshed Point, launch site 1, and the Calliope River.
- Changes to siltation rates in the vicinity of Boatshed Point and the Calliope River.

The potential impacts on tidal storage in the vicinity of the mainland tunnel launch site were assessed qualitatively in the EIS and were not modelled. This site was included in the hydrodynamic modelling conducted for the supplementary coastal processes study.

Hydrodynamics, coastal processes and siltation rates at the LNG jetty site were not reassessed as part of the study as there were no major changes to project infrastructure at this site. Although dredging volumes have increased at this site (from 120,000 m^3 to 131,000 m^3), the volume is not considered large enough to change hydrodynamics to the point where coastal processes or siltation rates will change. The increase equates to approximately one additional day of effective dredging.

The behaviour and fate of dredge plumes at all sites during dredging works were not remodelled as the findings presented in the EIS were still considered to be valid irrespective of the project description changes. Assuming dredging rates remain as modelled for the EIS, the main change is allowance for a longer duration of dredging due to the increased volumes to be dredged at Boatshed Point. Impacts on water quality of longer dredge durations are discussed in Chapter 13, Marine Water Quality. Siltation rates at Boatshed Point and launch site 1 were modelled as part of the supplementary coastal processes study.

The BMT WBM TUFLOW-FV model was used to investigate the changes to hydrodynamic conditions in the project area. BMT WBM's existing TUFLOW-FV model was calibrated and updated to include the new bathymetric and LIDAR data sets and the changes to the design of marine facilities. The base-case hydrodynamic conditions used for the modelling included dredging and construction activities associated with the Wiggins Island Coal Terminal, GLNG and QCLNG projects and the Western Basin Reclamation Area.

14.3.2 Assessment Method

The modelling results were used to review the findings of the coastal processes impact assessment as presented in the EIS. This review focused on validating the impacts and mitigation measures committed to in the EIS and on presenting new impacts and mitigation measures where applicable.

Assessment of impacts on coastal processes was limited to instances where the findings were inconsistent with those presented in the EIS and followed the method set out in the EIS (significance approach).

14.4 Study Findings

The findings of the supplementary coastal processes study undertaken by BMT WBM are presented below.

14.4.1 Impacts to Tides and Water Currents

The revised layout of marine infrastructure and dredging activities planned at Boatshed Point and in the Calliope River may change the predicted impacts on the existing tidal regime and water current patterns. These changes may, in turn, affect sediment transport and shoreline processes.

The modelling shows that project activities will not have an effect on water levels in Port Curtis, either within or outside the study area (apart from the entrance to the Calliope River, which is discussed below). The impacts to tides outside of the Calliope River entrance therefore remain as assessed in the EIS, i.e., negligible.

Boatshed Point

Modelling predicts that the construction of the sheet-piled retaining structures adjacent to Boatshed Point has the potential to cause changes in current patterns and velocities during the flood and ebb tides (Figure 14.1). Current velocities are reduced by up to 0.65 m/s within the swing basin and the ferry manoeuvring basin during a peak flood spring tide. The decrease in velocities is larger than that described in the EIS (0.5 m/s). The extent of this change is restricted to the area adjacent to project infrastructure. The impacts on water currents presented in the EIS remain valid for this area of Port Curtis and are of minor significance.

During peak ebb spring tides, current velocities are predicted to reduce by up to 0.9 m/s in the dredged areas in the swing basin and the ferry manoeuvring basin. There is an associated increase in current velocities on the mud flat to the north of the dredged area of up to 0.23 m/s. As with flood tide impacts, the modelled decrease in velocities is larger than that described in the EIS (0.6 m/s). The impacts occur over a small area (adjacent to project infrastructure) and the significance of the impact remains minor and is consistent with the EIS.

Calliope River

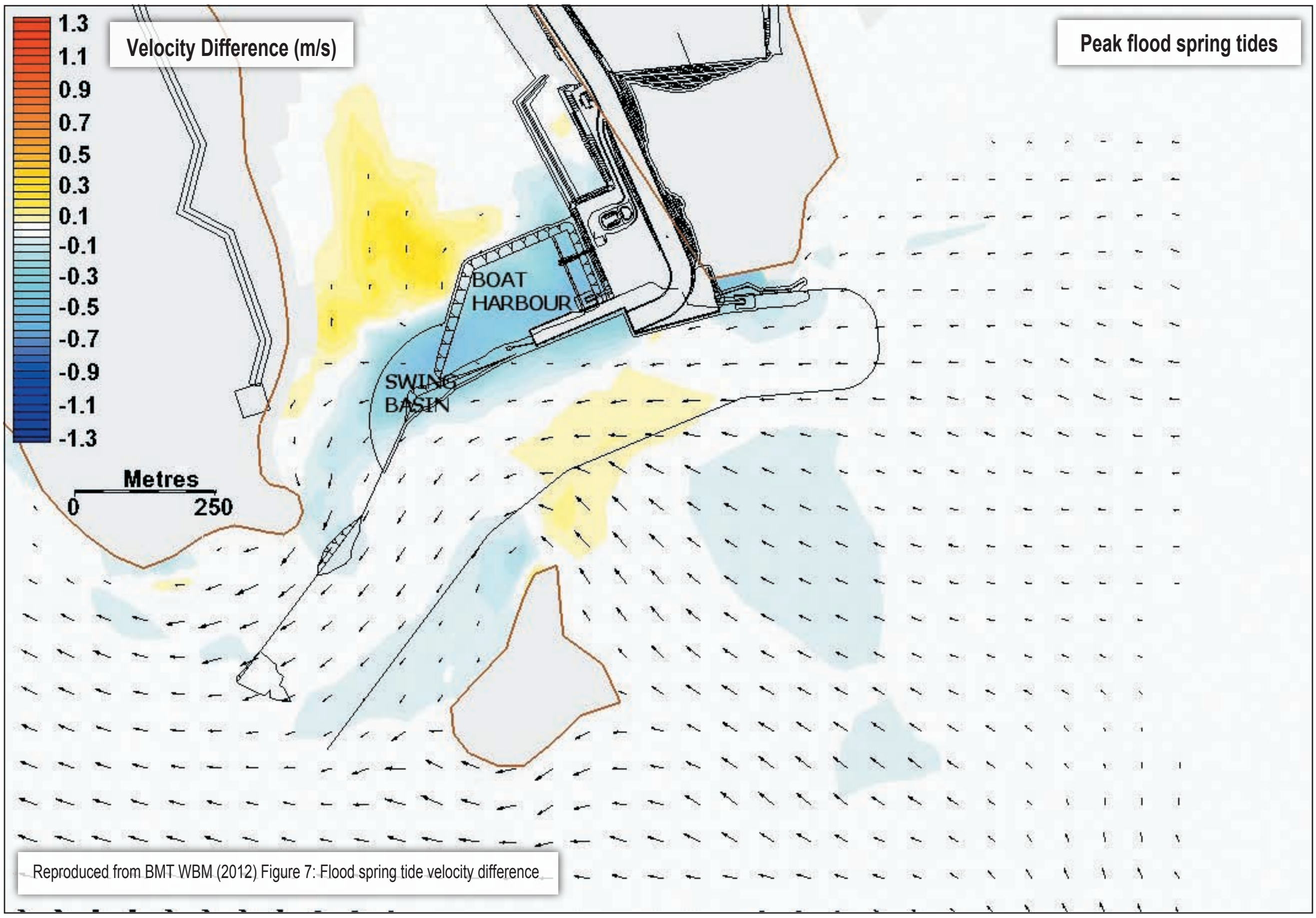
This section describes impacts in the Calliope River.

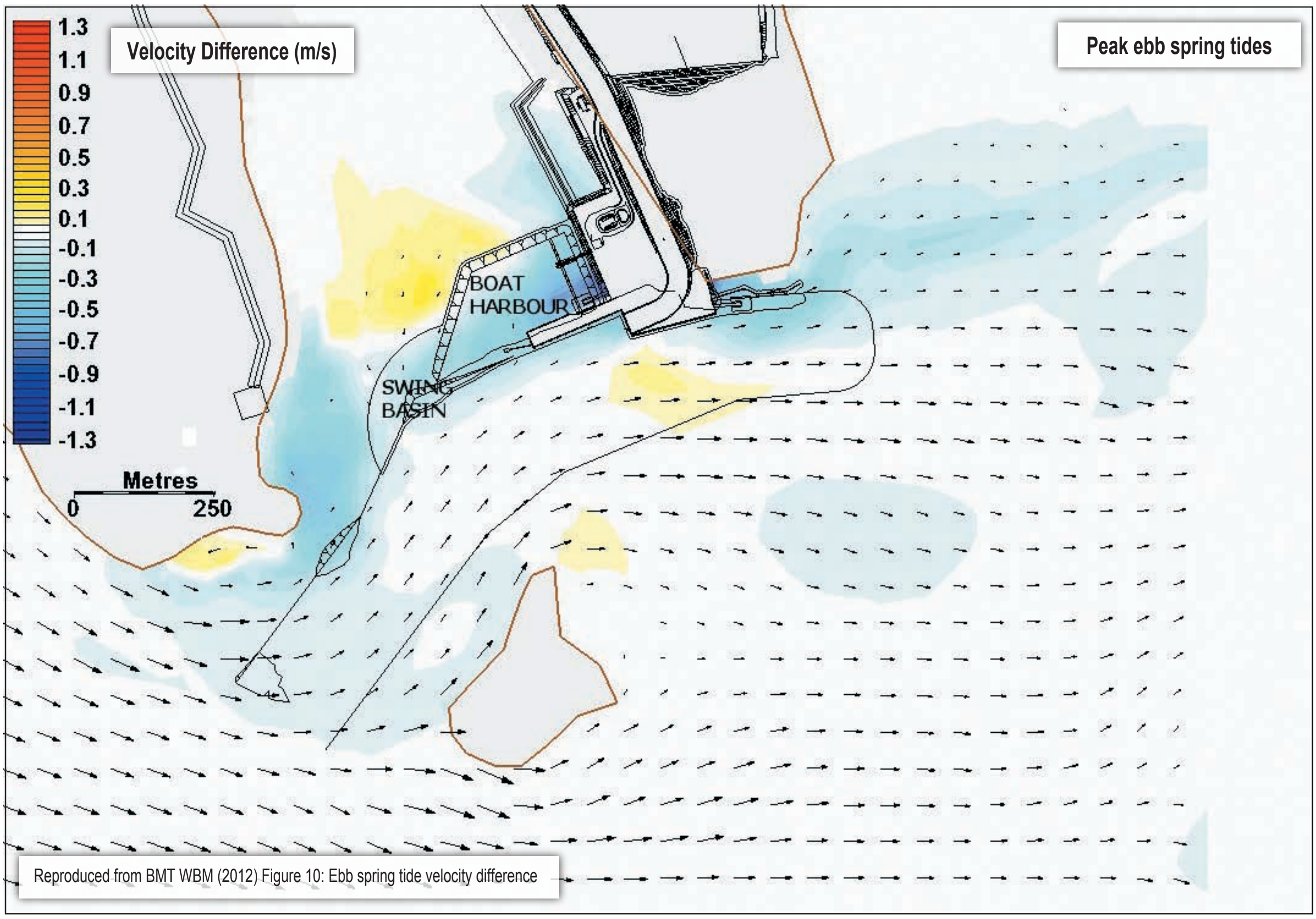
Tidal Changes

Modelling conducted to inform the EIS found that dredging the bar at the entrance to the Calliope River will lower the lowest low tide levels by up to 0.8 m within the river, causing some intertidal areas to be exposed for a greater percentage of the time.

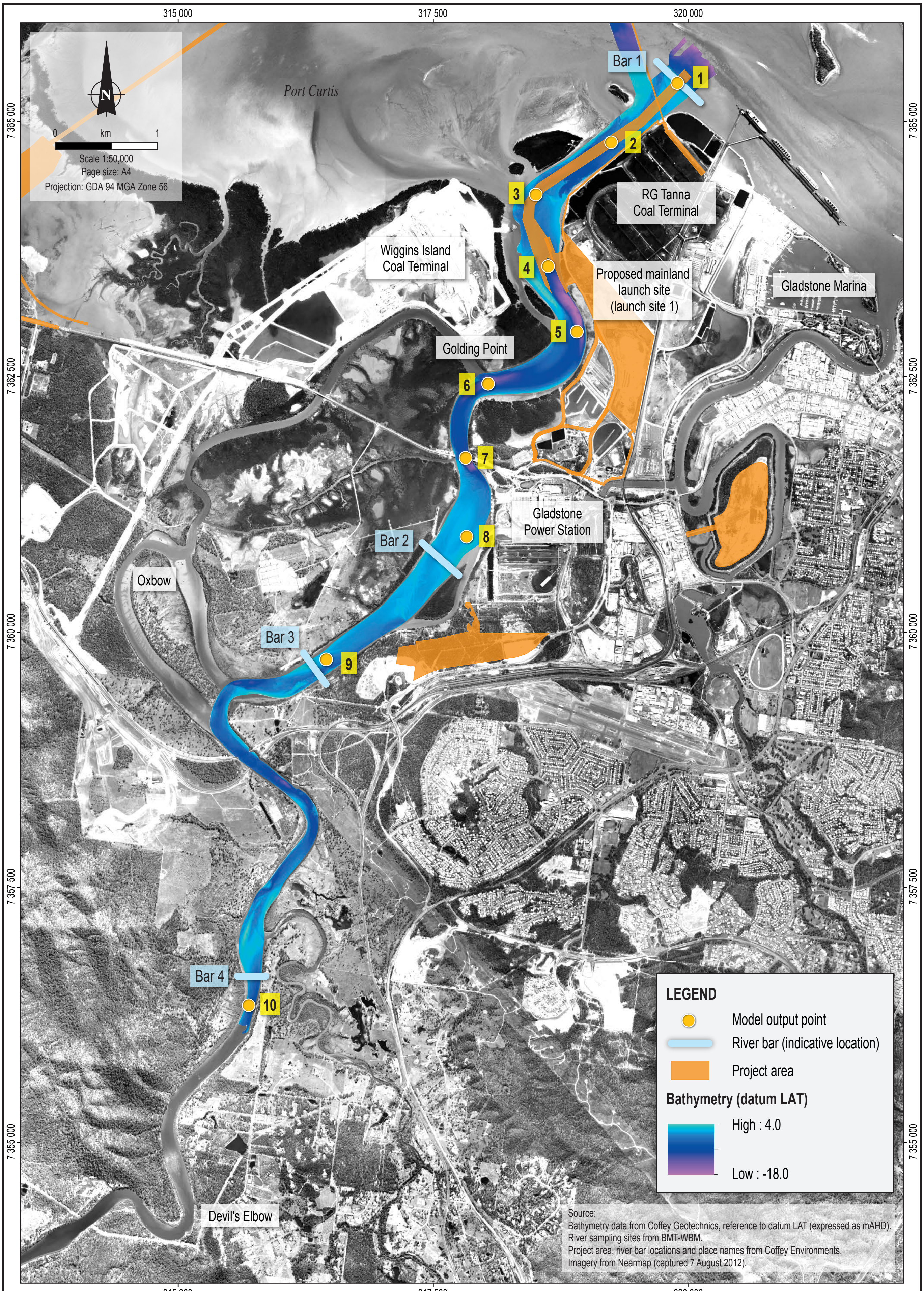
To verify these predicted changes, BMT WBM ran the model using updated dredging and bathymetric data over a 12-month period. Outputs were generated at four representative locations along the river (points 3, 6, 8 and 9 in Figure 14.2) and analysed to determine the changes in percentage dry time as a function of elevation (i.e., the percentage of time the river bed is dry due to the tidal cycle).

Figure 14.3 presents the percentage time dry as a function of elevation at all four locations and shows there is no difference between pre-dredging and post-dredging conditions in the upper range of tidal levels; however, changes do occur during low tides. Table 14.2 shows changes in percentage time dry for all four locations.

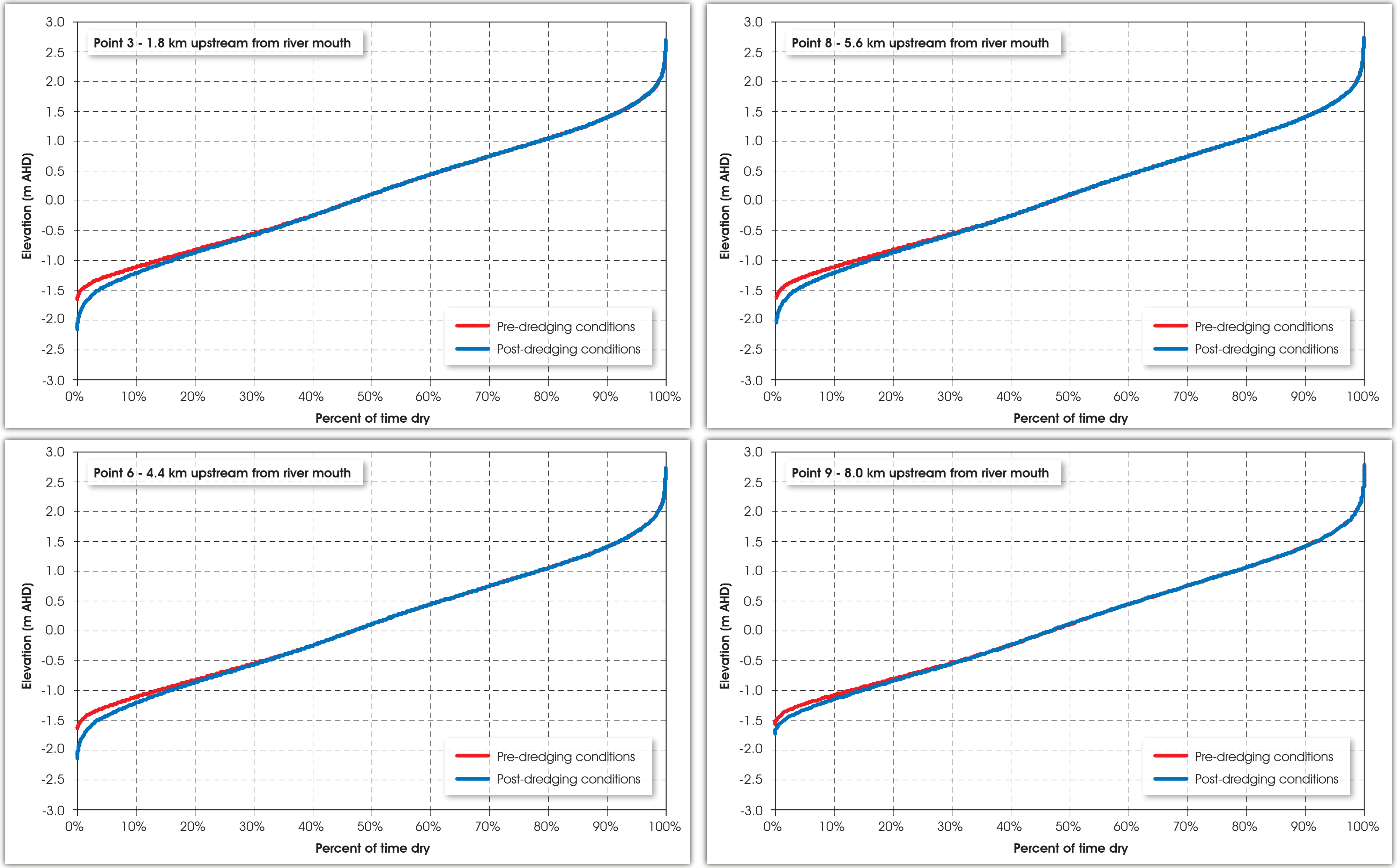




coffey environments	Date: 04.12.2012	Arrow Energy	arrow energy go further	Changes in current velocities at Boatshed Point	Figure No: 14.1
	File Name: 7033_16_F14.01_GL	Arrow LNG Plant			



coffey environments	Date: 07.12.2012 MXT: 7033CC_16_GIS078_v1_1 File Name: 7033_16_F14.02_GIS_GL	Arrow Energy Arrow LNG Plant	arrow energy go further	Calliope River physiography and bathymetry	Figure No: 14.2



Source: BMT WBM

coffey environments	Date: 30.10.2012	Arrow Energy	arrow energy go further	Changes in percentage exposed time with bed elevations at four separate points along the Calliope River	Figure No: 14.3
	File Name: 7033_16_F14.03_GL	Arrow LNG Plant			

Table 14.2 Changes in percentage time dry at model output locations 3, 6, 8 and 9

Percentage time dry	Modelling output location (see Figure 14.2 for each location)							
	Point 3		Point 6		Point 8		Point 9	
	Pre-dredging level (mAHD)	Post-dredging level (mAHD)	Pre-dredging level (mAHD)	Post-dredging level (mAHD)	Pre-dredging level (mAHD)	Post-dredging level (mAHD)	Pre-dredging level (mAHD)	Post-dredging level (mAHD)
100%	2.700	2.700	2.737	2.734	2.767	2.764	2.796	2.793
80%	1.040	1.041	1.050	1.050	1.057	1.058	1.065	1.064
60%	0.436	0.439	0.442	0.442	0.439	0.442	0.441	0.444
50%	0.100	0.102	0.105	0.107	0.101	0.108	0.101	0.106
40%	-0.252	-0.254	-0.250	-0.250	-0.249	-0.251	-0.246	-0.242
30%	-0.556	-0.577	-0.555	-0.572	-0.559	-0.572	-0.551	-0.565
20%	-0.831	-0.876	-0.830	-0.871	-0.831	-0.873	-0.820	-0.855
10%	-1.118	-1.219	-1.119	-1.217	-1.119	-1.212	-1.095	-1.166
8%	-1.179	-1.298	-1.180	-1.296	-1.179	-1.288	-1.152	-1.233
6%	-1.246	-1.383	-1.248	-1.382	-1.246	-1.375	-1.214	-1.307
5%	-1.278	-1.428	-1.281	-1.431	-1.279	-1.417	-1.246	-1.343
4%	-1.313	-1.479	-1.318	-1.479	-1.316	-1.470	-1.281	-1.384
3%	-1.355	-1.548	-1.358	-1.542	-1.356	-1.529	-1.316	-1.431
2%	-1.407	-1.632	-1.410	-1.628	-1.404	-1.607	-1.360	-1.484
1%	-1.478	-1.757	-1.484	-1.759	-1.482	-1.726	-1.430	-1.561
0%	-1.668	-2.171	-1.671	-2.166	-1.669	-2.065	-1.604	-1.749

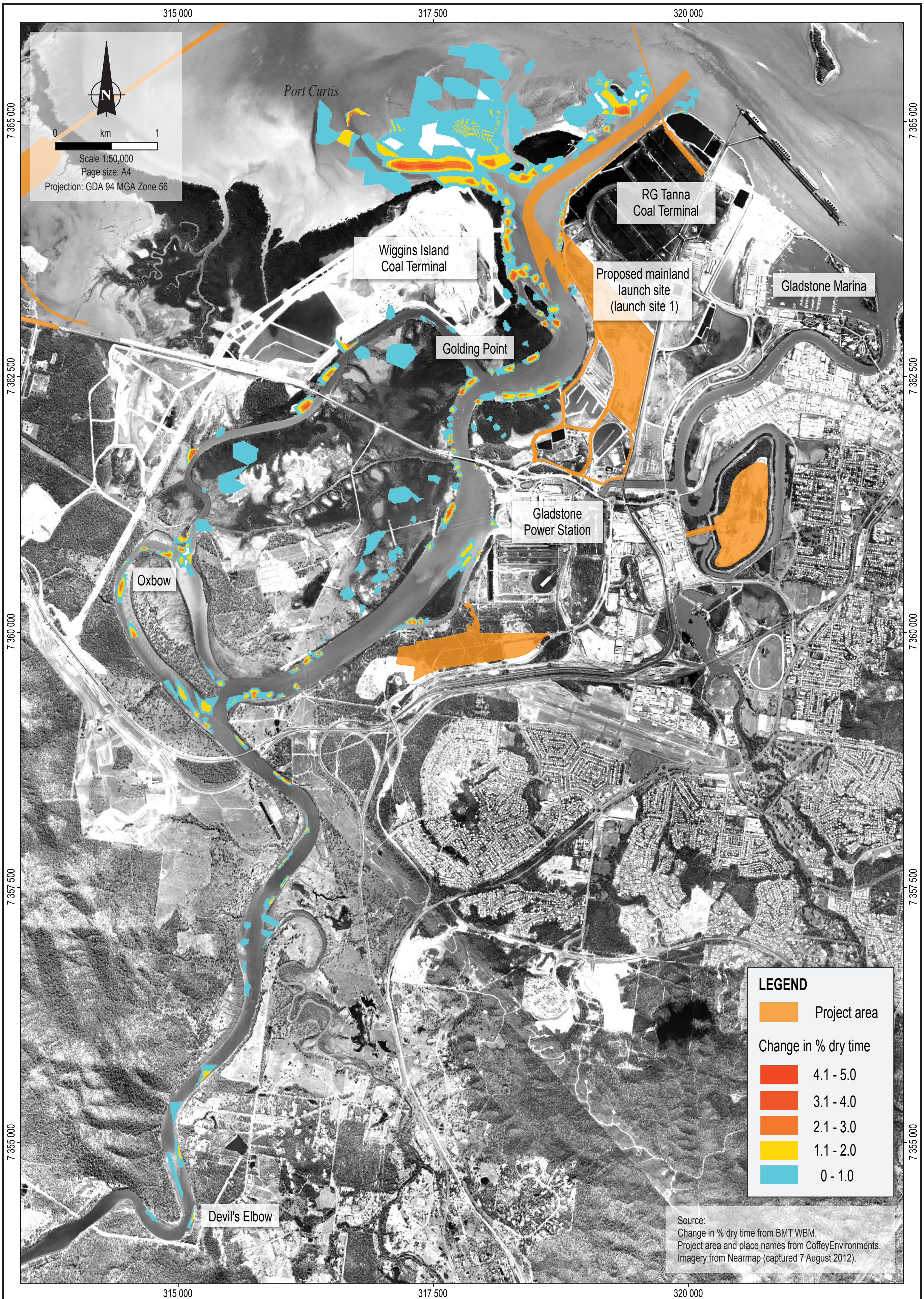
Figure 14.4 shows the difference in the percentage time dry between pre-dredging and post-dredging in the Calliope River. The maximum difference occurs in the mouth of the river, where a maximum increase of 5% occurs (i.e., approximately 18 days per year).

Changes in Minimum Water Level and Depth

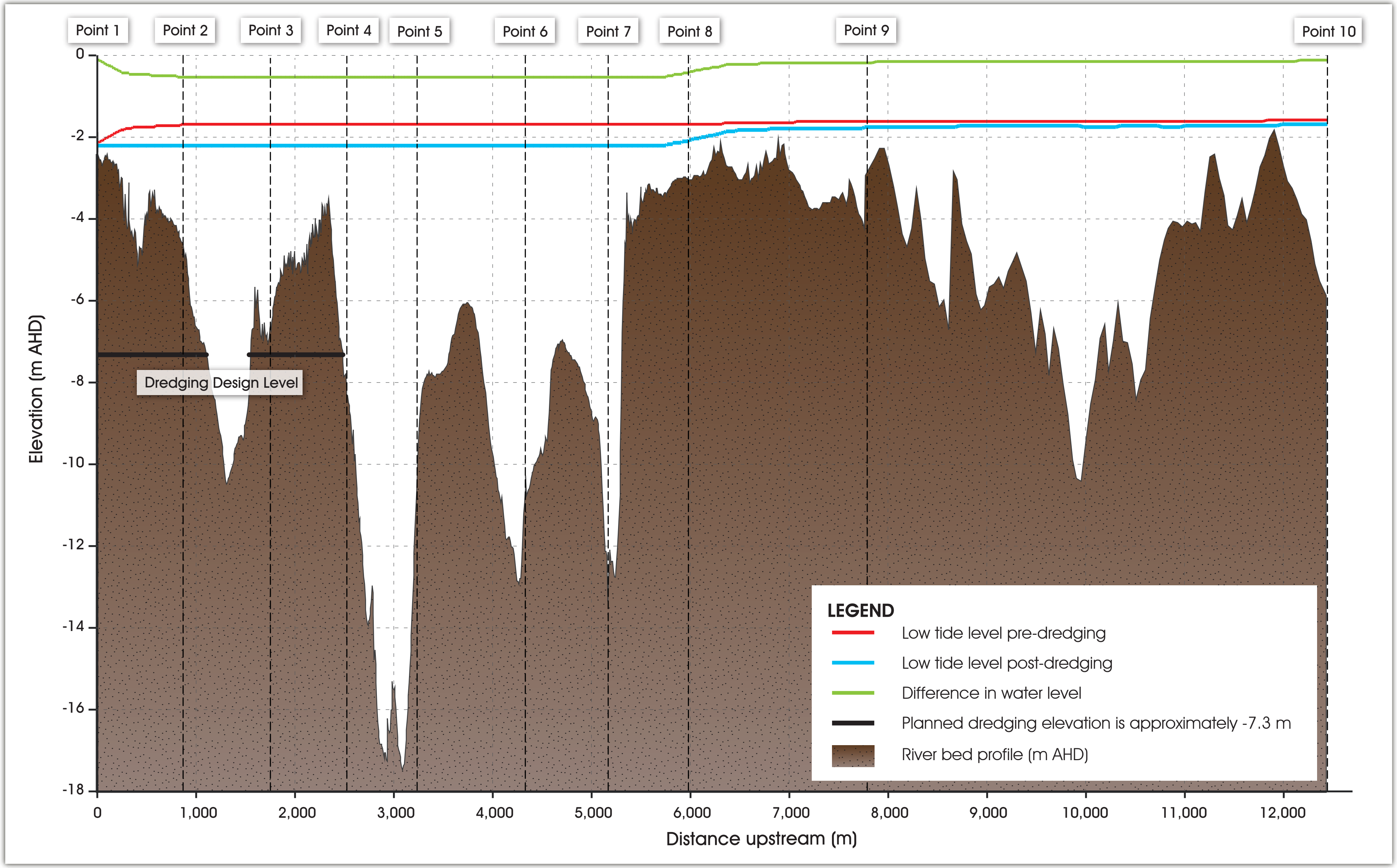
Figure 14.5 shows pre- and post-dredging changes to minimum water levels in the Calliope River from points 1 to 10 over the 12-month modelling period. Figure 14.6 shows the predicted changes in lowest water levels between pre- and post-dredging conditions, and Figure 14.7 shows the 30 ha of additional bank areas that will be exposed during lowest low tides. The increase in frequency and duration of exposure of these areas is relatively small (equivalent to less than a 4% increase in exposure time on average).

Changes in water levels are greatest between points 1 and 8, and the most significant change in minimum water level occurs at point 3 downstream of launch site 1 where the predicted minimum tidal level is 0.5 m lower than existing conditions. Upstream of point 8, changes in water levels are relatively minor compared to the changes downstream.

The ecological impacts of changes in low tide levels including percentage time dry and bank exposure are discussed in Chapter 17, Estuarine Ecology (Calliope River).



coffey environments	Date: 10.12.2012 MXT: 7033CC_16_GIS096_v1_1 File Name: 7033_16_F14.04_GIS_GL	Arrow Energy Arrow LNG Plant	arrow energy go further	Difference in percentage time dry between pre-dredging to post-dredging conditions	Figure No: 14.4



Source: BMT WBM

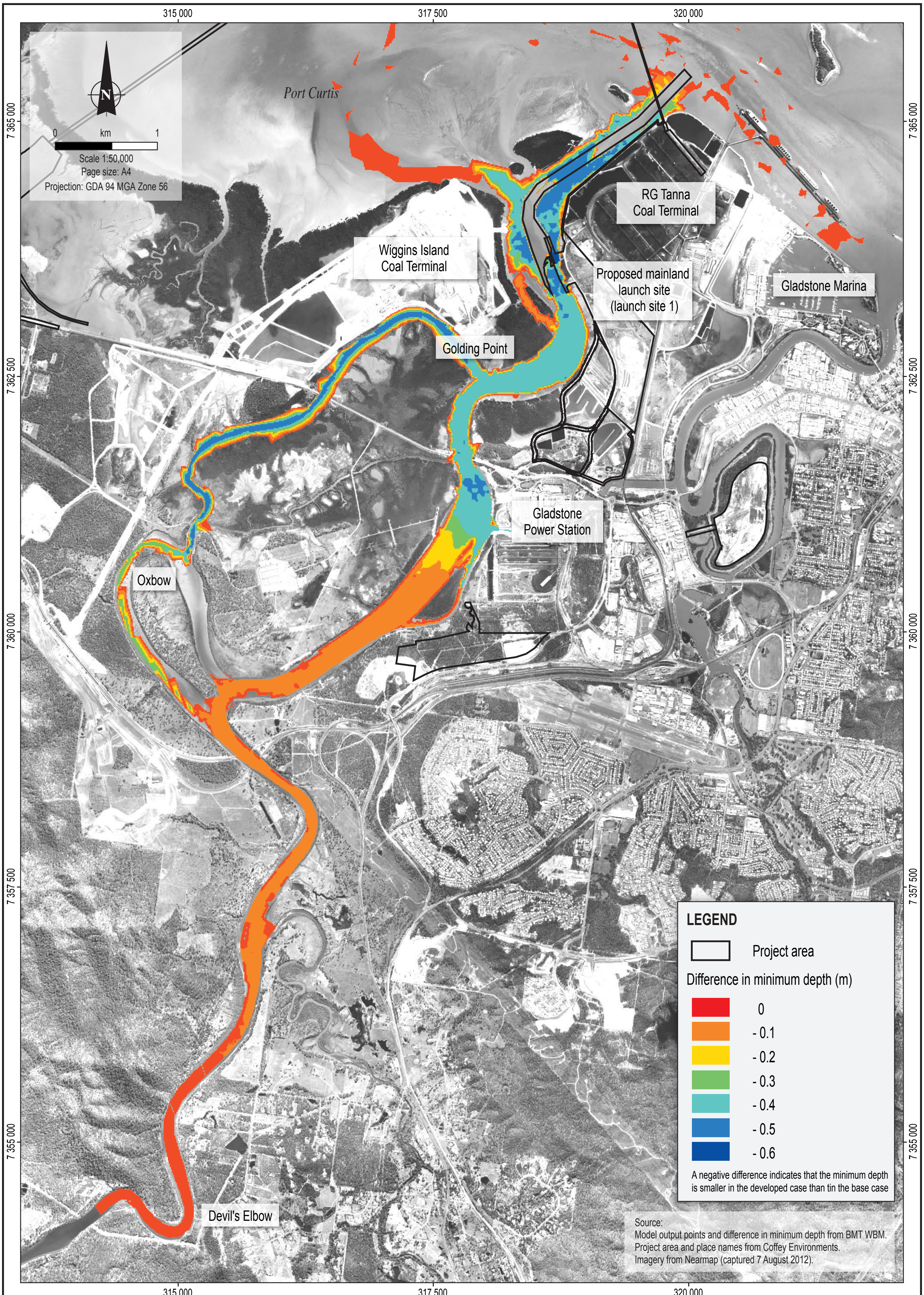
coffey environments

Date: 10.12.2012	Arrow Energy
File Name: 7033_16_F14.05_VS	Arrow LNG Plant

arrow energy go further

Predicted lowest low tide levels (m AHD) in Calliope River under pre- and post-dredging conditions

Figure No: 14.5



coffey environments

Date: 10.12.2012
MXT: 7033CC_16_GIS098_v1_1
File Name: 7033_16_F14.06_GIS_GL

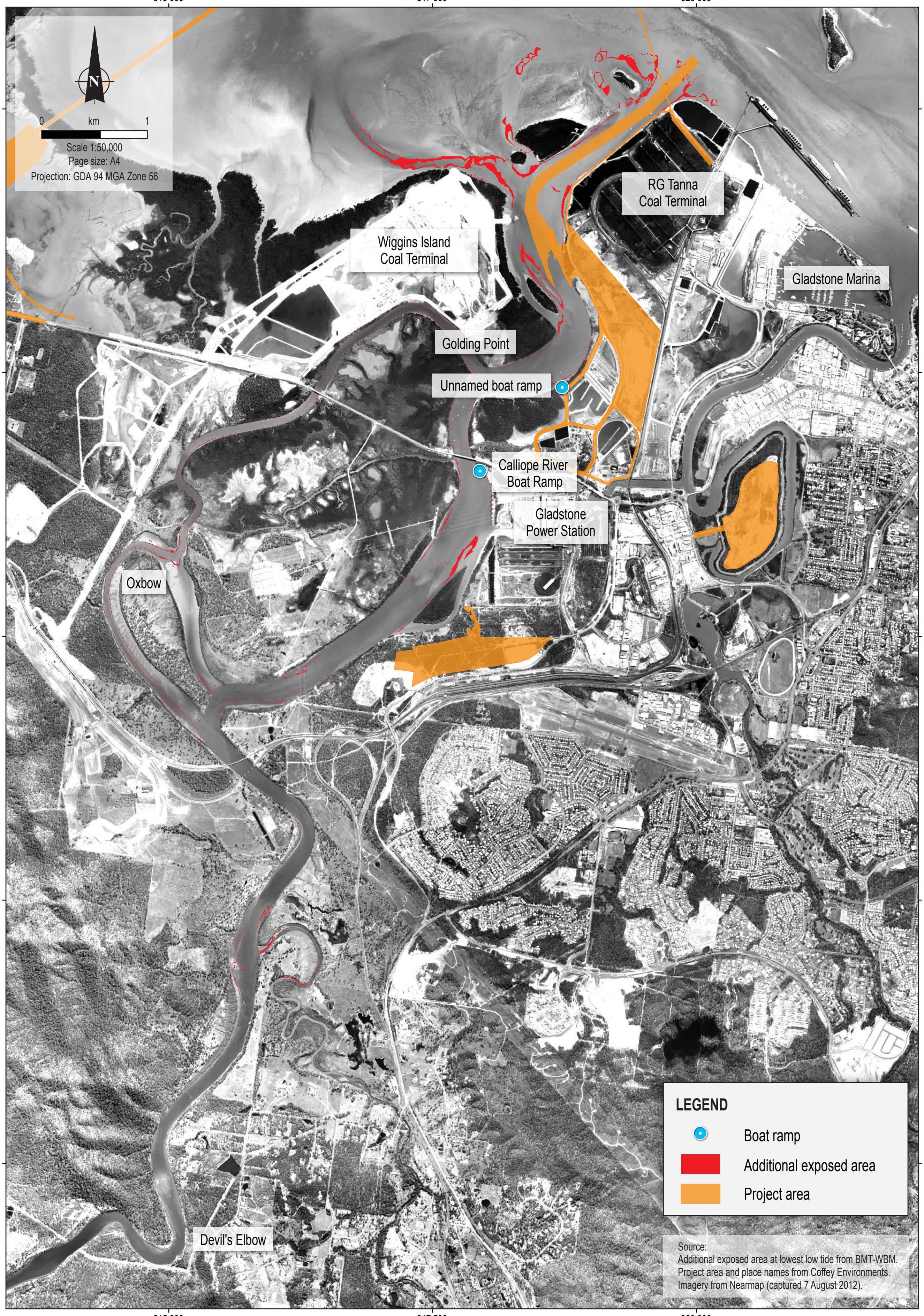
Arrow Energy

Arrow LNG Plant

arrow energy go further

Difference in minimum depth between pre- and post-dredging conditions

Figure No: 14.6



coffey environments	Date: 18.01.2013 MXT: 7033CC_16_GIS097_v1_2 File Name: 7033_16_F14.07_GIS_GL	Arrow Energy Arrow LNG Plant	arrow energy go further	Additional exposed area at lowest low tide	Figure No: 14.7

Changes to Navigability

The available depth for navigation will be reduced in the lower part of the Calliope River during low tides. This reduction will be most noticeable at shoals just upstream of point 8. At this location, the available depth is currently less than 1 m during spring low tides. The water depth will be reduced by up to 0.5 m following dredging and may limit access on spring low tides to areas upstream of the shoals for some vessels. Navigability at the Calliope River boat ramp adjacent to the power station (see Figure 14.7) may be affected at the lowest low tides. The duration of limited access is a few hours on each of five separate days per month. In contrast, the lower reaches of the river will be accessible under all tides as the bar will no longer provide a limitation on navigation.

Launch Site 1

The EIS described construction of launch site 1 wharfs and jetties using piles, with no structures that would significantly impede coastal processes. Potential impacts of the structures at launch site 1 were therefore not modelled in the EIS. Changes to the design now include sheet-pile retaining structures, and the potential impact of these structures on water levels and currents was modelled for the SREIS.

Modelling indicates water levels will not be affected by the changes to the design of launch site 1 marine infrastructure. Consequently, the magnitude of the impact to tides and significance of impacts are both negligible.

The results of the modelling of changes in currents at launch site 1 are provided in Figure 14.8 for both peak flood and peak ebb spring tides. Within the immediate vicinity of launch site 1, current velocities are reduced by up to 0.85 m/s during a peak flood spring tide with a corresponding increase in the current velocities in the main river channel of up to 0.11 m/s. During the peak ebb spring tide, current velocities in the immediate vicinity of the structure are reduced by up to 1.24 m/s with a corresponding increase in the current velocities in the main river channel of up to 0.24 m/s.

The change in velocities is confined to a relatively small area adjacent to project infrastructure. The magnitude of the impact to water currents is low, and the resulting significance is minor.

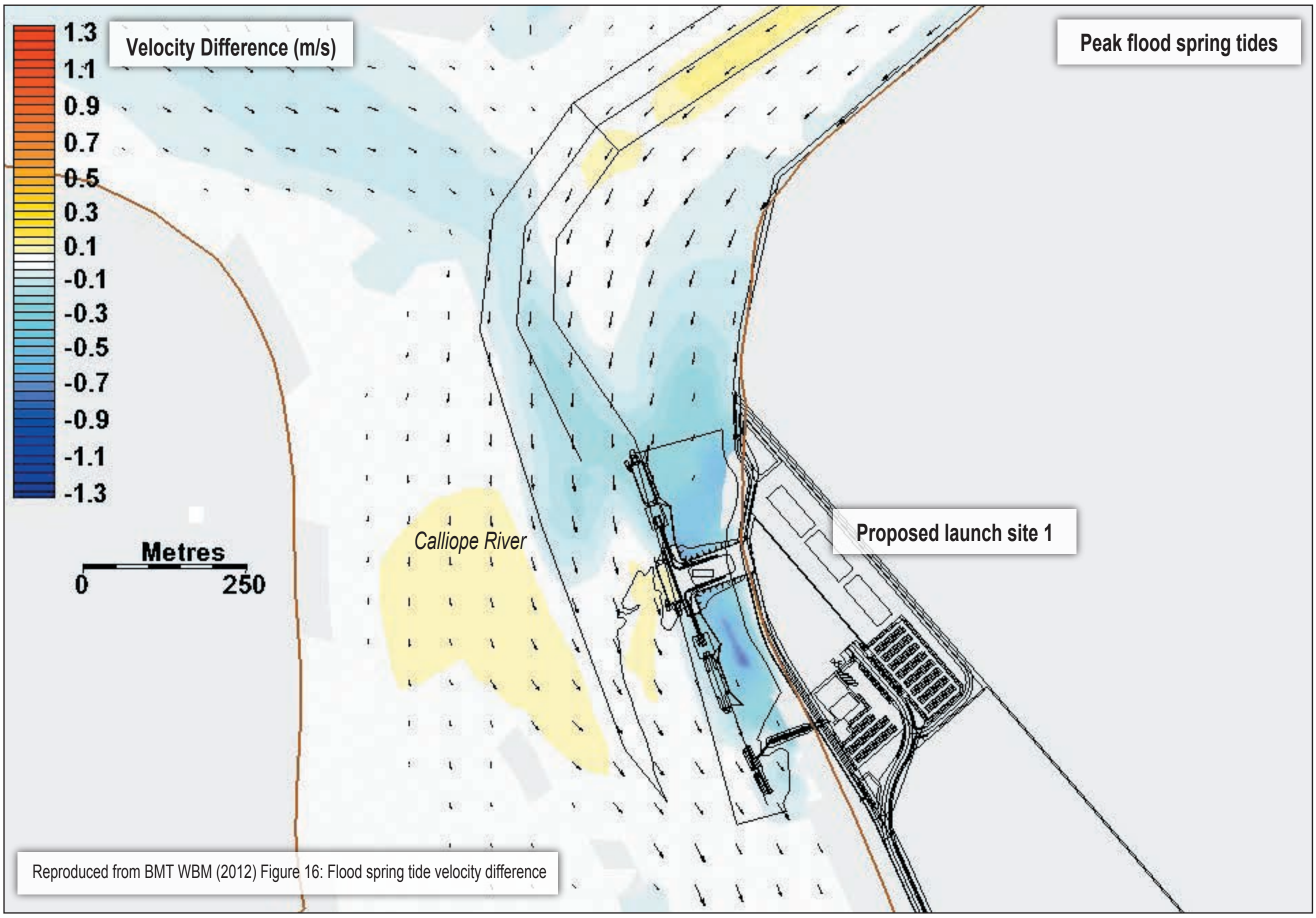
Mainland Tunnel Launch Site

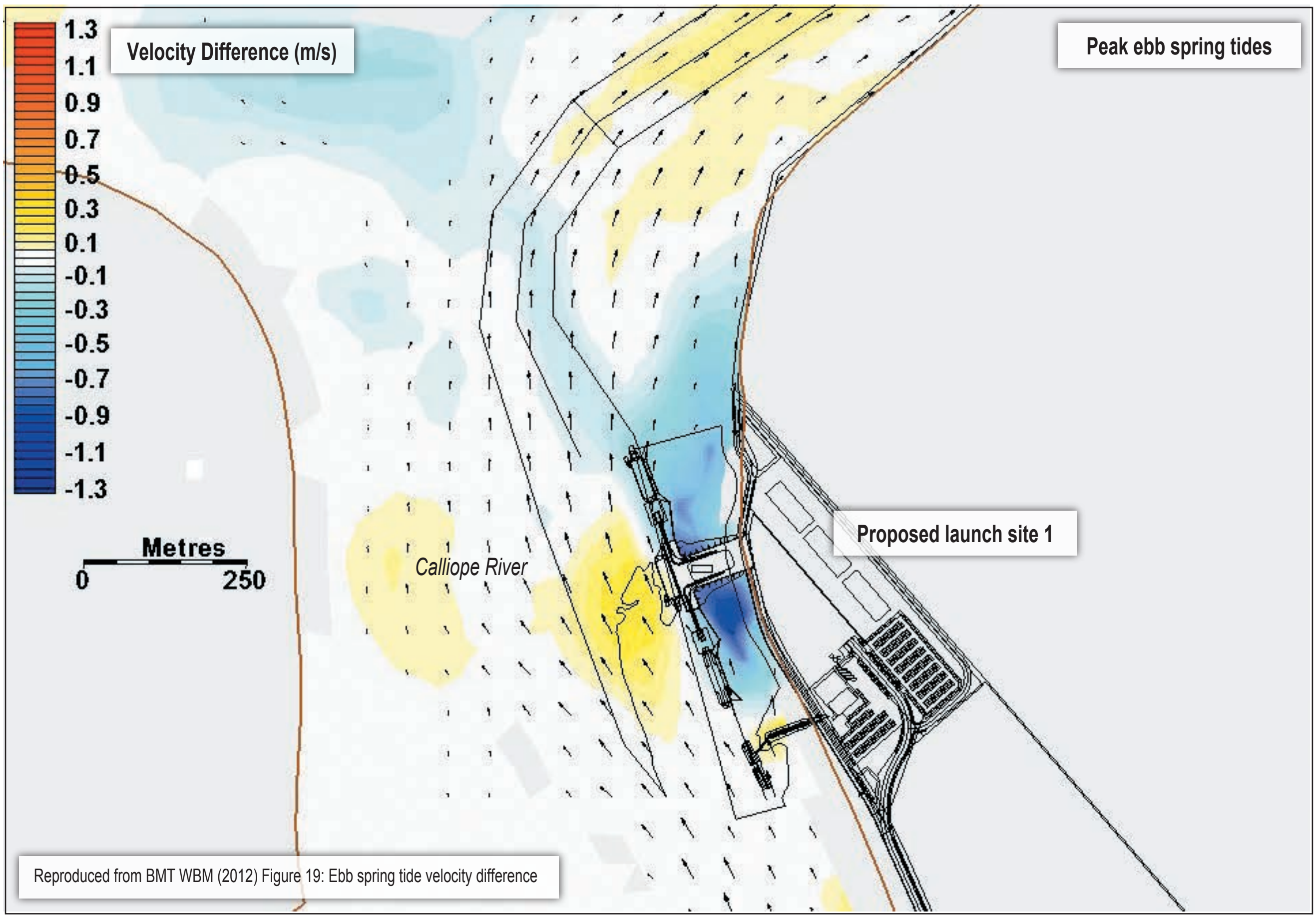
The construction and operation of the mainland tunnel launch site may impact the volume of upper tidal storage in the immediate vicinity of the proposed infrastructure. Other impacts on coastal processes are not expected as this site is above mean spring high tide level and is only inundated during some extreme high tides.

The impacts to tidal storage at the mainland tunnel launch site were assessed qualitatively for the EIS, which predicted the loss of some upper tidal storage volume. The potential reduction in tidal storage has been modelled to quantitatively assess potential impacts.

The existing ground elevation around the perimeter of the tunnel entrance site varies between 2.0 and 2.25 m AHD. The modelling shows water levels in the adjacent part of Port Curtis are lower than 2.0 m AHD for over 98.5% of the time. Tidal storage is reduced for a very small percentage of the time (equivalent to 5.5 days over a 12-month period) due to construction of the tunnel entrance facilities.

The tidal storage area will only be reduced during periods of large tidal amplitude. The existing maximum depth of inundation is less than 0.7 m at highest astronomic tide, and the total volumetric reduction is minor in the context of the total Port Curtis tidal storage volume.





coffey environments	Date: 07.12.2012	Arrow Energy	arrow energy go further	Changes in current velocities at launch site 1	Figure No: 14.8
	File Name: 7033_16_F14.08_GL	Arrow LNG Plant			

The significance of impacts to tides in Port Curtis was assessed as negligible in the EIS. This assessment remains valid as the majority of the area lost at the mainland tunnel launch site is above the tidal height for over 98.5% of the year.

14.4.2 Sediment Transport and Deposition

BMT WBM investigated the potential for sediment transport and deposition in light of design changes to the marine facilities at Boatshed Point and launch site 1. Estimates of sedimentation rates should be considered indicative only due to uncertainty in modelling assumptions and limited model validation.

At Boatshed Point, the model results show that fine sediment may accumulate at a rate of 0.14 m/month in the ferry manoeuvring basin and 0.2 m/month near the RORO barge berth. The manoeuvring basin is in a mudflat area, with generally low bed shear stresses and sediment accumulation in this area is to be expected. Sediment deposition occurs in the lee of the barge berth structure due to reduced current velocities.

Modelling of fine sediment deposition in the vicinity of launch site 1 indicates that deposition will occur largely outside the dredge channel with rates of up to 0.06 m/month near launch site 1.

Potential changes to bed load transport sand-size material within the Calliope River were reviewed using the existing Port Curtis computer model. Pre-dredging and post-dredging scenarios were modelled during spring tides (when maximum sediment transport is likely to occur). Results show a small reduction of sand transport potential. The reduction is not large enough to change the overall net sand transport within the river.

14.5 Conclusion

The results of detailed modelling carried out to inform the supplementary coastal processes and marine water quality technical study are consistent with the findings of the impact assessment presented in the EIS. In particular, the findings presented in the EIS relating to bank stability, channel width, highest and lowest tidal events, wave climate and tidal flushing are unchanged.

Minor changes to current velocities (up to 0.65 m/s) within the vicinity of Boatshed Point and launch site 1 will have a negligible influence on coastal processes in the study area as they occur over a small area within a large, well-mixed, dynamic environment.

Further modelling was carried out to assess the impacts on low tide levels in the Calliope River following the dredging of the bar at the river mouth. Intertidal banks between the river mouth and a point near the Gladstone Power Station (point 8) may be exposed by up to an additional 0.5 m on the lowest low tide. This lowering of water levels may restrict upstream access to some vessels on the lowest low tides for a few hours each month. Lower reaches of the river that currently experience restricted access will now be accessible under all tidal regimes.

Fine sediment will be deposited at varying rates at the Boatshed Point MOF and integrated passenger jetty and at launch site 1. This material will need to be removed during maintenance dredging. Overall, net sand transport within the Calliope River will not be affected by project activities.

Overall, the changes to the project description have a negligible influence on the predicted impacts to coastal processes and the hydrodynamic environment in the study area. The predicted impacts and the management measures presented in the EIS remain valid. Consequently, no changes to the coastal processes commitments set out in the EIS are proposed except

Commitment C15.06, which requires revision to reflect landowner views on future uses of facilities.

14.6 Commitments Update

The additional assessments have not identified any measures that would provide any further mitigation of project-related impacts. The changes to the tidal hydrodynamics in the Calliope River caused by dredging the bar at the entrance to the river cannot be mitigated by engineering measures. As discussed in the EIS, ongoing monitoring of erosion in the Calliope River will be needed during and after project works. Remedial measures may be required where erosion would present significant impact on existing ecological values or physical infrastructure.

The commitments presented in the EIS remain valid for mitigation of impacts to coastal processes and hydrodynamics and are included in Attachment 7, Commitments Update. Commitment C15.06 has been revised and is set out in Table 14.3.

Table 14.3 Commitments update: coastal processes

No.	Commitment	Comment
C15.06A	~~Decommission the LNG jetty and loading facilities in a similar fashion to the LNG plant. Dismantle the LNG jetty and cut the piles off at the seafloor. Remove the structure and piles as scrap. Remove debris from the concrete deck and building foundations for disposal on land.~~ Subject to landlord requirements, decommission the LNG jetty and loading facilities in a similar manner to the LNG plant.	Amended to reflect anticipated tenure arrangements