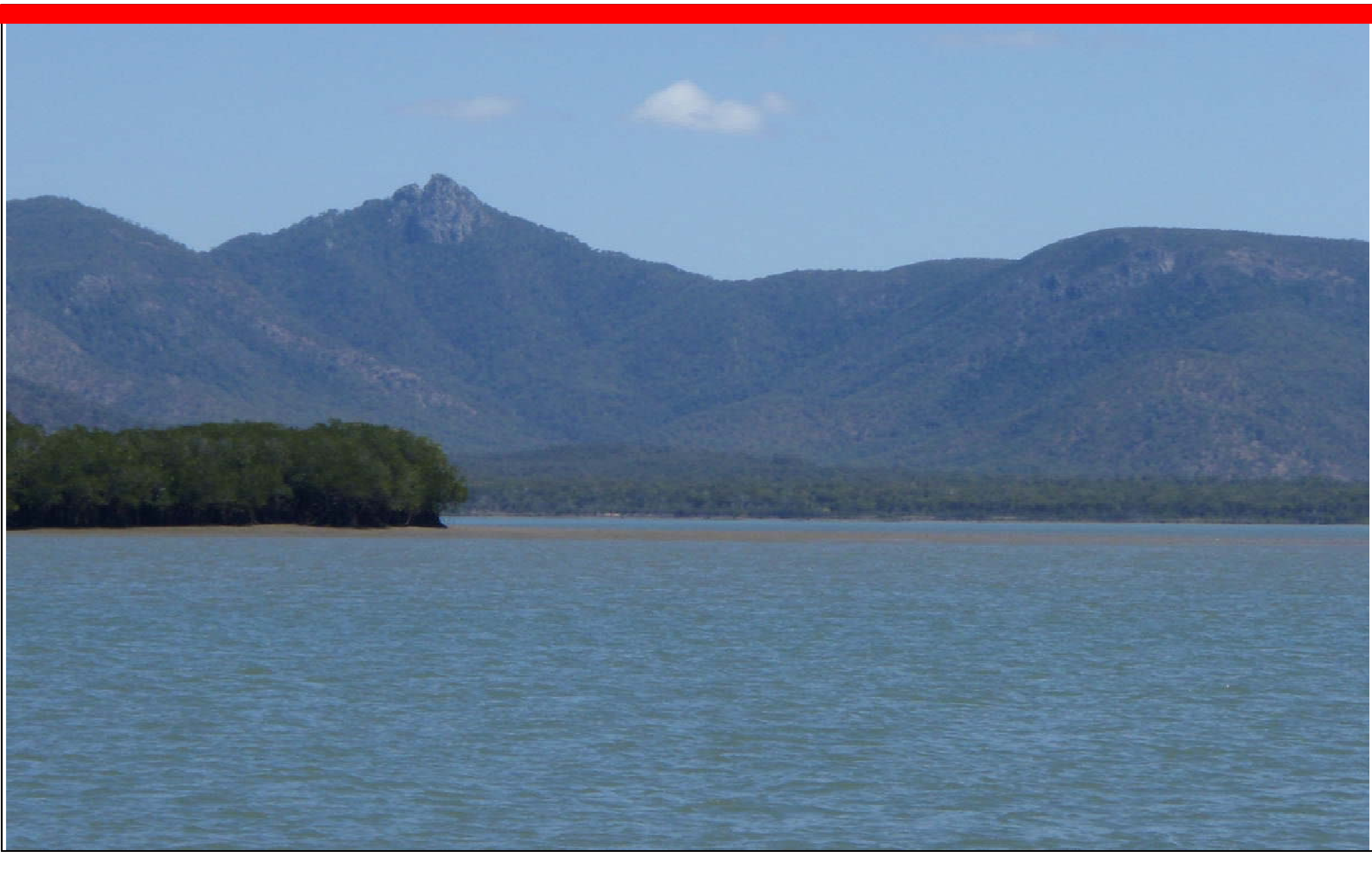
Australia Pacific LNG Project
Supplemental information to the EIS

Coastal Environment Report

LNG Facility



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Executive Summary

Supplementary information is presented in this report regarding new developments in relation to early works dredging activities and treated wastewater discharges which have the potential to impact on the coastal environment and water quality.

WorleyParsons on behalf of Australia Pacific LNG has undertaken the following scope of works as part of the supplementary EIS:

- Early works dredge plume modelling to assess potential impacts on marine ecology and water quality
- Field work assessments in relation to sediment characteristics and water quality in the vicinity of the early works dredging and wastewater discharge location
- Revised treated wastewater discharge modelling previously undertaken in the EIS
- Near-field and far-field modelling to achieve dilutions of discharge concentrations consistent with Water Quality Objectives (WQOs)

Australia Pacific LNG early works dredging covered in this supplementary report are the Embarkation Dock, Construction Dock and the Materials Offloading Facility (MOF) Dock. The Embarkation Dock located on the northeast corner of the existing Fisherman's Landing will be used for transfer of construction personnel, equipment and materials to the Curtis Island site. The Construction Docks on Curtis Island will include a Roll-on Roll-off Dock for barges transferring equipment and materials, a Construction Ferry Dock for personnel and day to day supplies, and a Rock Dock for delivery of armour rock and aggregates used in the construction of the LNG Facility site. The MOF Construction Access will include a ramp and revetment for the delivery of heavy and sizeable modules and provide anchorage for barges.

Modelling of sediment plumes is consistent with assumptions used in the Gladstone Ports Corporation (GPC) Western Basin Dredging and Disposal Project (WBDDP) EIS. Modelled results indicate the Total Suspended Solids (TSS) concentrations associated with the early works dredging, are not significant for the MOF Construction access and Embarkation Dock scenarios. For the Construction Docks dredging scenario TSS concentrations are characterised by elevated levels on the eastern side of The Narrows main channel for short durations at low tide. Statistical analysis of the modelled results was undertaken for selected locations at dredging localities and within sensitive seagrass areas. This analysis indicated that the 90th percentile TSS concentrations associated with the early works dredging scenarios would not exceed levels of normal background concentrations.

Updated values for the constituents of the desalination plant brine and wastewater discharges were used to develop cases for nearfield modelling of expected dilutions. The Desalination plant brine during operations would have salinity (TDS) of 50 000 to 60 000 mg/L with an average flow rate of 96 m^3/hr and a maximum flow rate of 150 m^3/hr based on four LNG trains in operation. During construction, the desalination plant brine would have a salinity of 60 ppt and be discharged at an average rate of 62.5 m^3/hr.

The brine may be combined with treated process and stormwater, and treated sewage in the same outfall pipe. The treated process and stormwater would have an average flow rate of 25 m^3/hr and a maximum flow rate of 100 m^3/hr, with an estimated TDS after treatment of 250mg/L. The treated sewage would have an average flow rate of 3.5 m^3/hr and a maximum flow rate of 15 m^3/hr, also with

an estimated TDS after treatment of 250mg/L. Numerous combinations of the ration of brine to wastewater were tested in sensitivity analysis.

Near field modelling of plumes from the desalination plant brine and treated wastewater discharge outfalls with an optimised diffuser design has shown that it is possible to achieve a dilution of 1 in 50 (exceeding the required dilution for salinity) within 12.8 m and 7.20 m of the diffuser, for construction and operations phase of the project, respectively, in all cases.

Modelling also indicated that dilution of brine in the nearfield zone is aided by the addition of treated wastewater by lowering initial concentrations. Accordingly, additional far field modelling was not considered necessary as it was addressed in the original EIS documentation for brine discharge only.

Contents

List of Tables

List of Figures

Appendices

1. Introduction

The Australia Pacific LNG EIS was lodged with the Queensland Government on 29th January 2010. Supplementary information is presented in this report in relation to early works dredging activities and treated wastewater discharges which have the potential to impact on the coastal environment and water quality.

1.1 Scope

Since the Australia Pacific LNG EIS was lodged in January 2010, there have been further developments and analysis concerning the early works dredging for embarkation from Fisherman's Landing Northern Expansion (FLNE) and access to the LNG plant on Curtis Island, in addition to the discharge of desalination plant brine and treated wastewater from the LNG facility site.

WorleyParsons on behalf of Australia Pacific LNG was engaged for the following scope of works to provide supplementary information to the EIS:

- Undertake early works dredge plume modelling to assess potential impacts on marine ecology and water quality. This work involves:
  - review project information including dredging schedule and materials expected to be encountered during proposed dredging
  - Refine hydrodynamic model at locations where early works dredging is to take place according to sequence of construction
  - Model dredge plumes in a manner consistent with GPC WBDDP EIS and according to material volume analysis
- Undertake field work assessments in relation to sediment characteristics and water quality in the vicinity of the early works dredging and desalination plant brine and treated wastewater discharge location. Sediment characterisation findings are reported in The Materials Offloading Facility, Jetty and Jetty Berth Sediment Characterisation Report (WorleyParsons, 2010)
- Revise discharge modelling previously reported in the EIS, involving:
  - conduct near-field and far-field modelling to achieve dilutions of discharge concentrations consistent with Water Quality Objectives (WQOs)
  - utilise modelling results to optimise the diffuser designs for the construction and operations phases of the project

1.2 Study Location

The proposed site on Curtis Island for Australia Pacific LNG's facility is Laird Point. Early works dredging is proposed at six locations as follows:

- Dredge Area 1 – Embarkation Dock
- Dredge Area 2 – Construction Docks dredging
- Dredge Area 3 – Materials Offloading Facility (MOF) Construction Access

- Dredge Area 4 – MOF Channel
- Dredge Area 5 – Jetty Construction Access
- Dredge Area 6 – Jetty Berth Dredging Limit

Dredging at the first three locations is part of the scope of the Australia Pacific LNG EIS and is described and assessed in Section 3. The remaining locations are assessed as part of the GPC WBDDP EIS.

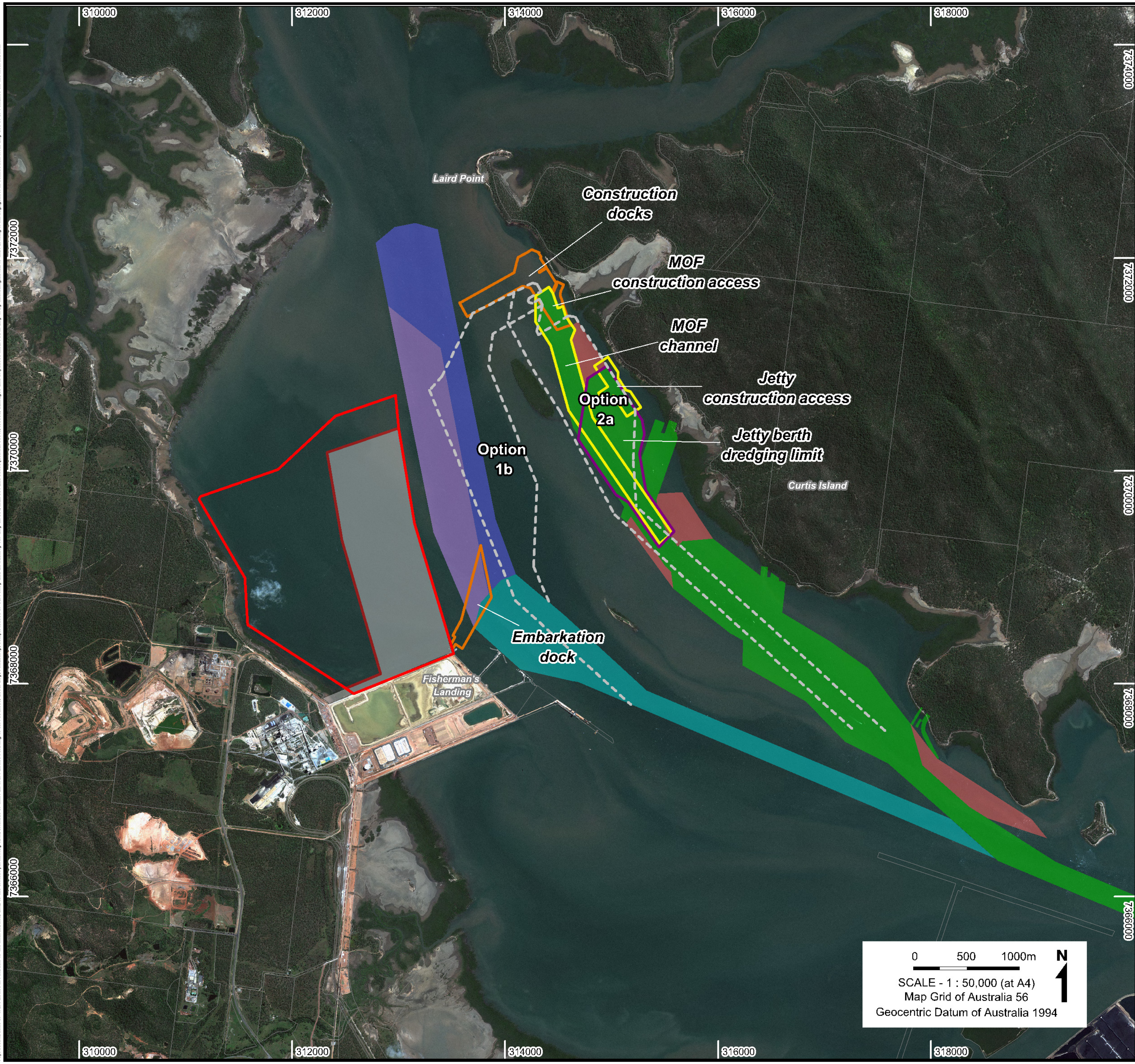
Dredge Area 1 is required to service the roll-on roll-off dock and passenger ferry dock at Fisherman's Landing Northern Expansion. Dredge Area 2 is required to construct and access the temporary rock dock, roll-on roll-off dock and construction ferry dock on Curtis Island.

Figure 1-1 shows the layout of the Australia Pacific LNG proposed early works dredged areas in relation to Other dredging activities and indicates proposed completion dates.

Treated wastewater intake and discharge during construction are located near the Construction Docks and during operation these locations will move to the southern LNG jetty platform.

1.2.1 Coastal Environment

The Coastal Environment of Gladstone harbour and North Passage was described in vol. 5, attachment 27 of the EIS. The tidal dynamics and coastal processes described in that document will apply to the early works dredging as well as the treated water discharges, and the general details are not repeated here. Section 2.2.1 describes additional current measurements collected at the Materials Offloading Facility (MOF) and Embarkation Dock to aid with coastal modelling tasks undertaken as part of the supplementary investigations.



LEGEND

- Cadastre
- WBDDP EIS Addendum Report areas
- Stage 1A - North China Bay LNG Precinct
- Stage 1B - Fisherman's Landing LNG
- Stage 2 - Laird Point LNG
- Stage 3 - Fisherman's Landing
- Stage 4 - Hamilton Point
- Fishermans Landing Northern Expansion
- Preliminary Reclamation Footprint

Dredge Areas

- Completion 2011
- Completion 2012
- Completion 2014

Source Information

Satellite imagery
Captured by GeoEye-1 on 24 March 2009
Proposed dredge area 1b
Digitised from Bechtel CAD drawing 25509-100-K0-K01-00001.dgn
supplied on 15/09/2009.
Proposed dredge area 2a
Digitised from Bechtel CAD drawing 25509-100-K0-K01-00002.dgn
supplied on 11/09/2009.
WBDDP dredge areas
Translated from GPC CAD drawing Footprint_030909.dxf supplied 10/09/2009
APLNG dredge areas
Translated from Bechtel CAD drawings received from ConocoPhillips 15/04/2010

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Figure 1.1
Dredge Area Comparison

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2. Study Methodology and Background

The methodology used in this report is similar to the previous work presented in the main EIS document. However a review has been undertaken of assumptions used in dredging assessments as adopted in other proponent's EIS studies to support their use in this report.

WorleyParsons' model of Gladstone Harbour, incorporating the existing bathymetry, has been used in this supplementary phase with modifications representing stages in the development of the Western Basin at the time the early works dredging is scheduled to proceed.

2.1 Review of EIS Documentation

EIS and supplementary EIS documents from the LNG projects listed in Table 2-1 have been lodged with the Queensland Government and provide a public source of relevant information for dredging and also for discharge of wastewater streams.

Table 2-1 LNG Proponents and Proposed Construction Dates

	Nominal LNG Production (MTPA)	Project construction start and end dates
Australia Pacific LNG Project[1]	18	2011 – 2014
GLNG Project (Santos)[2]	10	Q1 2010 – Q1 2014
QCLNG Project (BG group)[3]	12	2010 – 2013

[1]Australia Pacific LNG (2010), [2]URS (2009), [3]QGC Limited (2010).

LNG proponents have included in their EIS documentation assumptions used in relation to dredge material characteristics, dredging scenarios and plume source loads, and decant discharges from reclamations where relevant. Assumptions concerning sediment characteristics and dredge plumes used in proponents' EIS documents appear to be consistent with those adopted in the Gladstone Ports Corporation (GPC) Western Basin Dredging and Disposal EIS (WBDDP EIS). These are summarised in Sections 2.2 and 2.3 and compared to Australia Pacific LNG assumptions for the Laird Point site.

2.2 Currents and Sediments within Dredged Areas

For the early works excavation work or dredging operations proposed by Australia Pacific LNG, the sediment characteristics are one of the parameters governing the potential plume behaviour. A review was undertaken of the relevant in-situ bed material characteristics in Gladstone Harbour (Western Basin) from several publicly available reports.

Currents in the vicinity of the proposed early works dredging locations were monitored during field work undertaken on 14 and 15 May 2010. Details of currents measurements are provided in Appendix 1 - .

2.2.1 Currents

Current measurements were taken at the proposed LNG MOF channel and at the Embarkation Dock with a SonTek RiverSurveyor M9 Acoustic Doppler Profiler (ADP) during spring tides on the 14 and 15 May 2010. Transect locations and tidal velocities are presented in Appendix 1 - .

Tidal current measurements across the proposed LNG MOF channel can be summarised as follows:

- At the time of measurements near low tide and on the flood tide, currents were moving from near slack to peak speeds during the tidal phase. Mean current velocities were approximately 0.18m/s on the turn of the tide and 0.54m/s at mid-tide on the flood phase
- Currents are reasonably uniform across the channel, but on the turn of the tide the shallower, inshore, zone exhibits stronger current speeds
- The profile from the ADP shows the channel is bounded by a shoal attached to North Passage Island

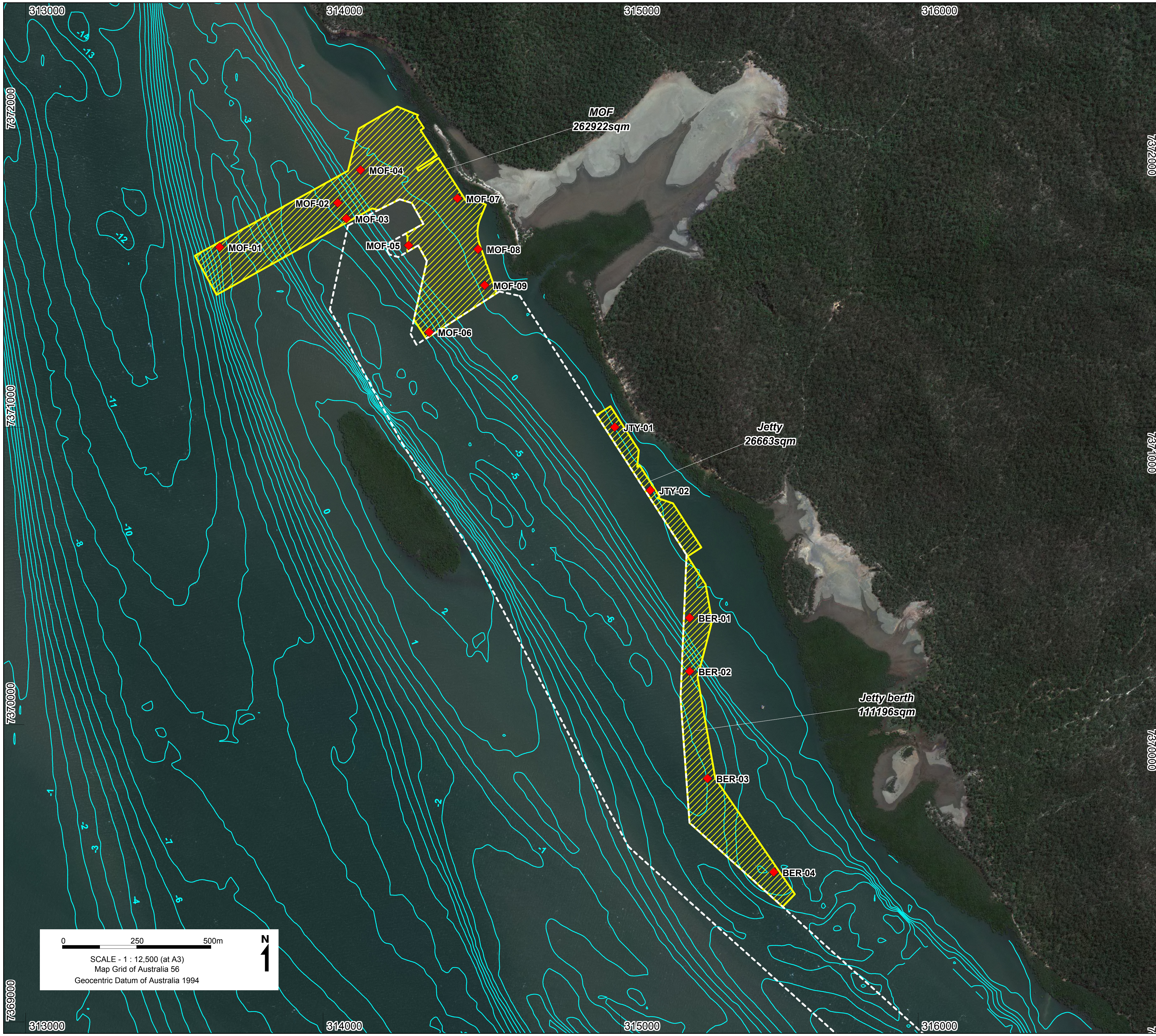
Tidal current measurements across the proposed Embarkation Dock location can be summarised as follows:

- At the time of measurements near high tide and on the ebb tide, currents were moving from near slack to peak speeds during the tidal phase. Mean current speeds were approximately 0.36m/s on the turn of the tide and 0.6m/s at mid-tide on the flood phase
- On the turn of the tide the ebb currents inshore are stronger than in the deeper water due to the mass transport of water from the tidal flats towards the main channel and out of the Western Basin
- At mid-tide the peak currents are reasonably uniform across the transect from inshore out to the main channel

2.2.2 Sediment Physical Characteristics

WorleyParsons (2010) sediment characterisation report indicates sediments at locations in shallower water, closer to the shoreline of Curtis Island have higher clay and silt content than those within the deeper channel areas. In comparison, the sites in the deeper channel areas consist predominantly of sand and gravel fractions. Clay content increases with depth across the majority of sites. One exception to this is MOF 05, where clay and silt fractions decrease with depth, while sand and gravel content increases.

Locations of relevant sampling sites are shown and listed in WorleyParsons (2010) and illustrated in Figure 2-1. Figure 2-2 presents a graphical summary of the percentage of clay, silt, sand and gravel present in sediment cores at particular sites and depth intervals. Table 2-1 provides summary statistics for the percentage of clay, silt, sand and gravel for the combined core samples from dredge areas associated with the Materials Offloading Facility (MOF) and Construction Docks.



LEGEND

- Sediment sampling locations
- Bathymetry contours (1m)
- Proposed dredge area outside APLNG Option 2A dredge area
- APLNG Option 2A dredge area

Source Information

Satellite imagery
Captured by GeoEye-1 on 24 March 2009
APLNG dredge areas
Translated from Bechtel CAD drawings received from ConocoPhillips 08/04/2010
Proposed dredge area 2a
Digitised from Bechtel CAD drawing 25509-100-K0-K01-00002.dgn
Sediment samping locations
Supplied by WorleyParsons 31/05/2010
Bathymetry contours
Calculated using Vertical Mapper from points data provided by Gladstone Ports Corporation July 2009

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Figure 2.1
Sediment sampling locations within the MOF, Jetty and Jetty Berth dredge areas

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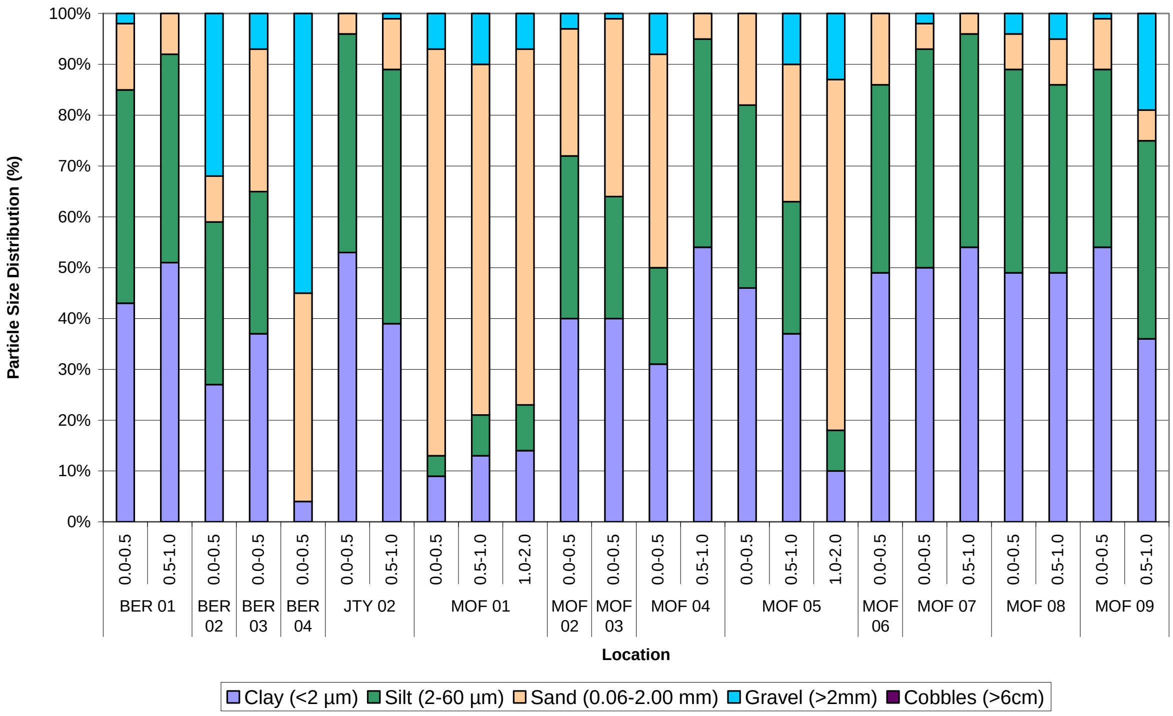


Figure 2-2 Percentage of Sediment Type within Samples in MOF and Construction Docks Dredge Areas

Notes: Construction Docks (JTY), Materials Offloading Facility (MOF) and MOF Berth (BER)

Table 2-2 Combined Sediment Type Percentages for MOF and Dock Dredge Area Sampling Sites

	Percent Clay (<2µm)	Percent Silt (2 - 60µm)	Percent Sand (0.06-2.00 mm)	Percent Gravel (>2mm)
Mean	37.0	29.8	25.3	7.8
Standard Deviation	16.0	14.4	24.2	12.5
Minimum	4	0	4	0
Maximum	54	50	80	55

Dredging of the proposed MOF channel and Construction Docks would involve areas within the intertidal zone, shown in Figure 2-3. As indicated in Table 2-2 a high percentage of fines are present in this material. The combined 24 sediment samples were comprised of clay (37%) with relatively even portions of silt (30%) and sand (25%).

Figure 2-3 Intertidal Zone adjacent to the Proposed LNG Facility

2.3 Dredge Production and Near-field Disturbance

A number of dredging studies have been published on behalf of the various LNG proponents wishing to establish on Curtis Island and also by the Gladstone Port Corporation in its mission to provide navigable channels within the Western Basin. Assumptions made in regard to dredging were documented in the various reports and, where these are relevant to the Australia Pacific LNG project, key points are identified.

As outlined in the WBDDP EIS, GHD (2009, Appendix J2), dredging within Gladstone Harbour would be staged and occur progressively. Dredging plant capable of undertaking this work was assumed as per the GPC WBDDP EIS as follows.

- Large Cutter Suction Dredge (CSD) having a production rate of 1000m^3/hr (in-situ volume)
- Medium CSD having a production of 500m^3/hr
- Slurry pipeline for transporting dredged material from the CSD to the Fisherman's Landing reclamation area, with the rate of decant discharge from the reclamation area being 2.5m^3/s for the large CSD and 1.25m^3/s for the medium CSD
- Large Trailer Hopper Suction Dredge (TSHD) having a hopper capacity of 10,000m^3 and operating on a cycle time of three hours, of which one hour would be allocated for transporting dredged material to the reclamation area. The TSHD would place material adjacent to the Fisherman's Landing extended reclamation area, then a medium sized CSD would pick it up and discharge into the reclamation area

For consistency with the GHD (2009) report for the WBDDP EIS, modelling of the early works dredging areas conducted on behalf of Australia Pacific LNG used the same dredge plant assumptions for general dredging activities. The assumptions used in the GHD (2009) report are considered to be conservative as a modern, 'large', CSD could have a production capacity one and a half to almost double the rate assumed in the WBDDP EIS. The major dredging companies have

many vessels in this class, therefore the early works dredging could be completed in a shorter timeframe than indicated.

Furthermore, large TSHDs are often fitted with equipment to allow 'rain-bowing' of the hopper material into the reclaimed area, thus avoiding the need for double handling by a medium CSD, although this method is time consuming. Many modern TSHDs are also fitted with an anti-turbidity overflow device which reduces the amount of air in the overflow mixture resulting in less turbulence.

Chapter 2 of GHD (2010b) provides details on the type of dredgers suitable for the WBDDP activities. The selection of a dredger for the early works dredge areas influences the duration, size, and character of plume associated with suspended sediments.

A CSD would produce a smaller plume closer to the bed because the suction line efficiently removes a high proportion of the disturbed material. The proposal to slurry the material to the reclamation via a pipeline eliminates plumes resulting from overflowing barge hoppers. Alternative dredging equipment which may be capable of undertaking the early works dredge areas includes mechanical dredgers such as:

- hydraulic backhoe
- clamshell or bucket dredge
- bucket ladder dredge
- bucket wheel dredge

Mechanical type dredges produce a plume through the water column depending on the size of the bucket and the rate material spills from the bucket as it is raised to the surface. Production rates associated with these mechanical dredgers (except for giant backhoe dredgers) are typically lower than for a large CSD and hence dredging would take longer.

The Construction Docks and the MOF Construction Access locations are within intertidal areas consisting of consolidated muds (fine sands, silts and clays) as identified by WorleyParsons (2010) and also in Golders geotechnical report (2009).

The disturbance made by a CSD depends on many factors and as stated in GHD (2009, Appendix J2, Section 4.2.3), "There is considerable uncertainty associated with prediction of dredge plume source loadings". However, to be consistent with GHD (2009) report, the same plume source loadings have been used in this assessment.

3. Proposed Development

3.1 Dredging Scenarios

The early works dredging program for Australia Pacific LNG (late 2010 to late 2012) included in Figure 3-1 shows the overlap with the Other dredging activities and The Narrows pipeline construction program. Completion dates were extracted from the GPC WBDDP EIS and the Australia Pacific LNG early works dredging program and durations of scheduled activities were derived using the assumed production rates of dredgers and calculated dredge quantities. As noted in Section 2.3, timeframes could be shorter and this is reflected in Figure 1-1.

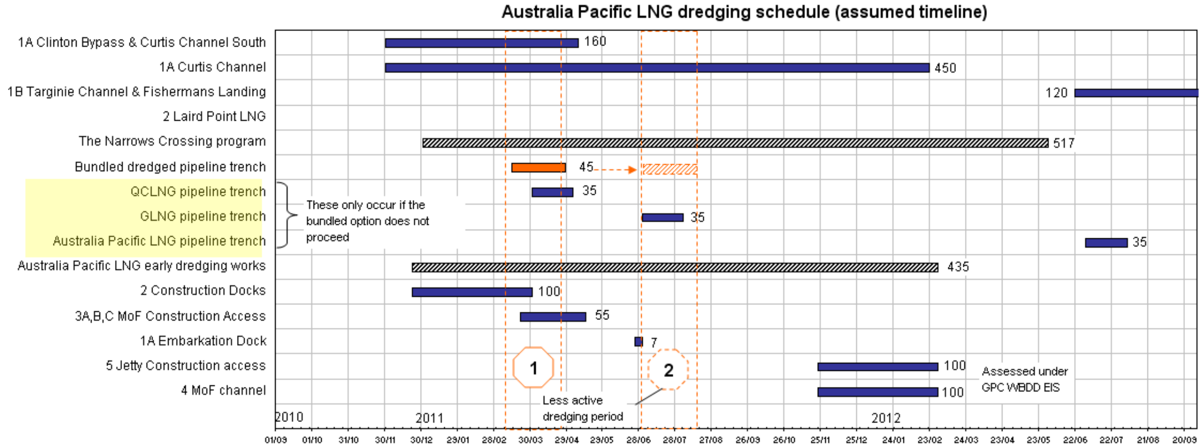


Figure 3-1 Assumed Timeline of Dredging Activities in the Western Basin

There is uncertainty surrounding the timing of dredging in the Western Basin due to the availability of dredging plant and approvals necessary to commence work. Therefore, Figure 3-1 provides one likely scenario of activities for the Australia Pacific LNG early works dredging timeline.

3.2 Early Works Dredging

It is planned to transfer dredged material from the Construction Docks, MOF Construction Access and other areas to the Fisherman's Landing reclamation area by pumping from the dredge. Early works dredge areas are less than three kilometres from the proposed reclamation and it is assumed this facility would be completed or temporary bunds were in place to contain dredged material.

The Construction Docks and MOF Construction Access are scheduled for completion in early 2011. The Construction Docks are necessary for earthworks at the LNG Facility site. Proposed completion dates for the early works dredge areas are as shown in Table 3-1.

Table 3-1 Early Works Dredging Completion Dates and Quantities

Location	Completion Date	Indicative Dredged Qty (m^3)	Depth (m LAT)
Construction Docks	1/4/2011	937,000	-5.6
MOF Construction Access	15/5/2011		
• Area 3A		24,000	-3.0

Location	Completion Date	Indicative Dredged Qty (m^3)	Depth (m LAT)
• Area 3B		361,000	-5.6
• Area 3C		108,000	-7.8
Embarkation Dock	1/7/2011	28,200	-3.3
MOF Channel *	1/3/2012	1,800,000	-7.8
Jetty Construction Access*	1/3/2012	935,000	-13.0
Jetty Berth Dredging Limit*	31/8/2014	5,500,000	-13.3
* Assessed under GPC WBDDP EIS			

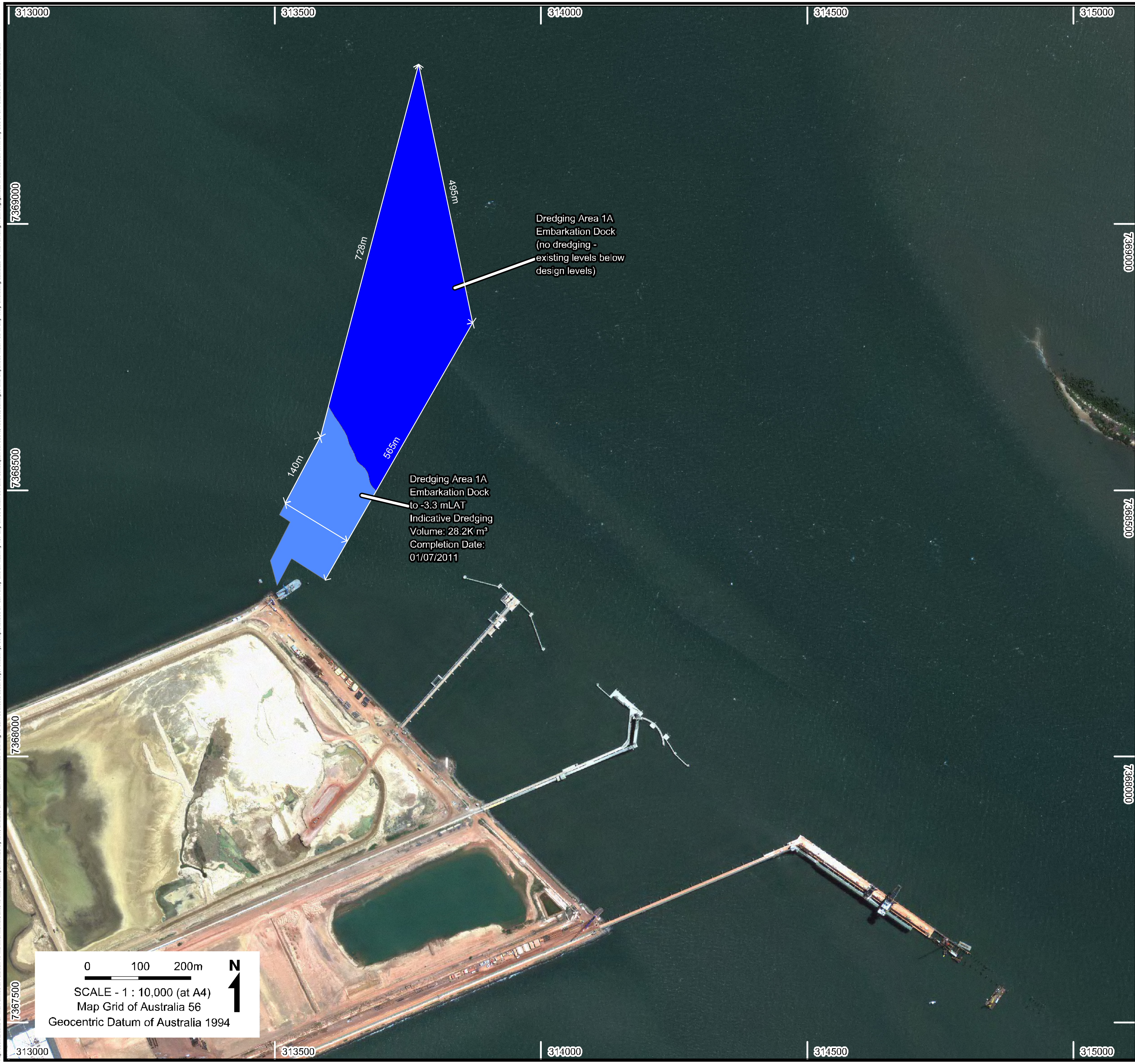
As shown in Table 3-1 the estimated volume for the early works dredging is 1,458,200m^3.

3.2.1 Dredge Area 1 – Embarkation Dock

The dredge footprint for the Australia Pacific LNG Embarkation Dock is shown in Figure 3-2. Dredge Area 1A is located on the northeast corner of the existing Fisherman's Landing reclamation and access is proposed via the roadway along the northern side.

The Embarkation Dock will be used for transfer of construction personnel, equipment and materials to the Curtis Island site. Offshore access is made up of three separate areas of which only one (area 1A) requires the seabed to be dredged. The Construction Conveyor Access (Area 1B) is a piled structure and no dredging is proposed for this area, while the Embarkation Dock in front of the existing Fisherman's Landing berths is located in the main channel where existing depths of more than 9m LAT are already sufficient for embarkation purposes. Dredge Area 1A requires an indicative volume of only 28,200m^3 of dredging in the inshore zone to achieve a minimum depth of -3.3m LAT as shown in Figure 3-2 by way of the sub-area within 1A.

The scheduled completion date for the Embarkation Dock is 1 July 2011 and since the total volume of material to be dredged is relatively minor, the time taken to dredge this quantity is estimated to be in the order of several days with a medium to large CSD. The footprint of the Embarkation Dock Area 1A is relatively larger than the actual area to be dredged and its overall length extends out to the main channel for safe navigation purposes. The channel width at the narrowest point in the footprint is 140m and provides for two way traffic of barges and ferries to and from Curtis Island.



LEGEND

- APLNG early works footprint
- Dredging areas

Source Information

Satellite imagery
Captured by GeoEye-1 on 24 March 2009
Proposed dredge areas
Extracted from Bechtel CAD drawing K0-K01-MD004.dwg

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Figure 3.2
Embarkation Dock
Dredge Area 1

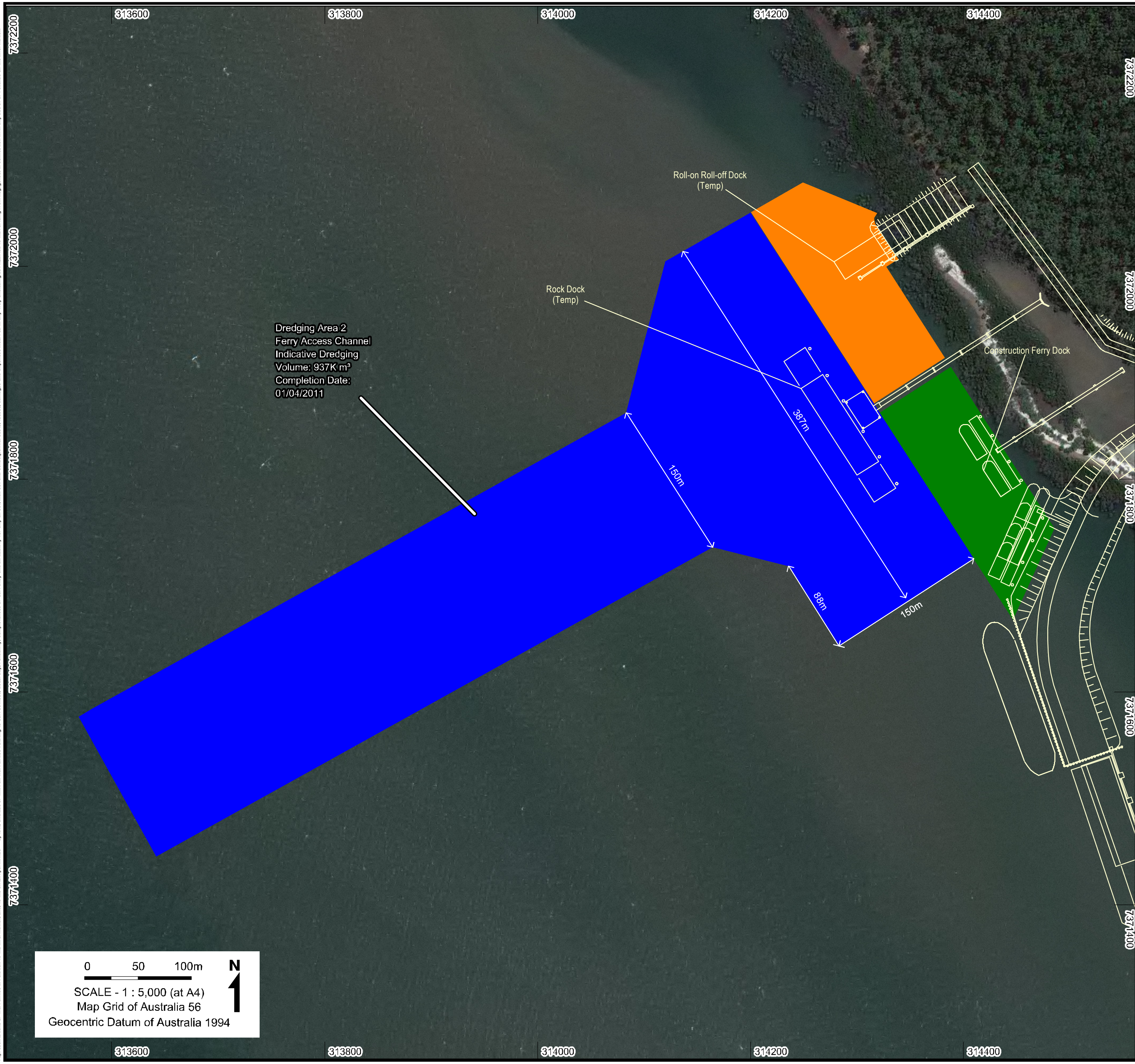
3.2.2 Dredge Area 2 – Construction Docks

The dredge footprint for the Australia Pacific LNG Construction Docks is shown in Figure 3-3. Three areas are proposed to be dredged to the following depths:

- Roll-on Roll-off Dock (orange colour) is to be dredged to -3.3mLAT and would cater for barges transferring earthmoving and other equipment and materials to the site
- Construction Ferry Dock (green colour) is to be dredged to -3.0mLAT and would be used for personnel coming to and from site, and for day to day supplies. A jetty would connect the piled wharf back to shore. Additional ferry berths for operations use are proposed nearby, on the MOF. The revetment would support gangways to reach vessels
- Rock Dock (blue colour) is to be dredged to -5.6mLAT for deeper draft vessels containing armour rock, and aggregates used in the construction of the LNG Facility site. A conveyor is proposed to transfer the aggregate to shore from barges

Navigable access to the Construction Docks and other landings is proposed via an access channel to be dredged through the sand shoal to the north of North Passage Island. The approach from Fisherman's Landing to Curtis Island would be from the main channel side of North Passage Island and across the shoals by the proposed access channel, dredged to a depth of -5.6mLAT. The access channel would be 150m wide and increases to a width of 387m near the Construction Docks to allow for vessel turning and for access to the Roll-on Roll-off Dock and Construction Ferry Dock on either side.

The dredged quantity for the access channel to the Construction Docks (and associated Roll-on Roll-off Dock and Construction Ferry Dock) is estimated to be 937,000m^3 and would have to be one of the first dredging activities to allow construction to commence on the LNG site. The completion date for Dredge Area 2 is 1 April 2011.



LEGEND

- Conceptual facility layout
- Area dredged to -5.6 mLAT
- Area dredged to -3.3 mLAT
- Area dredged to -3.0 mLAT

Source Information

Satellite imagery
Captured by GeoEye-1 on 24 March 2009
Proposed dredge areas
Extracted from Bechtel CAD drawing K0-K01-MD005.dwg
Conceptual Facility Layout
Public Version Overall Site Plan (Native File).dgn supplied by client 03/06/2010

0 50 100m
N
SCALE - 1 : 5,000 (at A4)
Map Grid of Australia 56
Geocentric Datum of Australia 1994

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Figure 3.3
Construction Docks
Dredge Area 2

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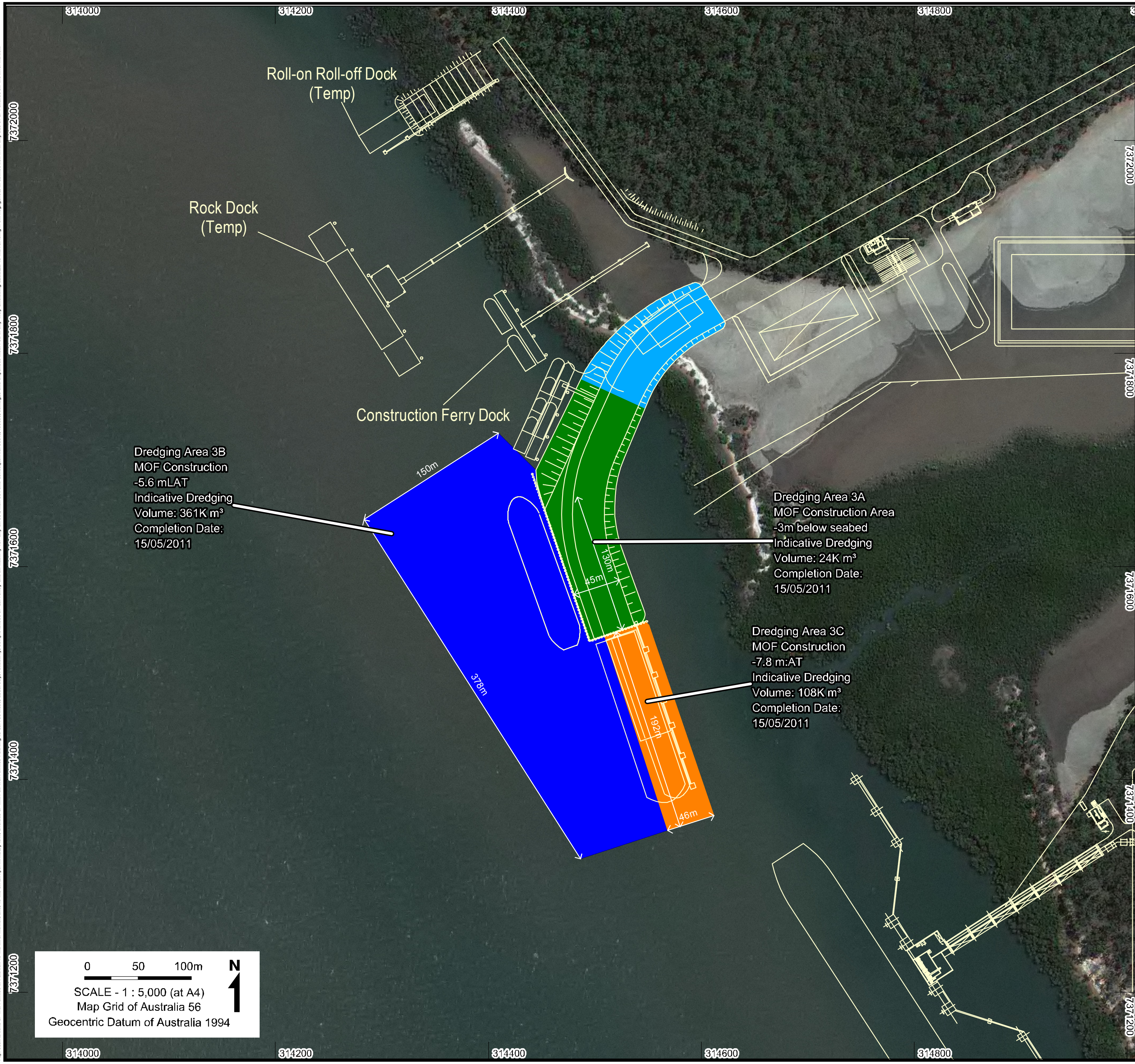
3.2.3 Dredge Area 3 – MOF Construction Access

The indicative dredge footprint for the Australia Pacific LNG MOF construction is shown in Figure 3-4. Three areas are proposed to be dredged to the following depths:

- Area 3A (green colour) to be dredged to -3m LAT to provide a working base for construction of the Material Offloading Facility ramp and revetment. The ramp and revetment would be used for delivery of heavy as well as sizeable modules used in the construction of the LNG Facility and is designed for high wheel loads
- Area 3B (blue colour) to be dredged to -5.6m LAT to provide anchorage for unladen barges after delivery of modules and adjoins the Construction Docks access channel to provide an alternative option for departure. Barges would be able to tie up against the vertical wall of the MOF
- Dredge Area 3C (orange colour) to be dredged to -7.8m LAT to provide deep access for loaded barges. A series of fendered piles lines up the access with the edge of the MOF ramp

The dredged quantity to provide a base for construction of the MOF ramp is relatively small at an indicative 24,000m^3. The dredging for barges and the deep access channel quantities are indicatively 361,000m^3 and 108,000m^3, respectively.

Onshore excavation is also proposed for the MOF ramp construction and is shown as a light blue colour in Figure 3-4.



LEGEND

- Conceptual facility layout
- Area dredged to -3.0 mLAT
- Area dredged to -5.6 mLAT
- Area dredged to -7.8 mLAT
- Area onshore to be excavated

Source Information

Satellite imagery
Captured by GeoEye-1 on 24 March 2009
Proposed dredge areas
Extracted from Bechtel CAD drawing K0-K01-MD002.dwg
Conceptual Facility Layout
Public Version Overall Site Plan (Native File).dgn supplied by client 03/06/2010

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Figure 3.4
MOF Construction Access
Dredge Area 3

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3.2.4 Other Early Works Dredge Areas

Other early works dredging activities associated with the Australia Pacific LNG project are shown in Figure 1-1 and listed in Table 3-1 (shown with *).

The assessment for these areas was included in the WBDDP EIS. Australia Pacific LNG will continue to consult with GPC on the assessment, approvals and execution of this dredging.

3.2.5 Hydrodynamic Model Description

Dredge plume modelling was based on WorleyParsons' model of Gladstone Harbour with calibration and verification of the existing hydrodynamics described in the EIS.

The model is a finite volume flexible mesh and resolves the important features within the harbour relevant to the hydrodynamics including wetting and drying of intertidal areas. The Danish Hydraulic Institute (DHI) software contains modules for the two-dimensional vertically depth averaged hydrodynamics, advection-dispersion, and mud-transport for fine cohesive sediments coupled to wave dynamics where necessary, and can incorporate meteorological forcing as required.

The model domain and bathymetry used for hydrodynamic modelling of the early works dredging is presented in Figure 3-5.

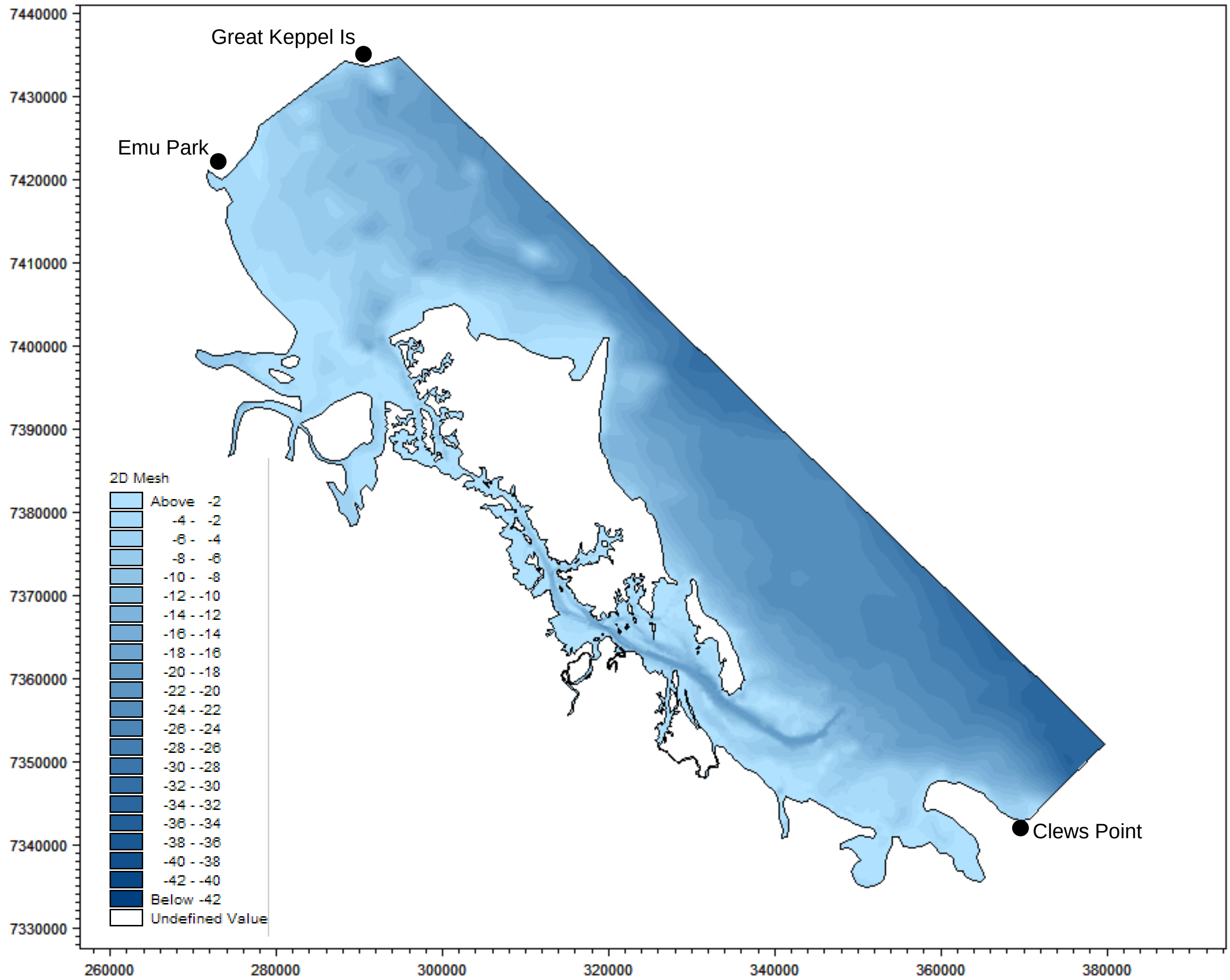


Figure 3-5 Gladstone Hydrodynamic Model Bathymetry

3.3 Early Work Dredging Plume Modelling

Modelling assumed that APLNG early works dredging will be undertaken by a CSD with the dredge material to be disposed of within Gladstone Ports Corporation's Western Basin Reclamation Area. Australia Pacific LNG will continue to consult with GPC about the disposal of dredged material associated with the project. The model assumes a floating pipeline is connected to the CSD and transfers the dredged material directly to the reclamation area. Pumping sediment slurry from the dredge to the reclamation mitigates the production of plumes generated by an overflowing barge that would have an additional impact on the marine environment. It is assumed a reclamation bund or a temporary containment area would be available by the time the APLNG early dredging works begins.

In the model the CSD is moved continuously in a three hour dredging cycle across the dredge areas. The dredge proceeds in straight runs commencing in deeper water and finishing in shallow water before returning to deeper water to begin the next run. Table 3-2 summarises the assumptions used for the CSD production in the early works modelling.

Table 3-2 CSD Production for early works dredging

Dredge Area	Dredge Production m^3/h	Dredging time hr/wk	Production m^3/wk	Indicative Dredge Volume m^3	Duration Days	Distance per day m	Hours of dredging each day
Embarkation Dock	1,000	100	100,000	28,200	2	259.7	14.3
Construction Docks	1,000	100	100,000	937,000	65.6	35.3	14.3
MOF Construction Access	1,000	100	100,000	493,000	34.5	25.5	14.3

Sediments encountered within the dredge area were discussed in Section 2.2.2 and an average composition of coarse material, silts and clays used in the modelling was as shown in Table 2-2.

Sediment settling velocities used in the modelling are shown in Table 3-3 for the fractions indicated. Settling velocities correspond to medium sediment sizes within the fraction and were adopted for the model runs. The minimum bed shear stress for full deposition of sediment flocs was set to $0.07 N/m^2$.

Table 3-3 Sediment characteristics used in dredge simulations

Fraction	Grain size (mm)	Percentage	Particle density (kg/m^3)	Settling Velocity (m/s)
Coarse material	> 0.06	46%	2650	0.02
Silt	0.06-0.002	20%	2650	0.001
Clay	<0.002	34%	2650	0.0001

APASA (2010) analysed background TSS concentration based on a satellite-derived 250m gridded dataset covering Port Curtis and determined the average TSS concentration to be approximately 20mg/L. Higher average TSS concentrations between 25 and 50mg/L were more indicative of the main navigation channels where stronger currents are present.

Time series points for the different dredge simulations are summarised in Table 3-4.

Table 3-4 Time Series recording locations

Marker	Locations	Easting	Northing
t1	Graham Ck N	313635	7373880
t2	APLNG Dock	314293	7371802
t3	Main Channel	313271	7372124
t4	Tidal Flats	311866	7371522
t5	Graham Ck S	314154	7373103
t6	The Narrows	311791	7373622

These locations are shown on Figure 3-6, Figure 3-12 and Figure 3-24.

3.3.1 Dredge Area 2 – Construction Docks dredging

Model results of dredge plumes associated with the Construction Docks dredging (not including other dredging activities or the Pipeline Dredging) are summarised in Figure 3-6 through to Figure 3-11. Model results of Total Suspended Solids (TSS) concentrations are reported as above natural background levels.

Figure 3-6 consists of snapshots of the model plumes generated from simulated dredging of the Construction Docks through ebb and flood tide shortly after dredging commences from the offshore area. These snapshots are typical of dredge plumes at various stages of the tide as the dredge works towards the shore.

The simulation indicates the plume will follow the eastern shoreline with some intrusion into Graham Creek until sediment eventually falls out of suspension. TSS are relatively high when water depths become shallower around the low tide. In the centre of the channel the TSS concentrations are significantly lower due to the deeper water and the dispersion from tidal currents. Over the duration of the simulation the modelled plume is characterised as follows:

- Dredging offshore produces low TSS concentrations due to deeper water-level and the plume tends to follow the main currents into The Narrows during the flood stages and as far as Fisherman's Landing on the ebb tides
- When the dredge is in the nearshore intertidal areas the plume exhibits higher TSS concentrations and moves towards Graham Creek on the flood tides and between North Passage Island and the proposed LNG facility during ebb tides. If containment is not utilised for the nearshore dredging there is potential for deposition of a coating of mud (silts and clays) on the sandy beaches at the entrance to Graham Creek
- Plumes in the simulation were observed to move over the time-series recording locations within the model domain as the result of a particular tidal flow direction and then move back over the same location with the turn of the tide; indicating TSS concentrations can be cumulative in some instances

Figure 3-7 and Figure 3-8 that present the analysis of TSS over the duration of the dredge simulation support the finding of relatively high concentrations over the intertidal areas and less significant concentrations in the centre of the channel.

Figure 3-7 shows the maximum TSS concentrations due to dredging of the Construction Docks. Peak values of 500mg/L (0.5kg/m^3) and above are predicted only within a small area in the shallow nearshore area. These peak concentrations are significant in magnitude but of short duration (half a tide cycle) as would be expected in shallow water during a receding tide while dredging takes place. If not contained, these concentrations would impact an area around the proposed dock. To mitigate this potential impact the dredge may be required to operate at specific stages of the tide for short periods to complete the Construction Docks dredging.

Figure 3-8 shows the mean TSS concentrations over the duration of the dredging simulation and shows significantly lower concentrations compared to the maximum concentrations in Figure 3-7. The mean values reflect the situation of peaks or spikes of high TSS concentrations at the location of the dredge while it is working but once it has moved on, concentrations return towards background levels. It is important to note that the scale used in Figure 3-8 indicating mean TSS concentration values ranges from 0 – 2.5mg/L (0.0025kg/m^3). This is several orders of magnitude less than illustrated for peak values in Figure 3-7. It is evident from this figure that the simulated dredging of the Construction Docks does not have a sustained impact over the duration of dredging activity. Rather, impacts are short lived over a day or two as indicated in the time series of TSS concentrations for selected locations.

Time series locations used in Figure 3-9, Figure 3-10 and Figure 3-11 are defined in Table 3-4. Time series locations of TSS concentrations are also shown in Figure 3-6.

Figure 3-9 presents (a) Graham Creek North (t1) and (b) Graham Creek South (t5). At the Graham Creek North location (t1) peak TSS concentrations coincide with high tides and occur on and off over the duration of the Construction Docks dredging. The highest peaks of between 2mg/L and 5mg/L occur fairly consistently during the first six weeks of the simulation. The range of TSS concentrations is indicated to vary up to a peak value of 4.9mg/L and is less than 3.4mg/L for 99% of the duration.

At the Graham Creek South location (t5) peak TSS concentrations follow a similar patter to Graham Creek North but larger peaks due to its closer proximity to the dredge operation. The highest peaks of between 6mg/L and 13mg/L occur over two periods for about 1.5 weeks at a time with a period of lower peaks in between. The peak value shown by the simulation is 12.8mg/L while a value of less than 7.2mg/L is recorded for 99% of the duration and less than 3.7mg/L for 90% of the duration.

Figure 3-10 presents (a) APLNG Dock (t2) and (b) Main Channel (t3). The APLNG Dock location (t2) is in the middle of the Construction Docks dredge area and large spikes in TSS concentration occur when the dredge is in this area. The highest peaks of more than 500mg/L occur over a 2 day period. The maximum value is seen to be 3,200mg/L when the dredge is working at this location. However, TSS concentrations are less than 146mg/L for 99% of the model duration and less than 5.4 for 90% of the model duration.

The Main Channel location (t3) is to the northwest of the dredge area in the centre of the channel. Depths in this area are typically around 12m at LAT. The water depth and distance from the dredge area are sufficient to result in a simulated peak TSS concentration greater than 4mg/L for less than a 2 day period. TSS concentrations at this location for 99% of the duration are seen to be less than 2mg/L.

Figure 3-10 presents (a) Tidal Flats (t4) and (b) The Narrows (t6). At the location of the Tidal Flats (t4), modelled TSS concentrations from the Construction Docks dredging are very low with a peak of less than 0.5mg/L and for 90 percent of the duration a concentration of less than 0.2mg/L.

TSS concentrations at The Narrows location (t6) are minor compared to background levels with a peak of just under 0.8mg/L and concentrations below 0.3mg/L for 90% of the simulated duration.

Table 3-5 below presents a summary of modelled TSS concentrations at the selected time series recording locations for the Construction Docks dredging simulation.

Table 3-5 Summary of modelled TSS concentrations (mg/L) for Construction Docks dredging

Location	Peak value	99th percentile	90th percentile	Mean value
Graham Ck N (t1)	4.9	3.4	1.5	0.5
APLNG Dock (t2)	3200	146	5.4	8.3
Main Channel (t3)	5.4	2.0	1.3	0.6
Tidal Flats (t4)	0.5	0.4	0.2	0.0
Graham Ck S (t5)	12.8	7.2	3.7	1.4
The Narrows (t6)	0.8	0.6	0.3	0.1

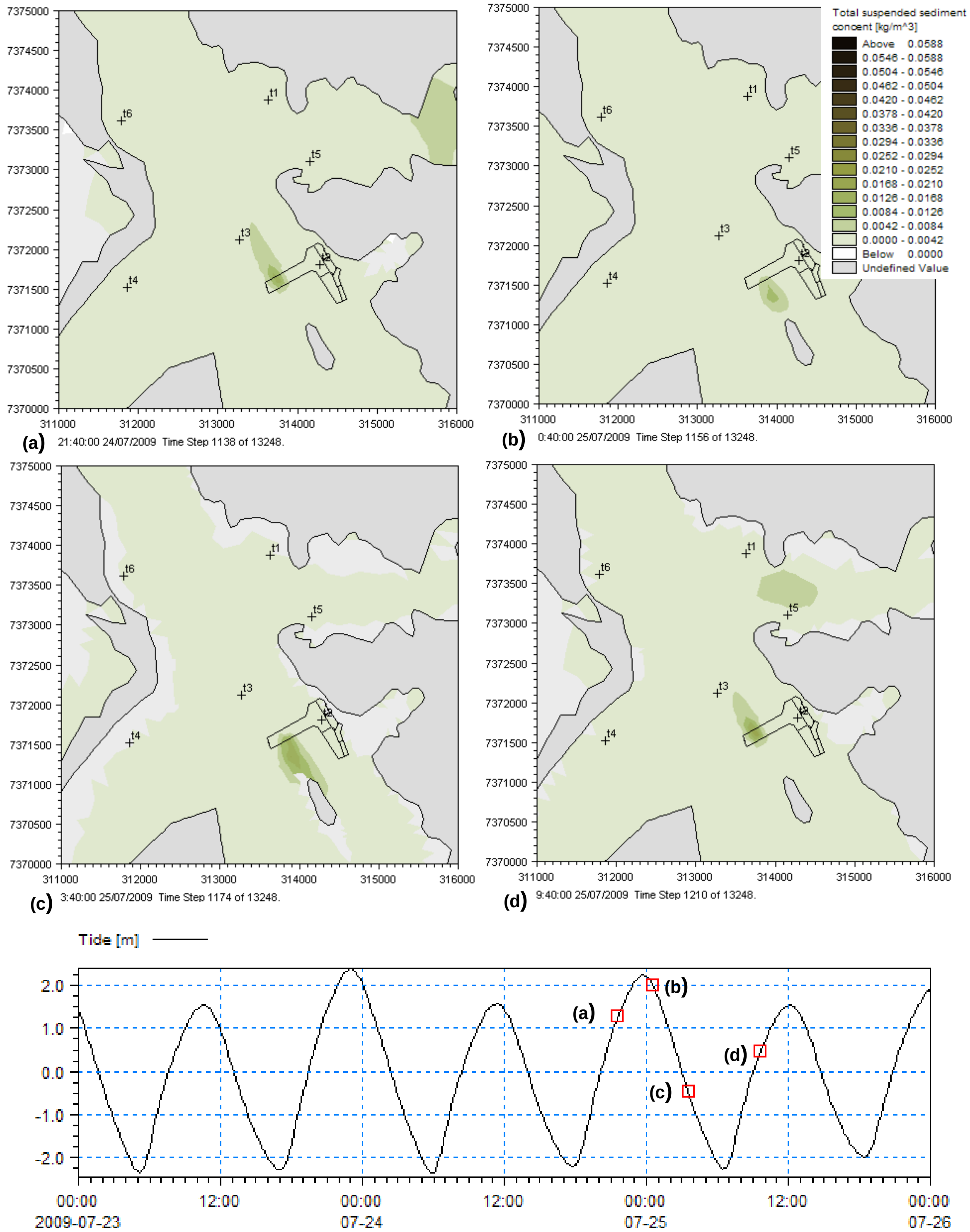


Figure 3-6 Construction Docks dredge plume snapshot

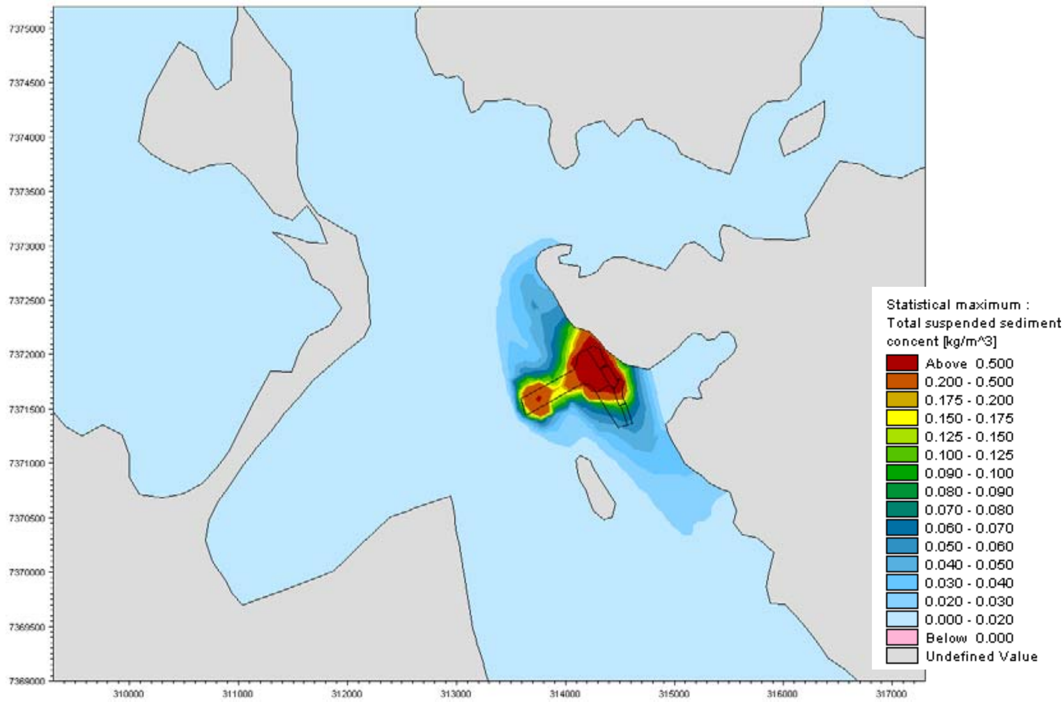


Figure 3-7 Construction Docks dredging - statistical maximum TSS concentration above background

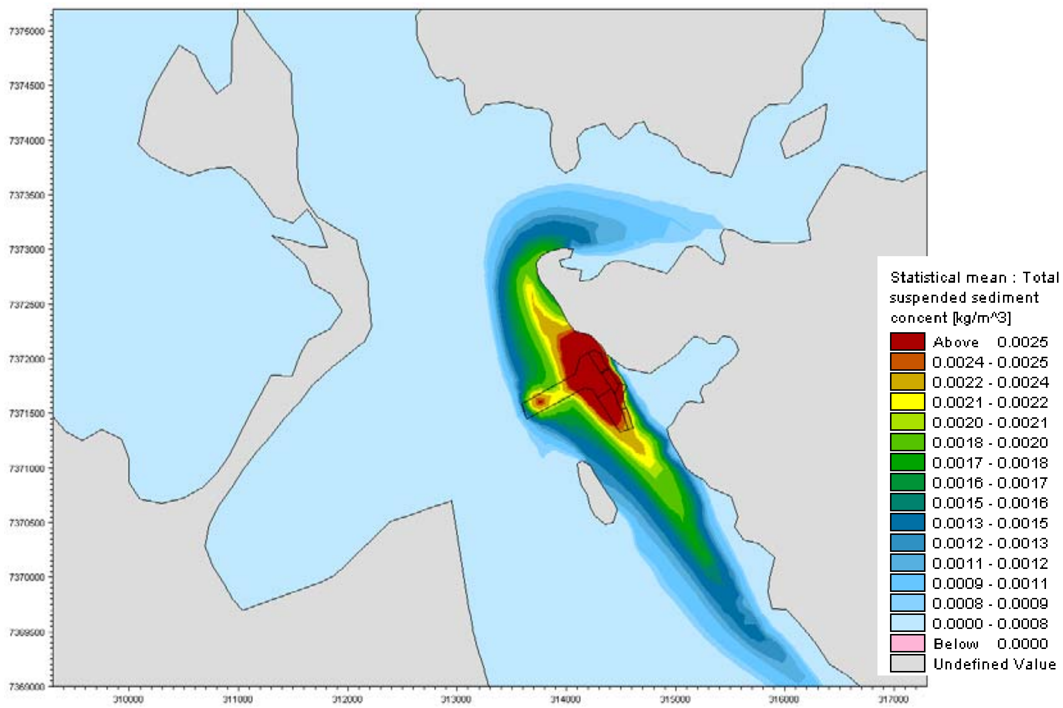
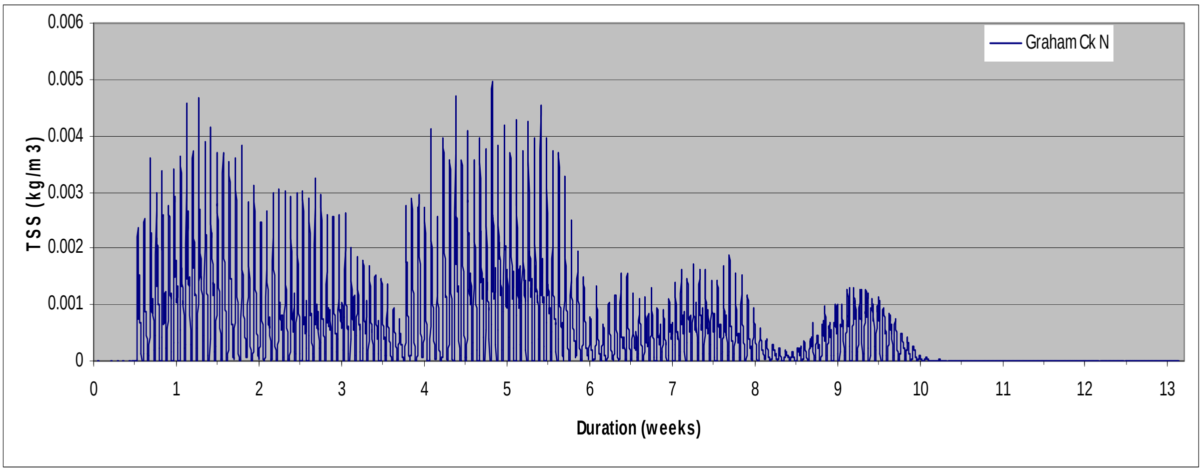
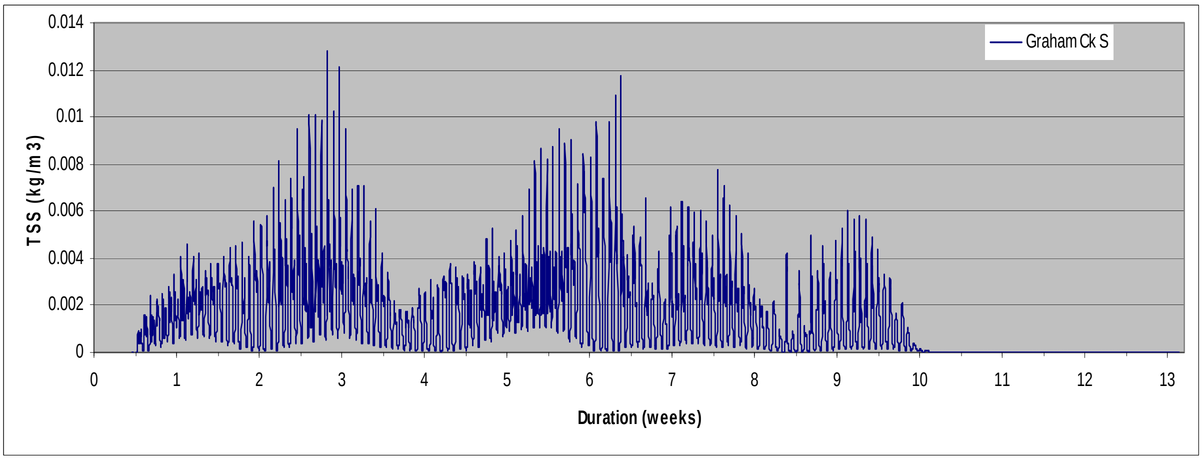


Figure 3-8 Construction Docks dredging - statistical mean TSS concentration above background

(a)



(b)



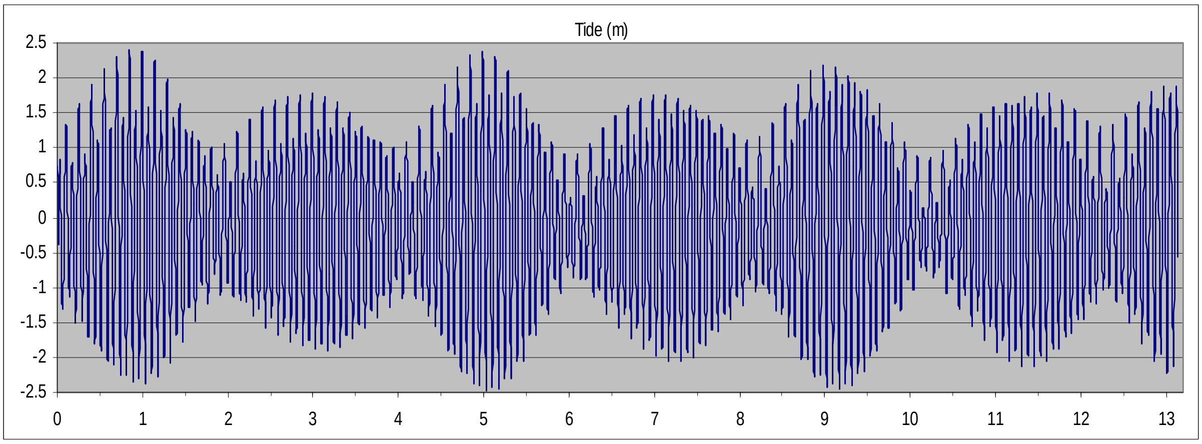


Figure 3-9 Construction Docks dredging TSS concentration time-series (a) Graham Ck N (b) Graham Ck S

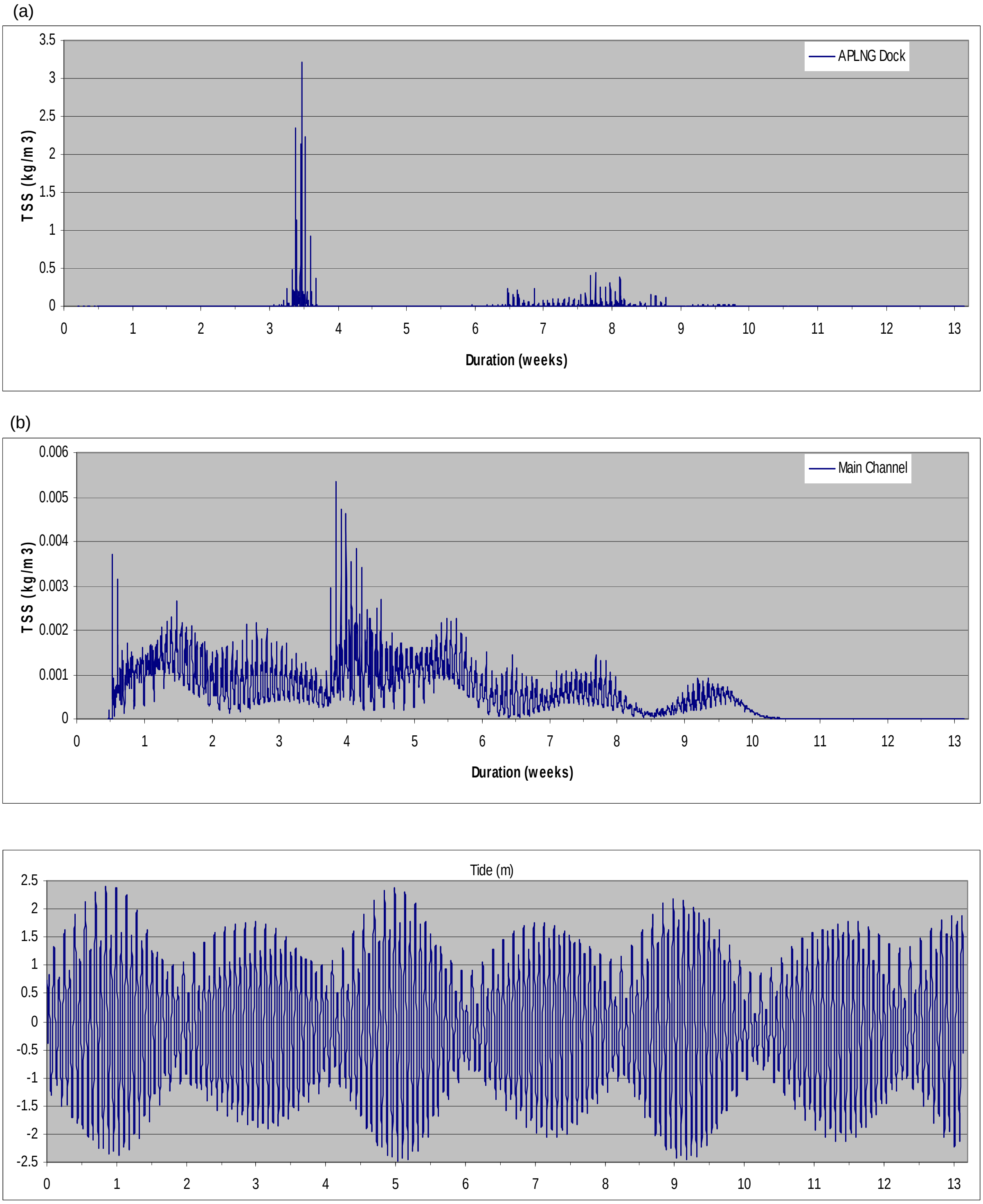


Figure 3-10 Construction Docks dredging TSS concentration time-series (a) APLNG Dock (b) Main Channel

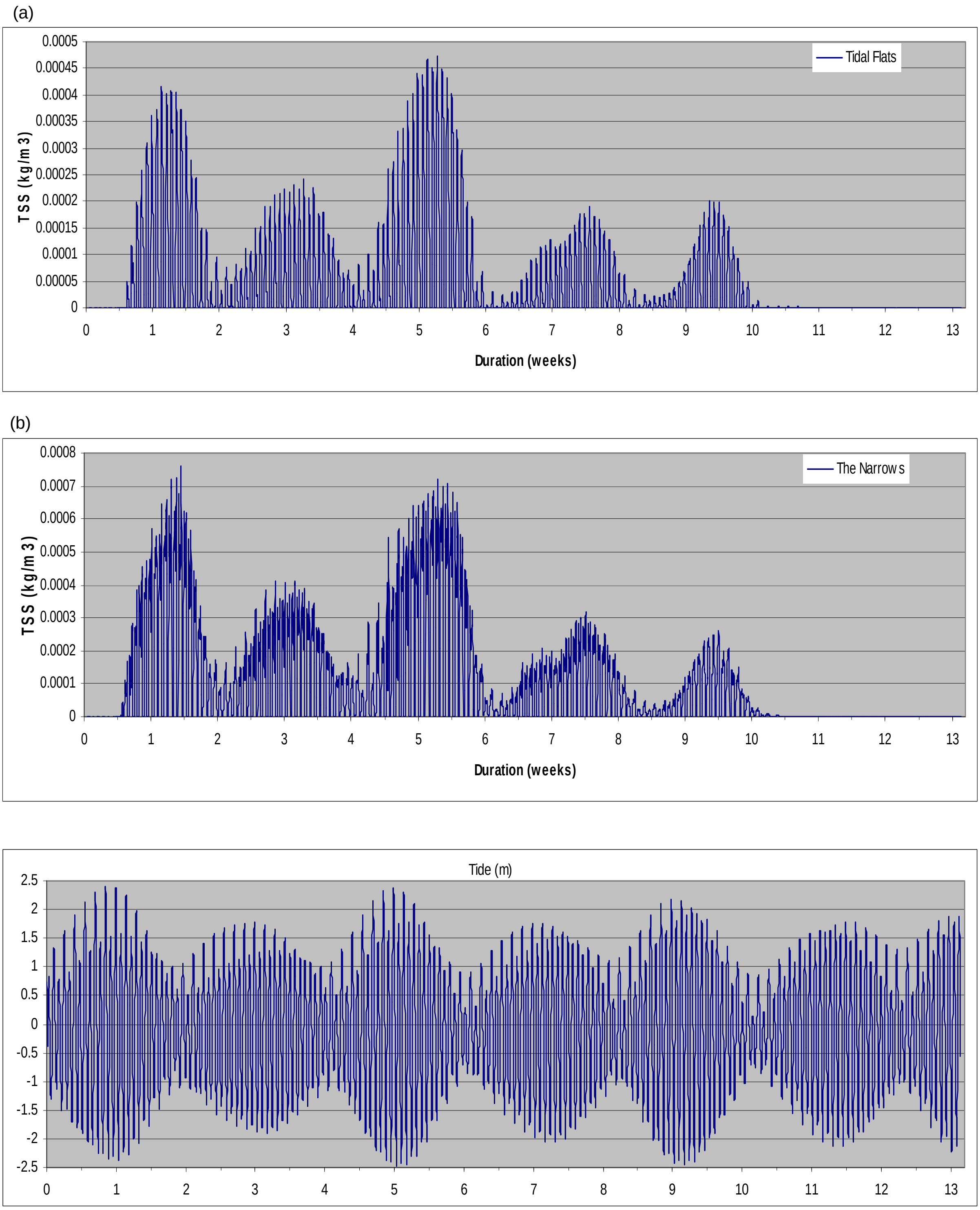


Figure 3-11 Construction Docks dredging TSS concentration time-series (a) Tidal Flats (b) The Narrows

3.3.2 Dredge Area 3 – MOF Construction Access

Model results of dredge plumes associated with the MOF Construction Access (not including other dredging activities or the Pipeline Dredging) are summarised in Figure 3-12 through to Figure 3-17 in a similar arrangement presented for the Construction Docks in Section 3.3.1. Model results of Total Suspended Solids (TSS) concentrations are reported as above natural background levels.

Due to the similarities in the location of the Construction Docks and MOF Construction Access, plumes simulated by the model for dredging of the MOF Construction Access had a similar general character to that described for the Construction Docks in 3.3.1. However, due to the smaller dredge volume, spatial extent of dredge area and therefore shorter duration of dredging; TSS concentration over the duration of the dredging are indicated to be significantly lower.

Table 3-6 below presents a summary of modelled TSS concentrations at the selected time series recording locations for the MOF Construction Access dredging simulation.

Table 3-6 Summary of modelled TSS concentrations (mg/L) for MOF Construction Access Dredging

Location	Peak value	99th percentile	90th percentile	Mean value
Graham Ck N (t1)	2.1	1.4	0.7	0.2
APLNG Dock (t2)	189	61	8.3	3.7
Main Channel (t3)	1.6	1.0	0.6	0.2
Tidal Flats (t4)	0.2	0.2	0.1	0.0
Graham Ck S (t5)	8.8	6.0	2.8	0.7
The Narrows (t6)	0.4	0.3	0.1	0.0

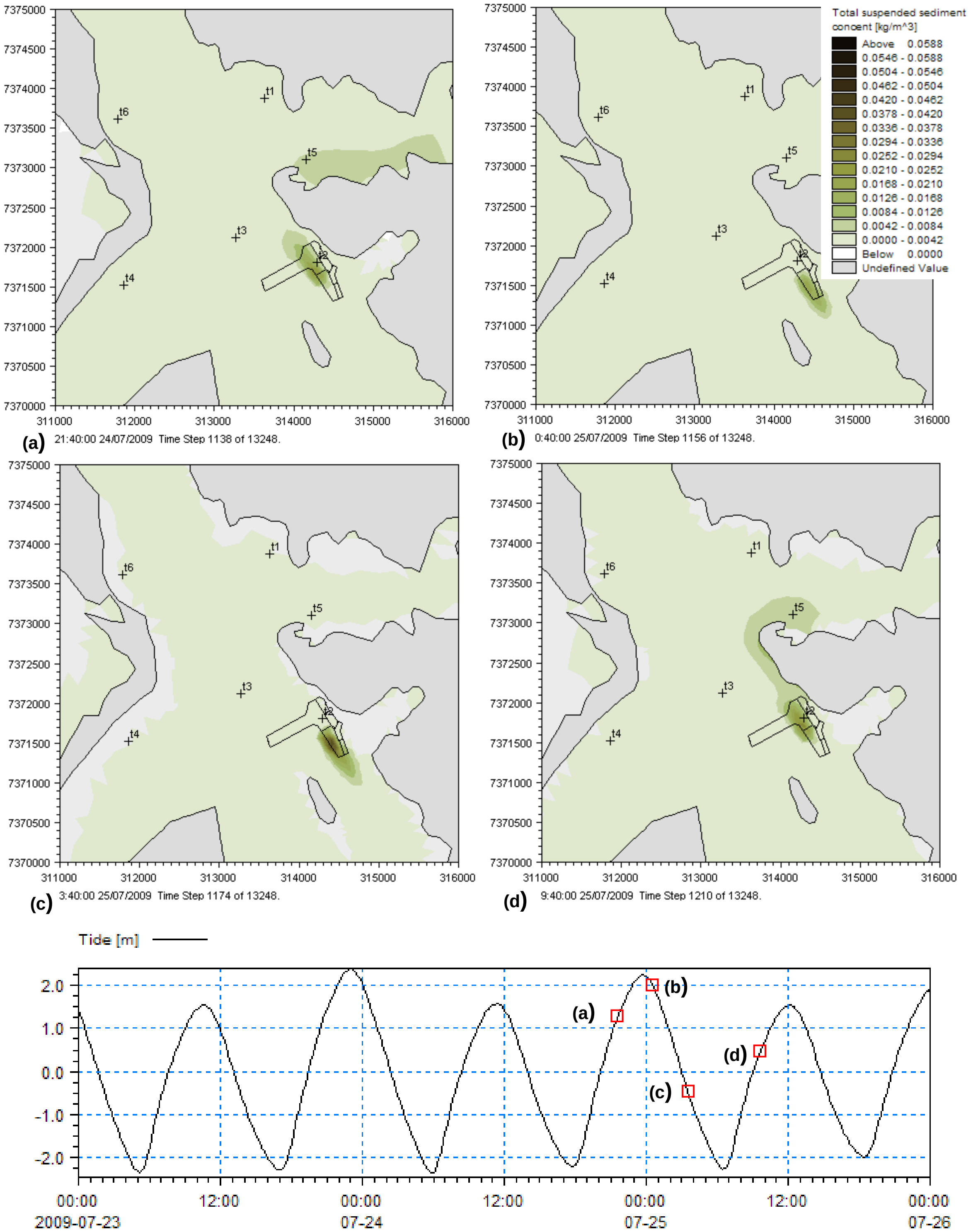


Figure 3-12 MOF Construction Access dredge plume snapshot

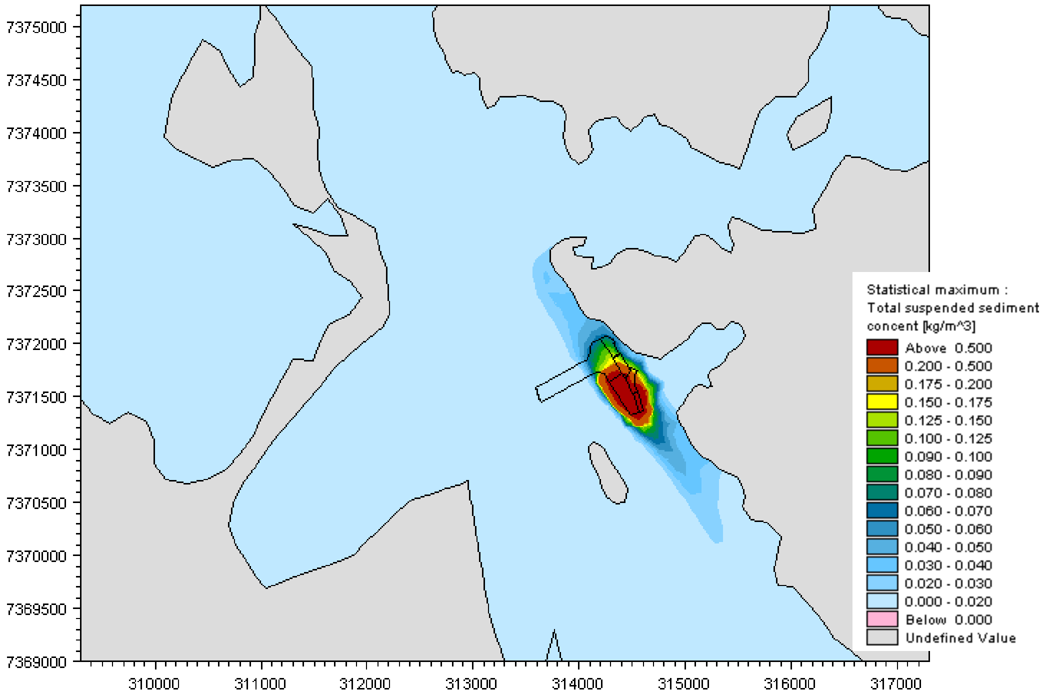


Figure 3-13 MOF Construction Access dredge - statistical maximum TSS concentration above background

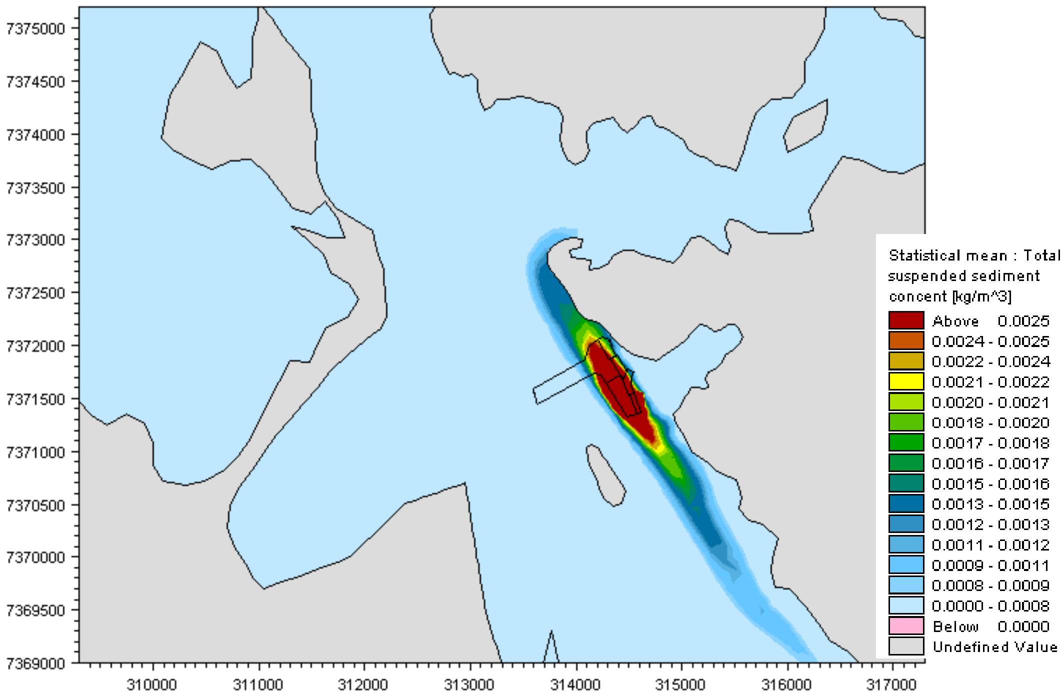
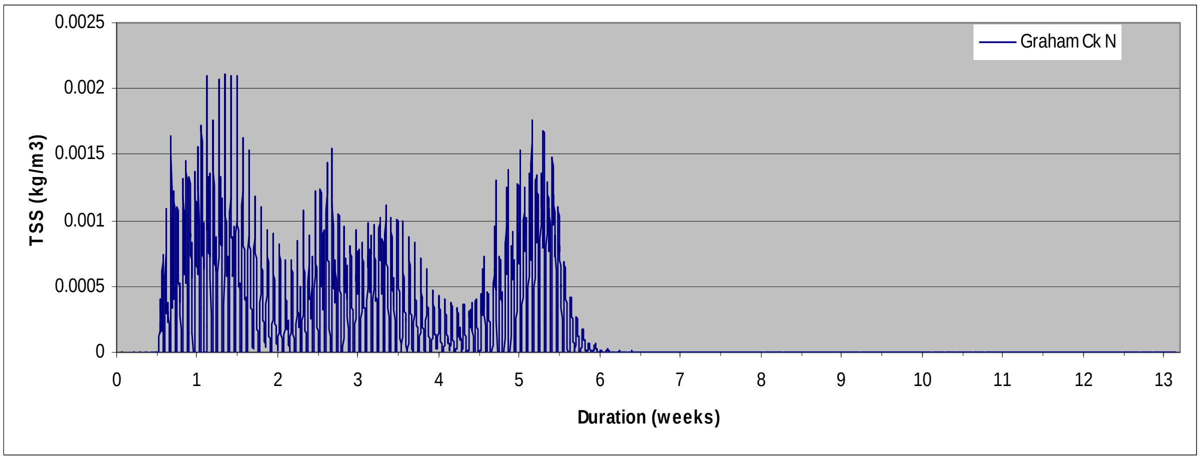
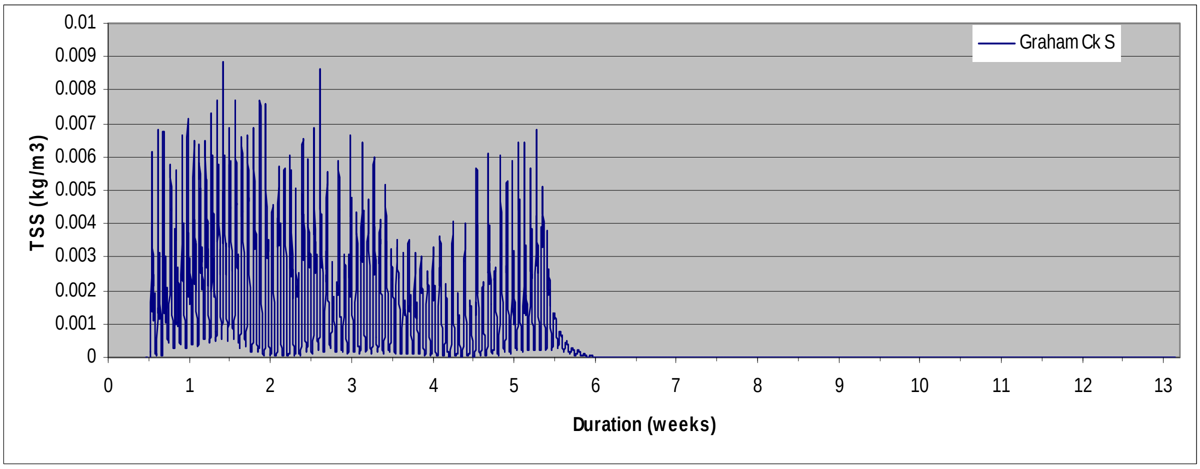


Figure 3-14 MOF Construction Access dredge - statistical mean TSS concentration above background

(a)



(b)



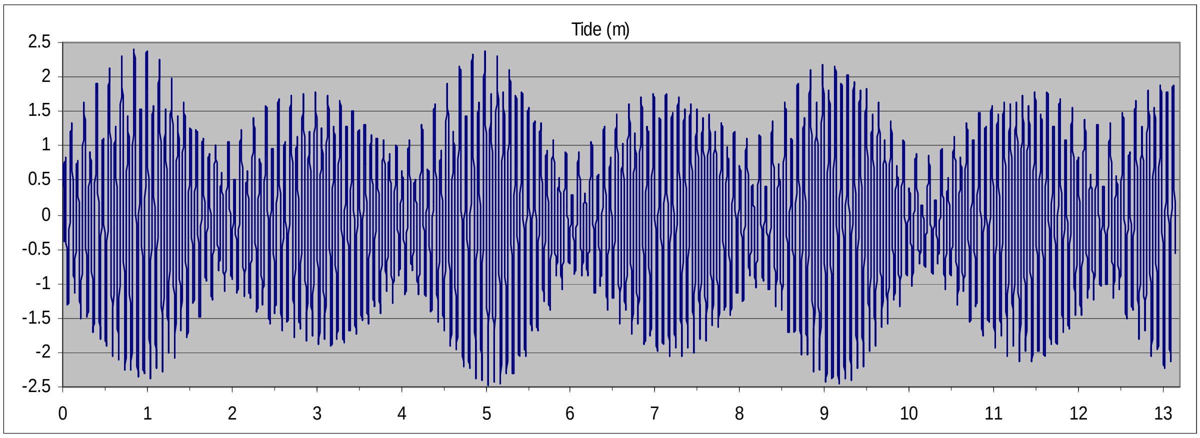


Figure 3-15 MOF Construction Access TSS concentration time-series (a) Graham Ck N (b) Graham Ck S

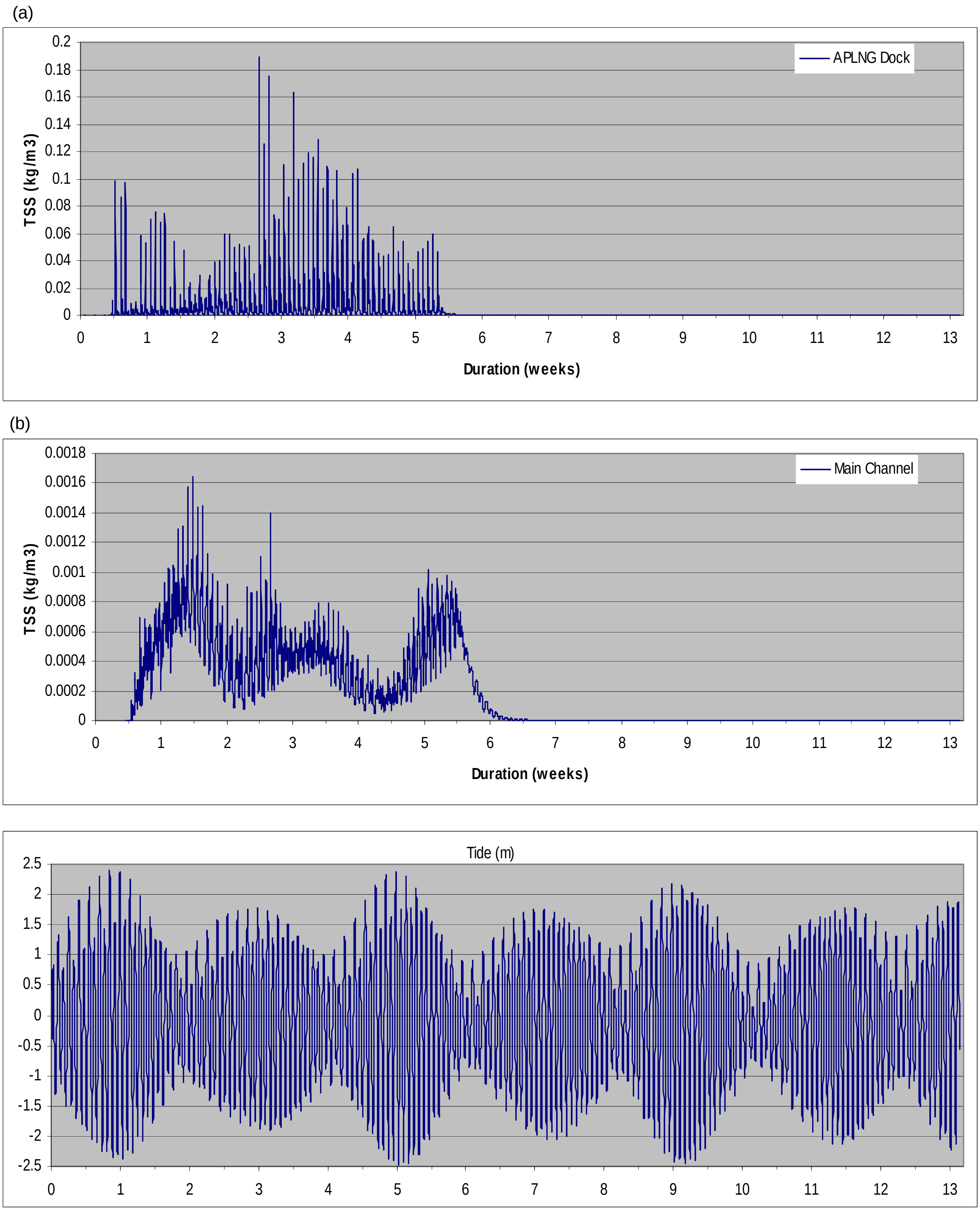


Figure 3-16 MOF Construction Access TSS concentration time-series (a) APLNG Dock (b) Main Channel

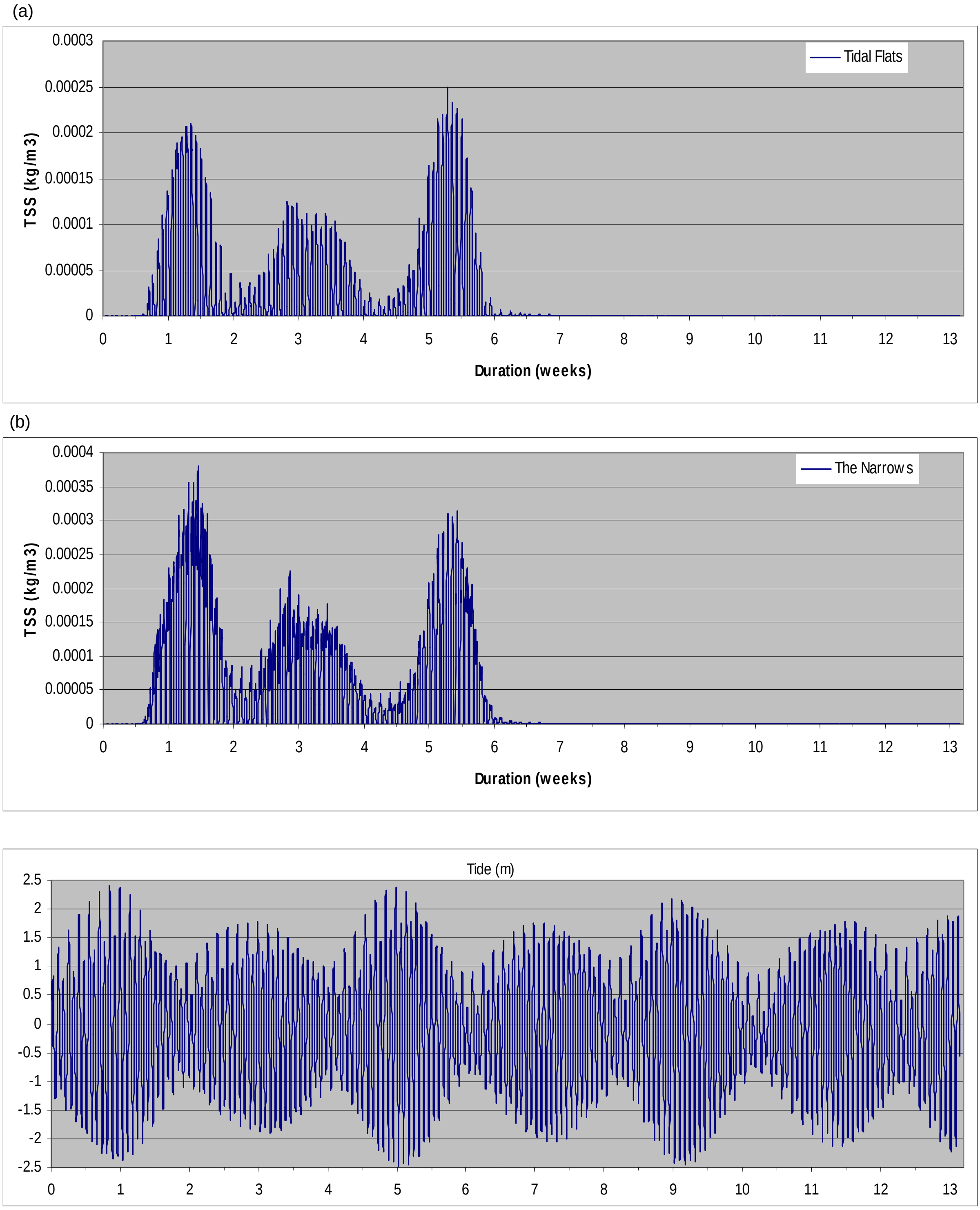


Figure 3-17 MOF Construction Access TSS concentration time-series (a) Tidal Flats (b) The Narrows

3.3.3 Dredge Area 1 – Embarkation Dock

Model results of dredge plumes associated with the Embarkation Dock in isolation are summarised in Figure 3-18 through to Figure 3-22 in a similar arrangement presented for the Construction Docks in Section 3.3.1. Model results of Total Suspended Solids (TSS) concentrations are reported as above natural background levels.

Due to the different area in which the Embarkation Dock dredging has an impact as compared to the Construction Docks dredging or the MOF Construction Access, alternate time series locations have been used for reporting the results of the Embarkation Dock dredge simulation. These points are summarised in Table 3-7.

Table 3-7 Alternate time series recording locations for Embarkation Dock dredge simulation

Marker	Locations	Easting	Northing
t1	Fishermans Landing S	314080	7367337
t2	Embarkation Dock	313643	7368459
t3	Channel	314379	7369344
t4	Tidal Flats	312671	7370928

These locations are shown on Figure 3-18.

Figure 3-18 consists of snapshots of the model plumes generated from simulated dredging of the Embarkation Dock through ebb and flood tide shortly after dredging commences from the offshore area. These snapshots are typical of dredge plumes at various stages of the tide as the dredge works towards the shore. (NOTE: the scale of snapshots and time step of snap shot is different to that presented for the Construction Docks and MOF Construction Access due to the short dredge duration (2 days))

The simulation indicates the plume will follow the western shoreline (along the bund for the reclamation area) until sediment eventually falls out of suspension. Due to the short duration, small spatial and volumetric extent of the dredging; TSS are only relatively high at the location of the dredge.

Table 3-8 below presents a summary of modelled TSS concentrations at the selected time series recording locations for the MOF Embarkation Dock dredging simulation.

Table 3-8 Summary of modelled TSS concentrations (mg/L) for Embarkation Dock Dredging

Location	Peak value	99th percentile	90th percentile	Mean value
Fishermans Landing S (t1)	5.4	0.9	0.0	0.0
Embarkation Dock (t2)	257	2.0	0.0	0.3
Channel (t3)	0.7	0.4	0.0	0.0
Tidal Flats (t4)	12.5	1.7	0.0	0.1

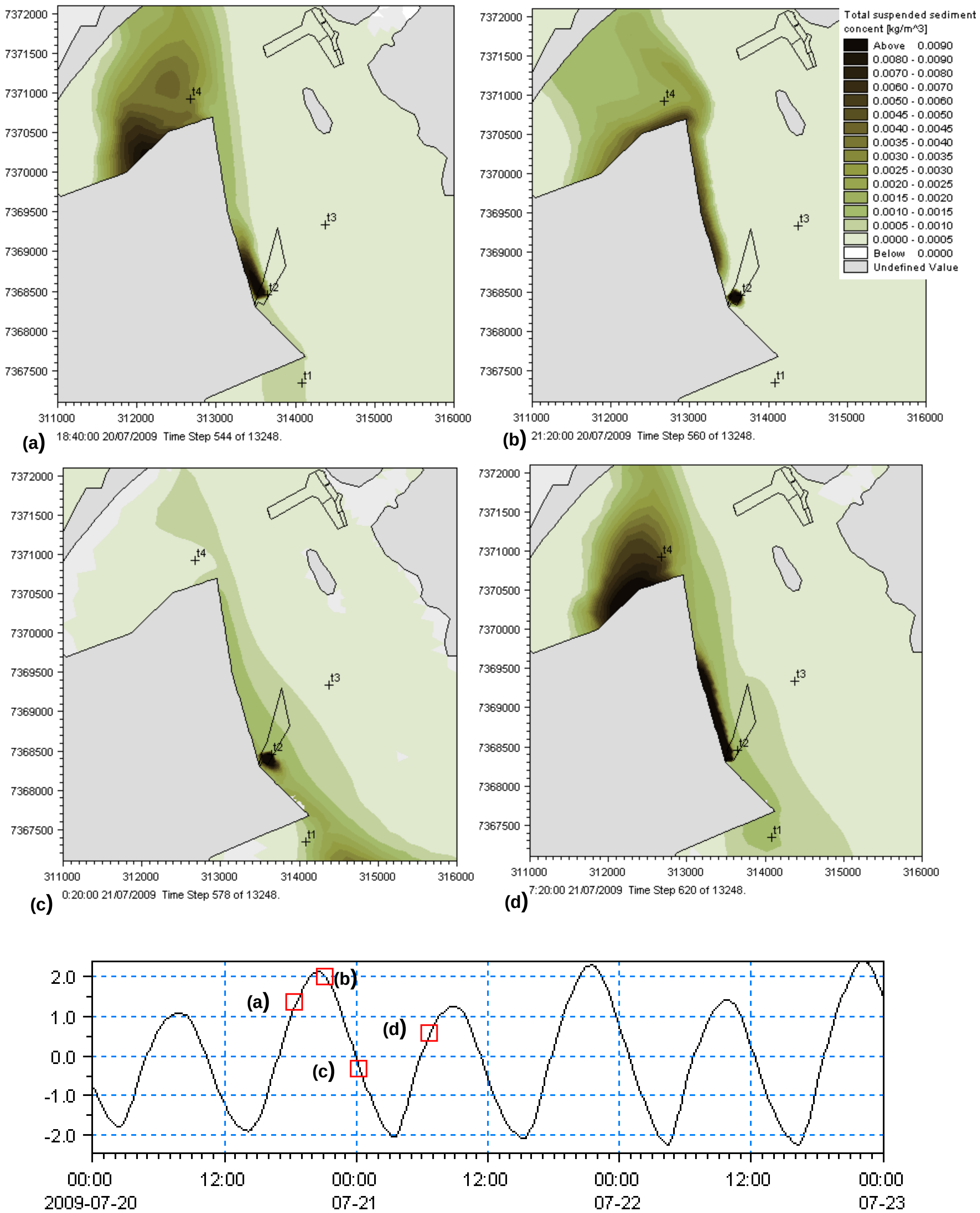


Figure 3-18 Embarkation Dock dredge plume snapshot

Figure 3-19 Embarkation Dock dredge - statistical maximum TSS concentration above background

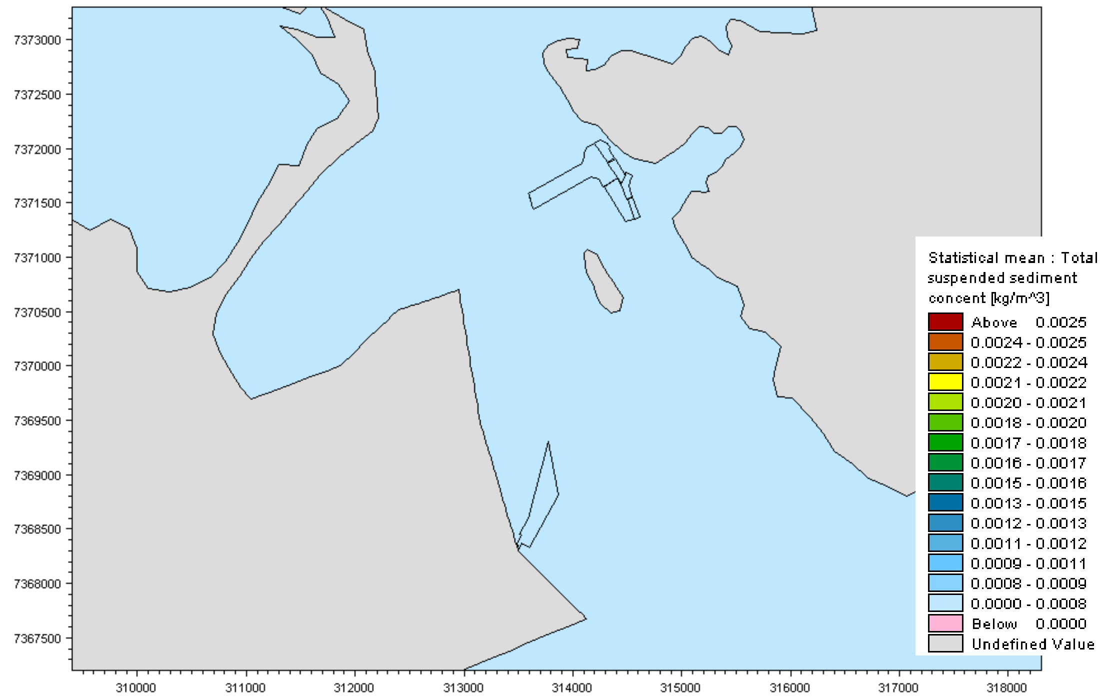
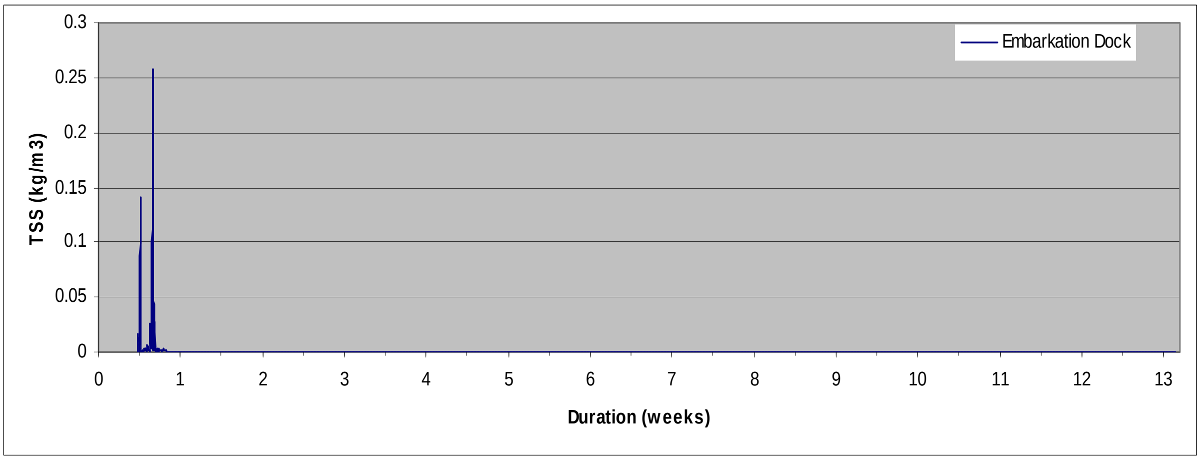
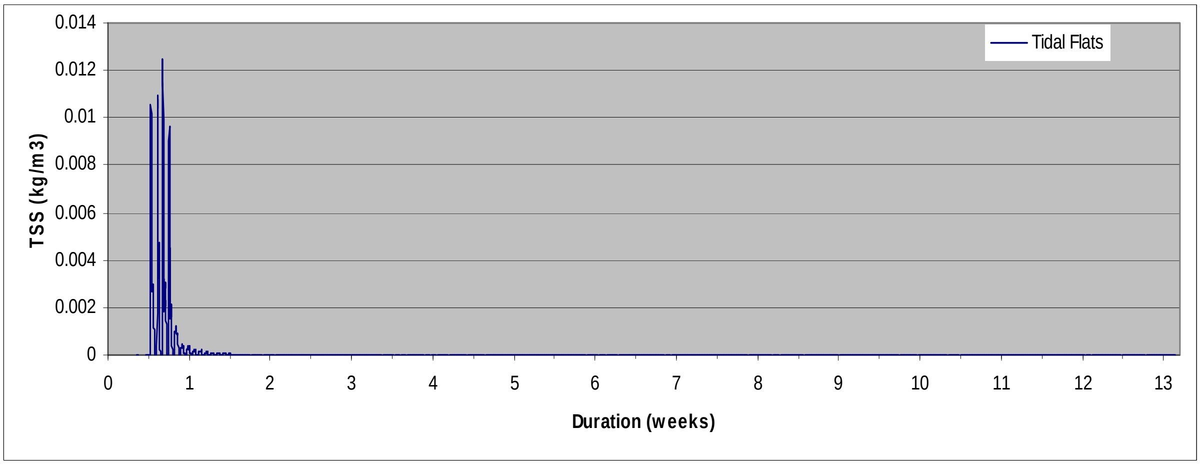


Figure 3-20 Embarkation Dock dredge - statistical mean TSS concentration above background

(a)



(b)



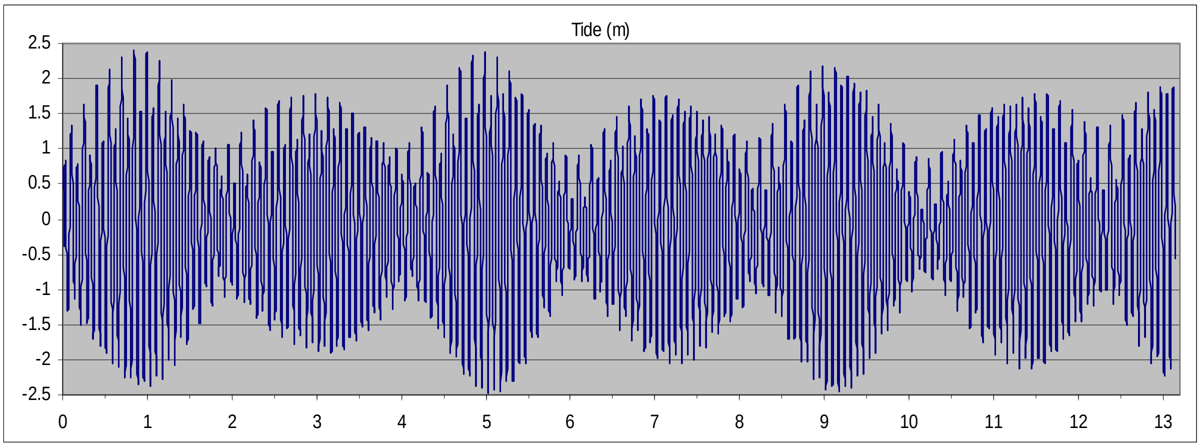


Figure 3-21 Embarkation Dock TSS concentration time-series (a) Embarkation Dock (b) Tidal Flats

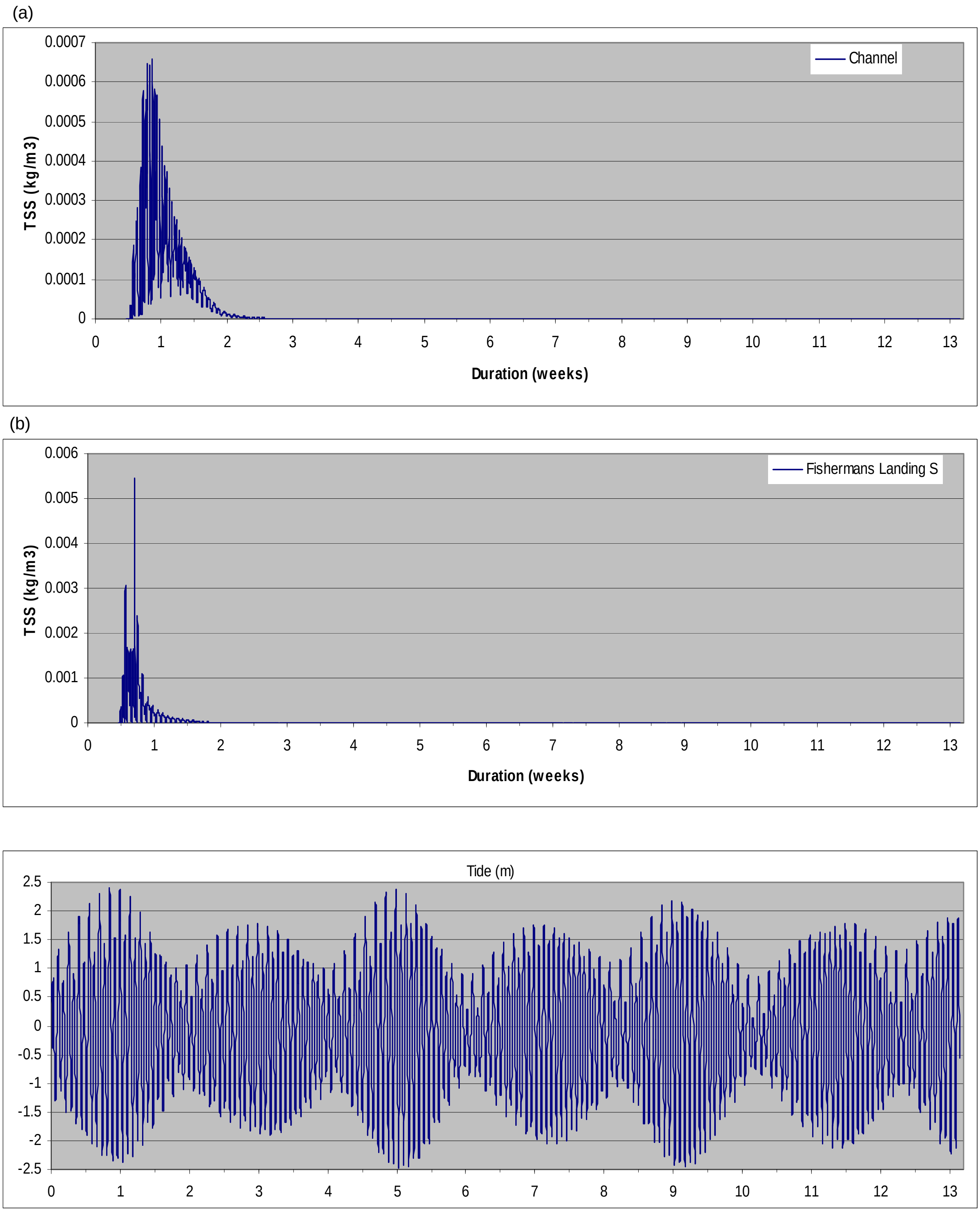


Figure 3-22 Embarkation Dock TSS concentration time-series (a) Channel (b) Fishermans Landing S

3.3.4 Combined Dredge Scenario (Construction Docks dredging and Other Dredging Activities)

The range of dredging operations proposed for Gladstone Harbour were summarised in Section 3.1. One likely scenario of activities for the Australia Pacific LNG early works dredging timeline was presented in Figure 3-1. This figure shows that the early works dredging would overlap with other dredging activities assessed by GPC.

For comparative purposes and to assess the cumulative impact of dredging the Australia Pacific LNG Early Works while other dredging is occurring inside the Western Basin; a combined dredge simulation was undertaken that included plume source loadings for the Construction Docks dredging and other dredging.

The relevant plant for other dredging activities is outlined in Section 2.3 and for consistency is also included in the simulation. Table 3-9 summarises the relevant dredge plume source loadings used in the combined dredging simulation and Figure 3-23 illustrates the locations of these loadings. Also for comparison, figures have been framed within the same spatial extent and around similar timing of events presented for the Construction Docks dredging only simulation.

Table 3-9 Dredge plume scenarios and associated TSS loadings

Description	TSS Loading
Western Basin Middle with large CSD	4kg/s continuous
Decant from piped slurry from Western Basin Middle & North direct to reclamation	100mg/L TSS @ 5m^3/s
Dumping adjacent to Fisherman's Landing reclamation area with large TSHD	340kg/s for 10minutes every 3 hours
Rehandle at Fisherman's Landing with medium CSD	4kg/s continuous
Bundled pipeline trench CSD	4kg/s for 2 hours in every 3hours

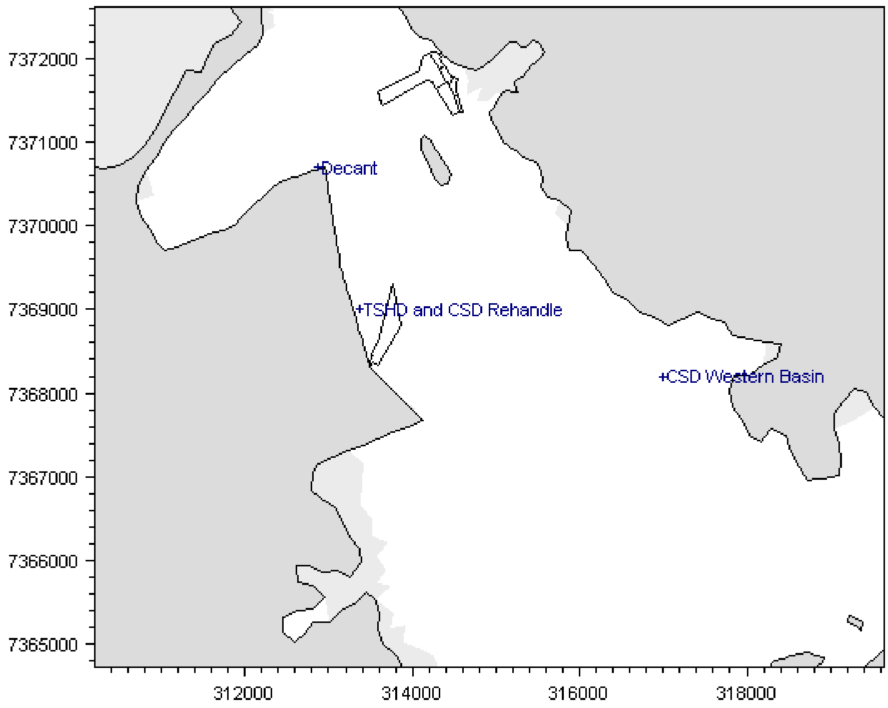


Figure 3-23 TSS loading locations

Figure 3-24 is a repeat of the Figure 3-6 snapshots for the Construction Docks of the simulated model plumes in the same sequence Model results of Total Suspended Solids (TSS) concentrations are reported as above natural background levels. The simulation indicates that plumes from other dredging activities advect into the same area as the early works dredging and have a cumulative effect on TSS concentrations in areas of The Narrows. The snapshots indicate the following:

- Plumes from Other dredging activities, especially the TSHD loads, are spatially larger than those generated by the early works dredging and advect with the flood tide into The Narrows, especially along the western side of The Narrows
- Dredging the early works dredge areas has a much smaller impact on the seagrass areas of the intertidal flats and The Narrows than the plumes generated by Other dredging activities
- TSS concentrations reduce quickly going from the shallower Friend Point side of the channel towards the deeper centre of the main channel
- TSS concentrations on the Laird Point side are relatively unaffected by the plumes generated by other dredging activities

Figure 3-25 shows the maximum TSS concentration model result from simulating the combined dredging of the Construction Docks and the Other dredging activities. High maximum TSS concentrations fill the area north of the decant area (to the north of Fishermans Landing) showing how individual plumes (see snapshots in Figure 3-24) cover a substantial part of the seagrass area over the duration of dredging the early works dredge areas (Other dredging activities are much longer in duration). The maximum TSS concentrations in the centre of the channel and on the Laird Point side effectively remain the same as in Figure 3-7 for the Construction Docks dredging only simulation.

Figure 3-26 shows the mean TSS concentration model result from simulating the combined dredging of the Construction Docks and the other dredging activities. This figure clearly indicates that over the duration of dredging the Construction Docks, the mean TSS concentrations are practically indistinguishable from the mean TSS concentrations associated with the Other dredging activities and reclamation activities (note the colour legend scale has changed from that shown in Figure 3-8). Mean TSS concentrations of 5 to 7.5mg/L are evident at the end of the Construction Docks approach channel and were in the order of 1mg/L for the Construction Docks dredging only. The cumulative impact from the simulation of other dredging activities accounts for the indicated increase in TSS concentrations at this location.

Time-series locations (t1 - t6) used in Figure 3-27, Figure 3-28 and Figure 3-29 are defined in Table 3-4 and are shown in Figure 3-24.

Figure 3-27 presents (a) Graham creek North (t1) and (b) Graham Creek South (t5). At the Graham Creek North location (t1) peak TSS concentrations coincide with high tides and occur on and off over the duration of the Construction Docks dredging. The highest peaks of more than 14mg/L occur over a period of three days. The range of TSS concentrations is indicated to vary up to a peak value of 15.4mg/L, is less than 12.8mg/L for 99% of the duration and less than 6mg/L for 90% of the duration.

At the Graham Creek South location (t5) peak TSS concentrations follow a similar patter to Graham Creek North but with larger peaks due to its closer proximity to the dredge operation. The highest peaks of more than 15mg/L occur for over a period of up to 5 days at a time with a period of lower peaks in between. The peak value shown by the simulation is 19.2mg/L, while a value of less than 15.3mg/L is recorded for 99% of the duration and less than 9.2mg/L for 90% of the duration.

Figure 3-28 presents (a) APLNG Dock (t2) and (b) Main Channel (t3). The APLNG Dock location (t2) is in the middle of the Construction Docks dredge area and large spikes in TSS concentration occur when the dredge is in this area. The highest peaks of more than 500mg/L occur over a 2 day period on two occasions. The maximum value is seen to be 2,039mg/L when the dredge is working at this location. However, TSS concentrations are less than 140mg/L for 99% of the duration and less than 12.6mg/L for 90% of the duration.

The Main Channel location (t3) is to the northwest of the dredge area in the centre of the channel. Depths in this area are typically around 12m at LAT. The water depth and currents in the channel help to reduce concentrations at this point. The peak concentration is 26.6mg/L, with concentrations below 19.9mg/L for 99% of the duration and below 15.6mg/L for 90% of the duration.

Figure 3-29 presents (a) Tidal Flats (t4) and (b) The Narrows (t6). At the location of the Tidal Flats (t4), modelled TSS concentrations reach much higher peaks due to the Other dredging activities than from the Construction Docks dredging alone. The simulation shows a peak of 98.7mg/L on a single day, while for 99% of the duration the concentration is below 45.5mg/L and for 90% of the duration the concentration is at or below 24.1mg/L.

TSS concentrations at The Narrows location (t6) are also significantly elevated when compared to dredging of the Construction Docks only. A peak concentration of 69.6mg/L occurs on a single day with a few isolated one day peaks above 50mg/L. For The Narrows location the TSS concentration is below 36.0mg/L for 99% of the simulation and below 13.7mg/L for 90% of the simulation.

Table 3-10 below presents a summary of modelled TSS concentrations at the selected time series recording locations for the Combined Dredge Scenario (incorporating the Construction Docks dredging

and Other dredging activities). TSS concentrations for this scenario are higher than for dredging of the Construction Docks only.

Table 3-10 Summary of modelled TSS concentrations (mg/L) for Combined Dredge Scenario (Construction Docks dredging and Other dredging activities)

Location	Peak value	99^{th} percentile	90^{th} percentile	Mean value
Graham Ck N (t1)	15.4	12.8	6.0	2.0
APLNG Dock (t2)	2038	139	12.6	10.3
Main Channel (t3)	26.6	19.9	15.6	5.1
Tidal Flats (t4)	98.7	45.5	24.1	6.9
Graham Ck S (t5)	19.2	15.3	9.2	3.2
The Narrows (t6)	69.6	36.0	13.7	3.5

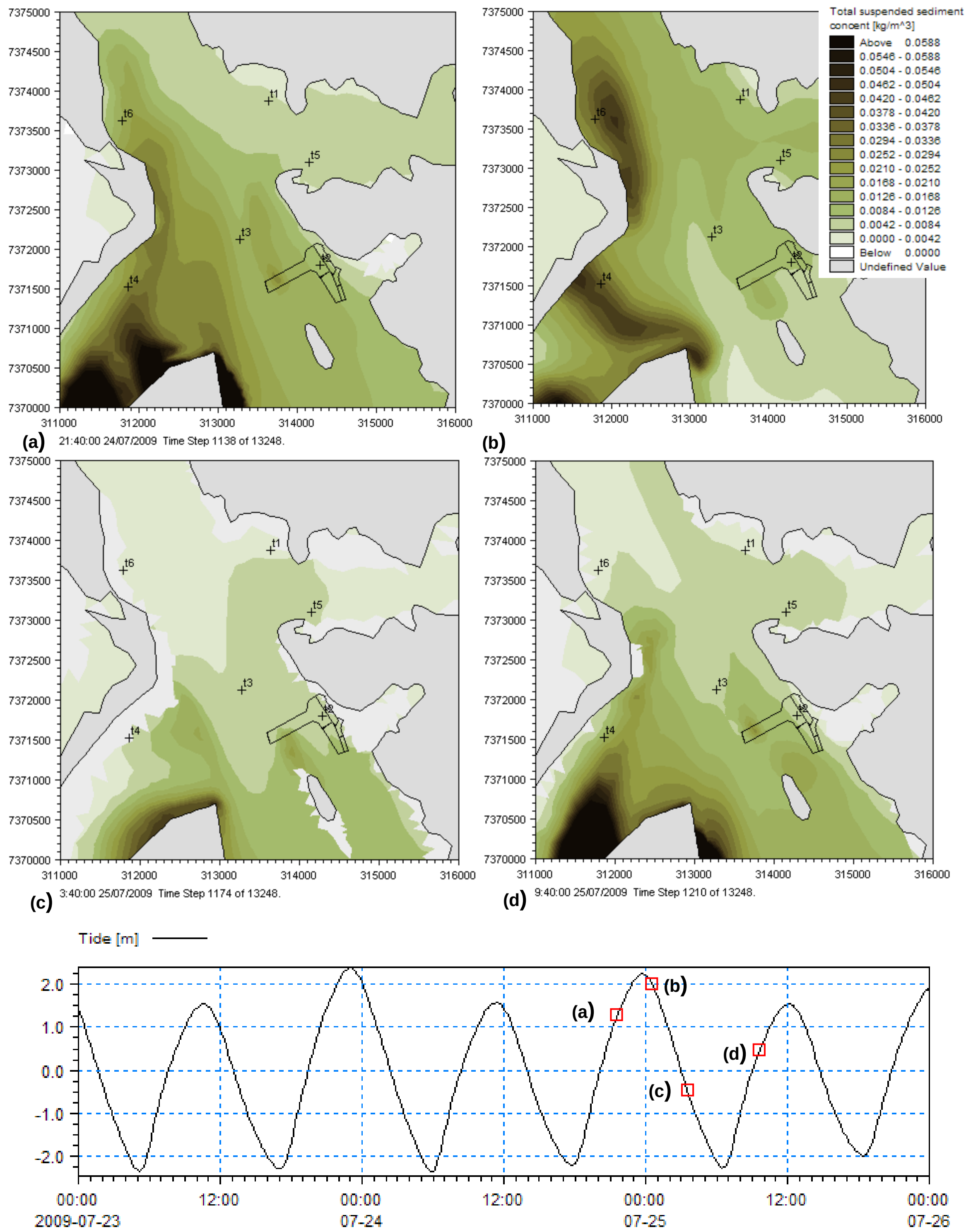


Figure 3-24 Construction Docks dredging with other dredging activities plume snapshot

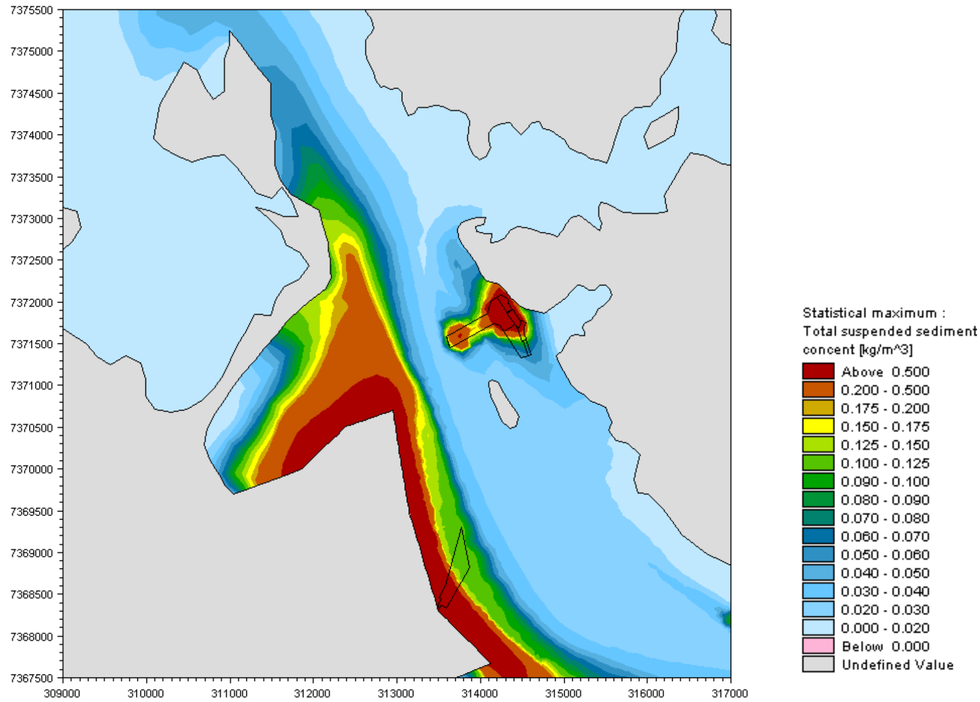


Figure 3-25 Construction Docks dredging with other dredging activities - statistical maximum TSS concentration above background

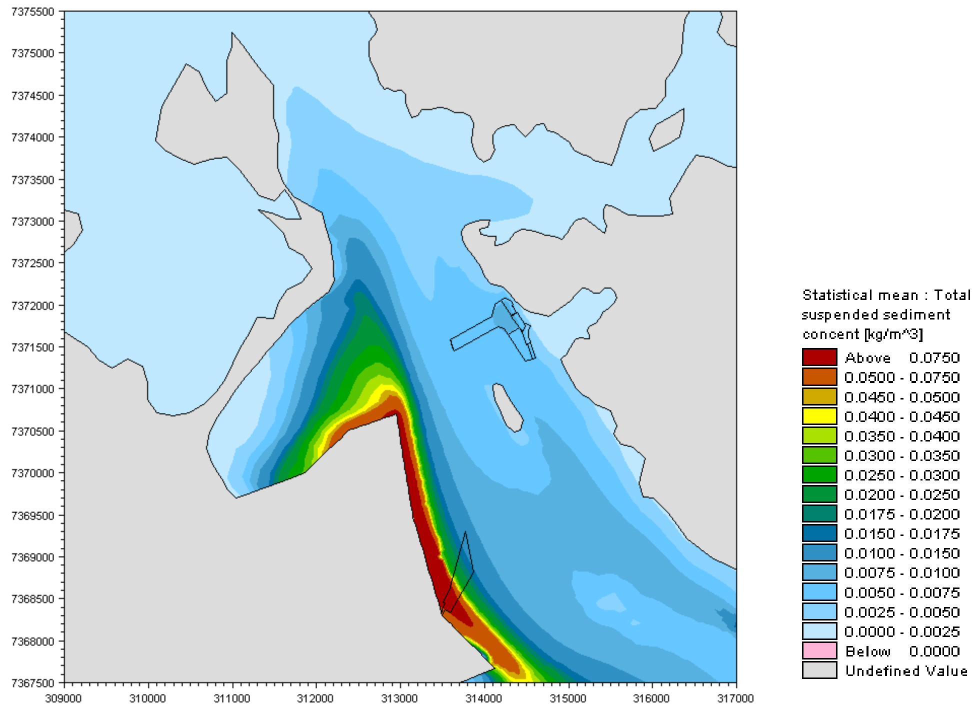
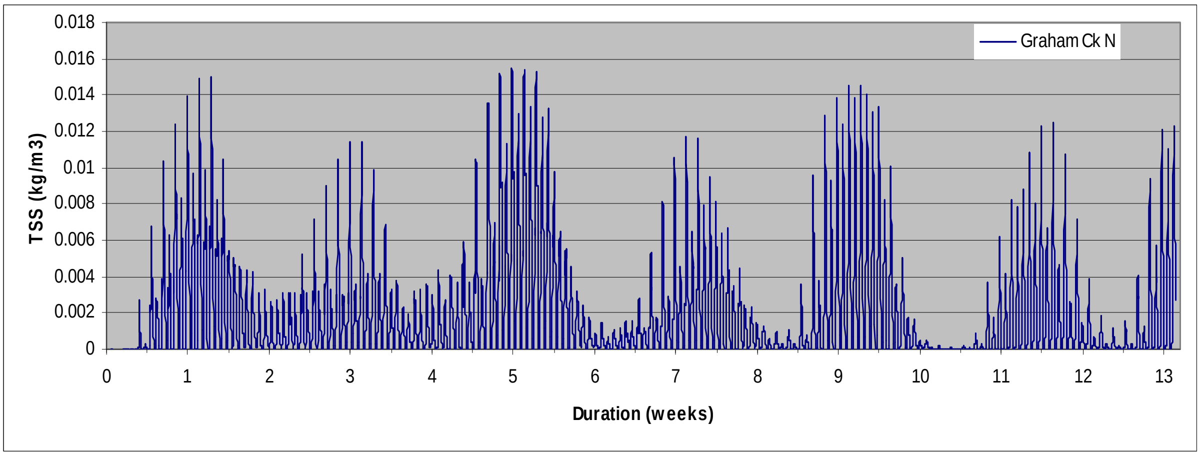
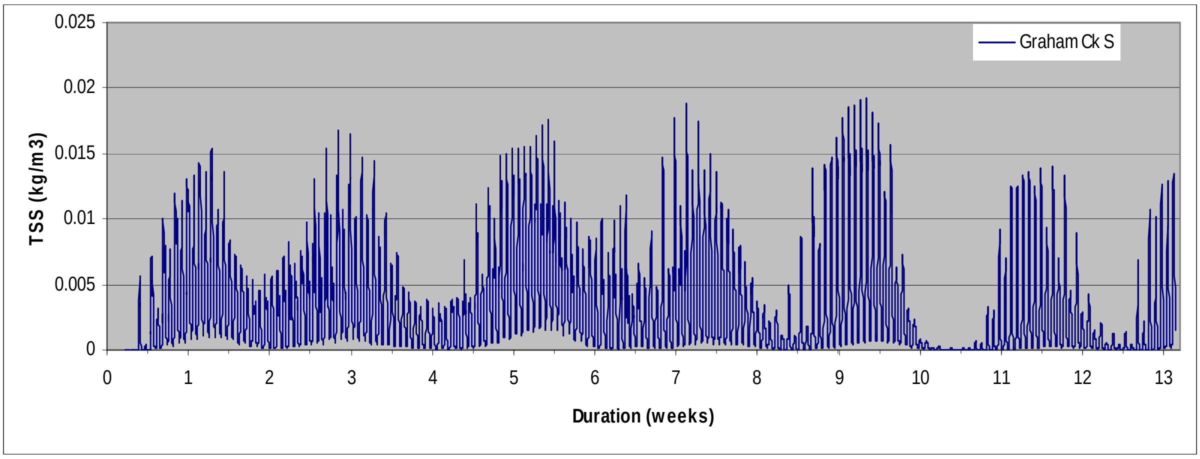


Figure 3-26 Construction Docks dredging with other dredging activities - statistical mean TSS concentration above background

(a)



(b)



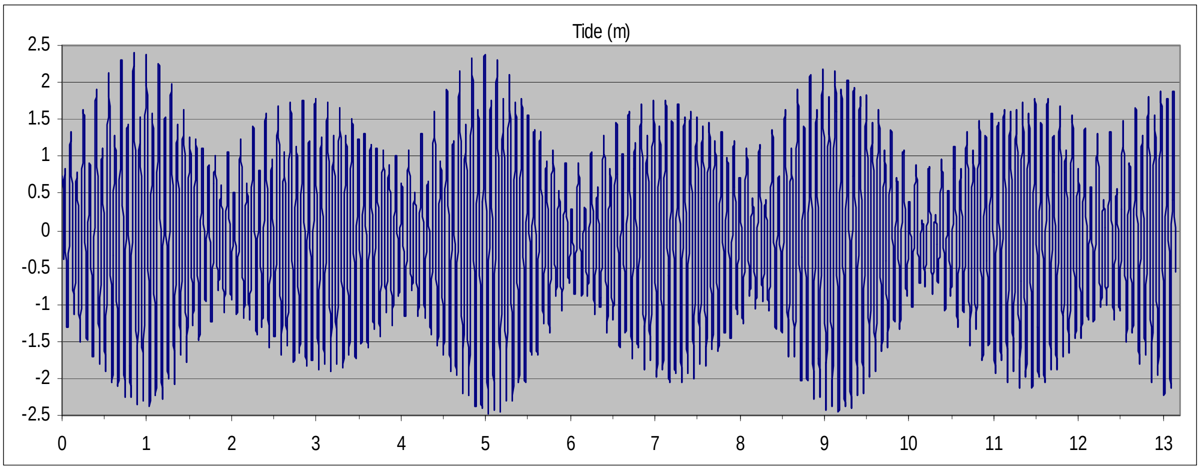


Figure 3-27 Construction Docks dredging with other dredging activities TSS concentration time-series (a) Graham Ck N (b) Graham Ck S

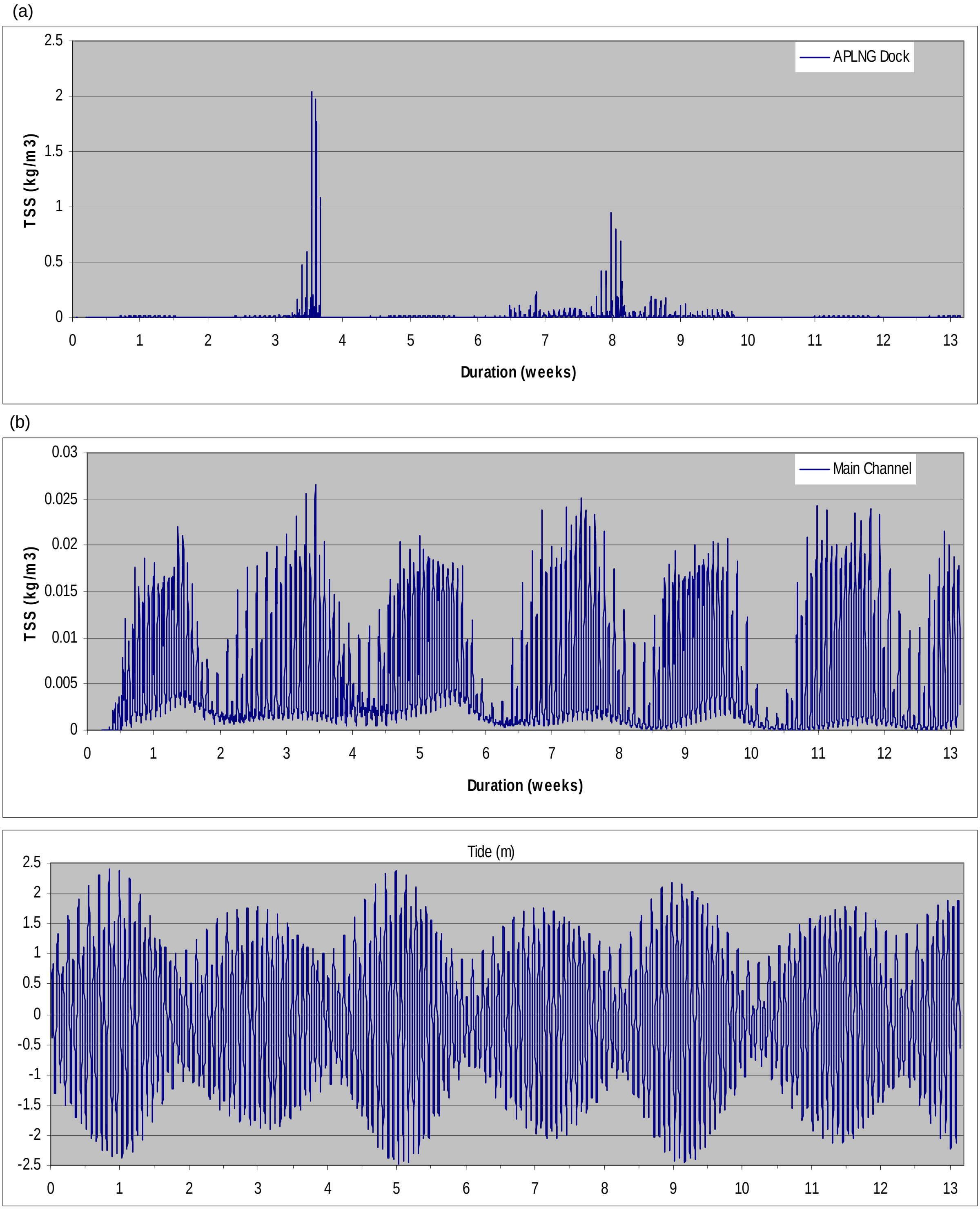


Figure 3-28 Construction Docks dredging with other dredging activities TSS concentration time-series (a) APLNG Dock (b) Main Channel

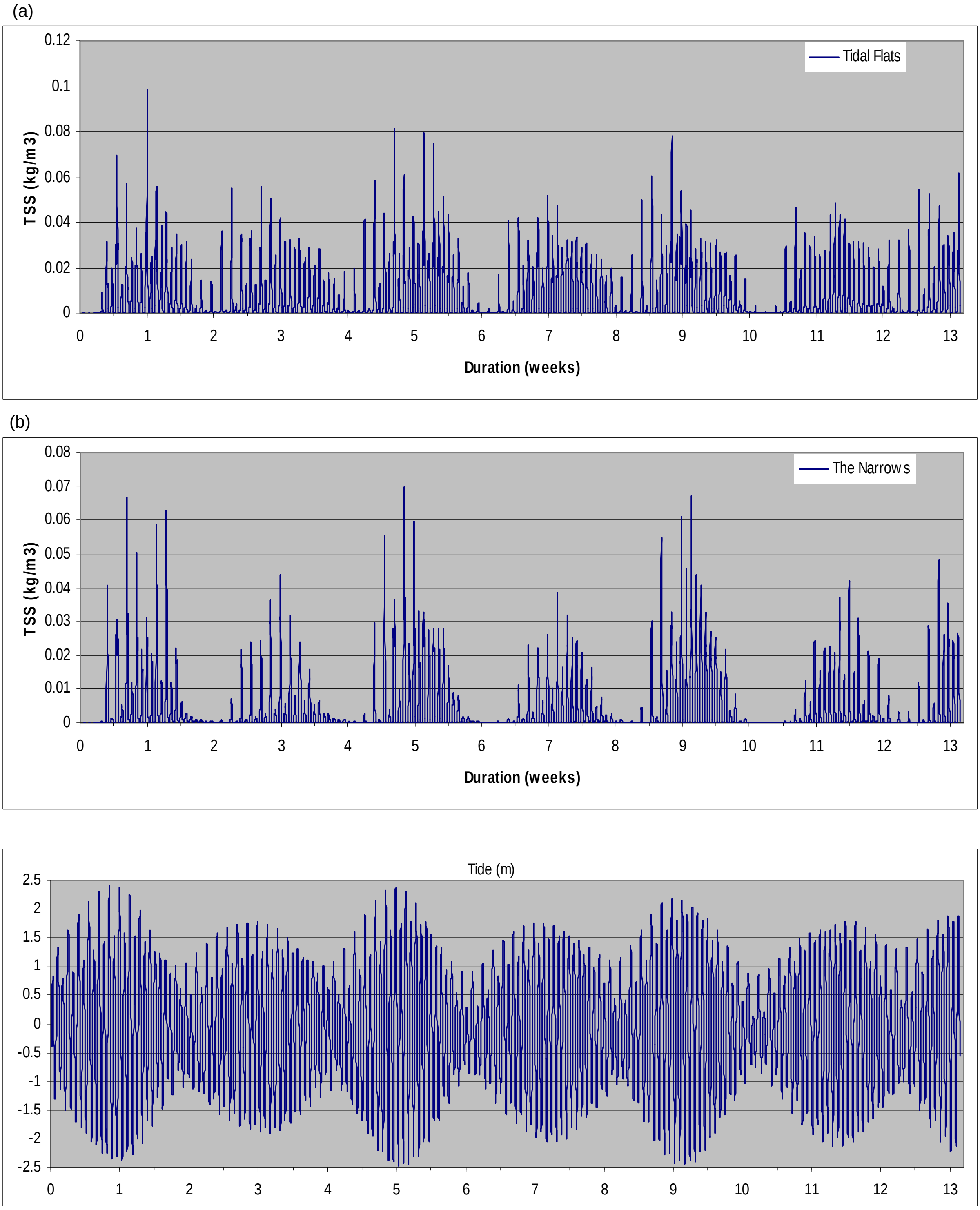


Figure 3-29 Construction Docks dredging with other dredging activities TSS concentration time-series (a) Tidal Flats (b) The Narrows

3.4 Combined Desalination Plant Brine and Treated Wastewater discharges

3.4.1 Description of Proposed Development

Australia Pacific LNG proposes to discharge desalination plant brine and treated wastewater into Port Curtis. Two sites are proposed:

- Construction Docks during the construction phase
- Product Loading Jetty during the operations phase

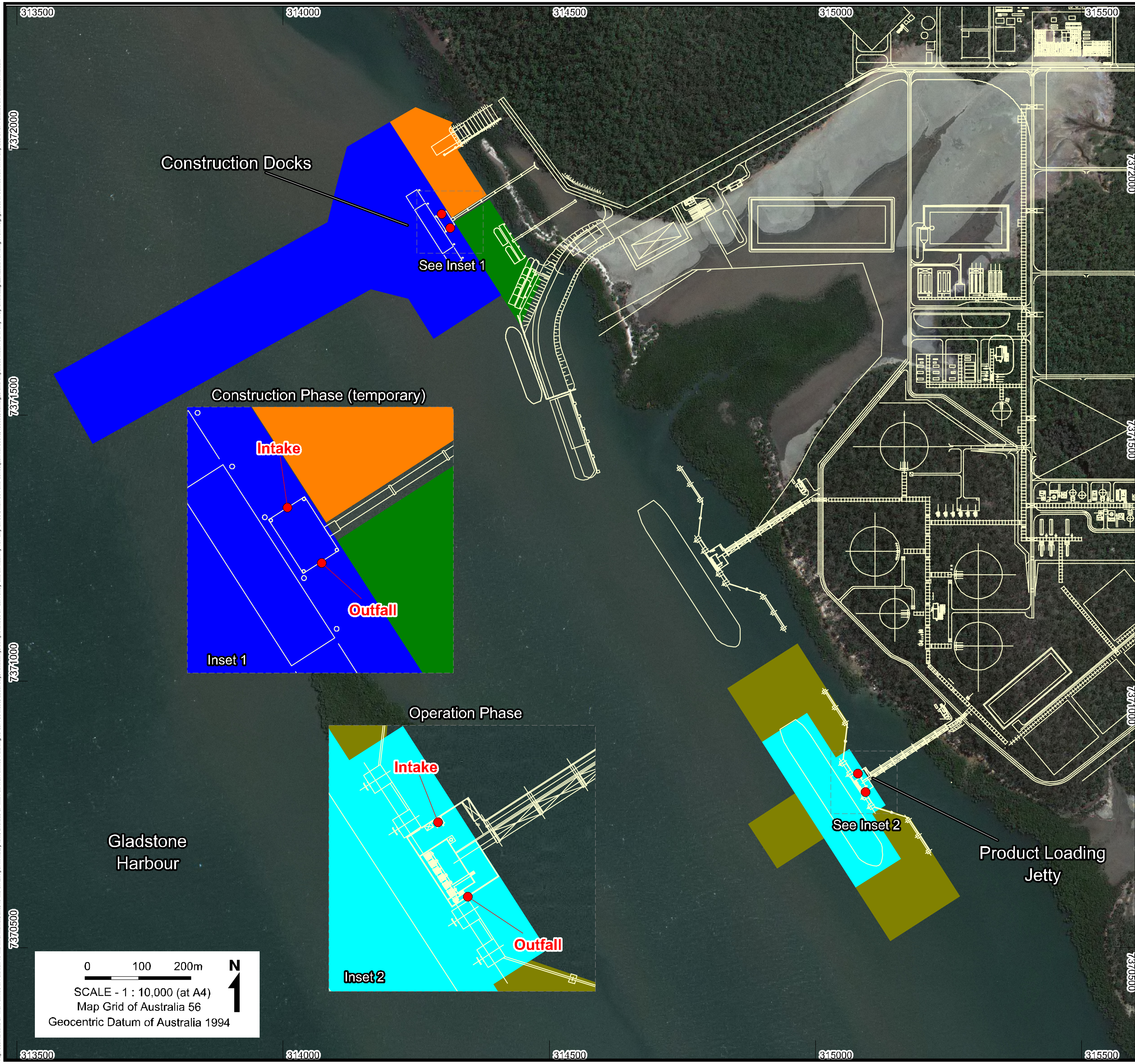
At each location it is proposed to separate the seawater inlet for the desalination plant and outfall as shown in Figure 3-30. The distance between the inlet and outfall during construction and operation is approximately 30m and 40m respectively.

The Reverse Osmosis (RO) reject and filter backwash from the desalination plant would be collected in an in-ground concrete sump and pumped, on a continuous basis, through an outfall to a diffuser system. Treated oily water (process and contaminated stormwater) and treated sewage would be sent to an irrigation field during permanent operations, except in the event that the irrigation field was saturated. In this case, treated oily water and sewage would be combined with desalination plant brine.

An estimated seawater intake rate of 137 m^3/hr is required on a continuous basis for the desalination plant during construction. The upper range of the intake rate is estimated to be 360 m^3/hr on an intermittent basis, to account for periods when the source water from the Western Basin is too turbid and the intake pumps are shut down. Vertical seawater intake pumps would be mounted on a floating pontoon with the suction intake point at one metre below the water surface.

During operation, the estimated seawater intake rate is 198 m^3/hr. This rate is based on four LNG trains operating on a continuous basis. To account for periods when the source water is too turbid, the maximum intake rate is estimated to be 364 m^3/hr on an intermittent basis. The vertical seawater intake pumps would be located on the Product Loading Jetty platform with the suction intake point at one metre below LAT.

The outfall discharge would mostly be continuous, but the rate of discharge would vary with number of LNG trains in operation. The discharge outfall pipe would extend from the jetty platform into a subsea diffuser system located at a water depth of at least 3 m below LAT in both the construction and operation cases. The diffuser system would be designed to provide the necessary dispersion. The seabed would be dredged to 5.6 m below LAT at the Construction Docks, and 13.0 m below LAT at the Product Loading Jetty.



LEGEND

- Conceptual facility layout
- Area dredged to -5.6 mLAT
- Area dredged to -3.3 mLAT
- Area dredged to -3.0 mLAT
- Area dredged to -13.0 mLAT
- Area dredged to -3.0 mLAT

Note:

1. Intake and Outfall during construction phase located on Aggregate Dock.
2. Intake and Outfall during operations located on Production Jetty.
3. Intake supplies desalination plant.
4. Outfall dischages combine brine reject and treated sewerage water.

Source Information

Satellite imagery
Captured by GeoEye-1 on 24 March 2009
Proposed dredge areas
Extracted from Bechtel CAD drawings K0-K01-MD003.dwg & K0-K01-MD005.dwg
Conceptual Facility Layout
Public Version Overall Site Plan (Native File).dgn supplied by client 03/06/2010

AUSTRALIA PACIFIC LNG
AUSTRALIA PACIFIC LNG PROJECT

Figure 3.30
Location of intake and outfall for desalination plant

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3.4.2 Nature of the Discharge

The Emissions, Discharge and Disposal Plan (Bechtel 2010) provides updated values for the constituents of the discharge for the operations site in Table 11 (reproduced in Table 3-11).

During operations, the Desalination plant brine would have salinity (TDS) of 50 000 to 60 000 mg/L with an average flow rate of 96 m^3/hr and a maximum flow rate of 150 m^3/hr based on four LNG trains in operation. The Desalination plant brine may be combined with treated process and stormwater and treated sewage in the same outfall pipe. The treated process and stormwater from process areas would have an average flow rate of 25 m^3/hr and a maximum flow rate of 100 m^3/hr, with an estimated TDS after treatment of 250mg/L. The treated sewage would have an average flow rate of 3.5 m^3/hr and a maximum flow rate of 15 m^3/hr, also with an estimated TDS after treatment of 250mg/L.

The proportion of brine to treated wastewater in the discharge is important in determining the density of the discharge, which affects mixing with the receiving waters. On average, a mixture of 80:20 brine to treated wastewater will be discharged. However, it seems unlikely that such a mixture would be maintained at all times. In this study, a range of cases, such as brine only, average brine + average wastewater flow, maximum brine + maximum wastewater flow, were considered so that a worst-case could be established (Table 3-12). It was assumed that the discharge temperature would be similar to ambient seawater temperature. In addition to concentrated seawater salts in the desalination plant brine, the discharge would contain other chemicals as outlined in Table 3-11.

Table 3-11 Estimated Flows and Wastewater Characteristics for Four LNG Train Operation

Wastewater Stream	Flow (m^3/hr)		Estimated Characteristics
	Average	Maximum	
Treated Process and contaminated stormwater (Note 1)	25	100	pH = 6 to 7
			BOD_5 = 10 to 20 mg/L
			TSS = 5 to 10 mg/L
			TDS = 250 mg/L
			Oil = 5 to 15 mg/L
Desalination Plant Brine (Note 2)	96	150	pH = 6 to 8
			TDS = 50,000 to 60,000 mg/L
			Calcium, Ca = 600-750 mg/L
			Magnesium, Mg = 2,000-2,500 mg/L
			Potassium, K = 600-800 mg/L
			Sodium, Na = 19,000-22,000 mg/L
			Chloride, Cl = 30,000-33,000 mg/L
			Fluoride, F = 1.5-3mg/L
			Sulfate, SO4 = 4,000-6,000 mg/L
			Strontium, Sr = 15-25 mg/L
			TSS, average = 20-30 mg/L
			TSS, maximum = 40 mg/L
			Chlorine < 1 mg/L
			Anti-Scalant = 8 mg/L
			Flocculent = 5 mg/L
			Polymer = 1 mg/L
			SIO_2 = 1-2 mg/L
			BOD_5 = 5 to 10 mg/L
Treated Sewage (Note 3)	3.5	15	pH = 6.5 to 7.5
			BOD_5 = 10 to 20 mg/L

Wastewater Stream	Flow (m^3/hr)		Estimated Characteristics
	Average	Maximum	
			Oil = 5 to 10 mg/L
			Total Nitrogen < 5 mg/L as N
			Total Kjeldahl Nitrogen = 1 to 5 mg/L
			Ammonia nitrogen = 1 to 5 mg/L
			Total Phosphorus = 1 mg/L
			Chlorine = 1 to 2 mg/L
			TDS = 250 mg/L

Note 1. The average flows are based on dry weather flows and includes filter backwash water and reject stream from the EDI section of the RO plant. The maximum flows are based on wet weather flows (i.e. strom water and includes dry weather (normal) flows.

Note 2. Based on First Pass RO Reject

Note 3. Based on an average population of 225 people (includes visitors and transient workers) and a maxium population of 375 people.

Source: Emissions, Discharge and Disposal Plan (Bechtel, 2010).

During construction, the desalination plant brine would have a salinity of 60 ppt and be discharged at an average rate of 62.5 m^3/hr. The Desalination plant brine may be combined with treated oily water and sewage in the same outfall pipe. The average combined flow rate would be about 70 m^3/hr (TDS of 53.5 ppt). Discharge temperature will be similar to ambient seawater temperature.

Table 3-12 Operations Flow Scenarios used in CORMIX Modelling

Discharge type	Ratio Brine: Treated Wastewater	Flow Rate (m^3/hr)
1. Brine only	100% brine	96 (average)
2. Brine only	100% brine	150 (maximum)
3. Combined: ave brine + ave wastewater	77:23	96 (brine) + 28.5 (wastewater) = 124.5
4. Combined: max brine + max wastewater	57:43	150 (brine) + 115 (wastewater) = 265
5. Combined: ave brine + max wastewater	45:55	96 (brine) + 115 (wastewater) = 211
6. Combined: max brine + ave wastewater	84:16	150 (brine) + 28.5 (wastewater) = 178.5
7. Combined: 80:20 mixture	80:20	96 (brine) + 24 (wastewater) = 120

3.4.3 CORMIX Modelling

Background

The mixing behaviour of treated wastewater discharge is governed by both the characteristics of the discharge and the receiving waters. The range of cases considered in this study included scenarios where the discharge would have a lower density than the receiving waters (positively buoyant) and those where the discharge would have a higher density than the receiving waters (negatively buoyant). A positively buoyant plume would be expected to rise to the surface under calm conditions.

This may cause concern where the discharge contains nutrients, such as nitrogen and phosphorus, at concentration which may result in algal blooms. However, as per Table 3-11, nutrient levels in treated sewage are estimated to be low due to on-site treatment.

Brine discharge would be negatively buoyant due to its higher salinity (and hence density) than the receiving waters, and would tend to sink to the bed under calm conditions. In this case, most mixing would occur as the negatively buoyant plume descends to the bed. Brine discharge may present a concern if mixing does not result in dilution such that the resultant salinity is not within 1 ppt of the average receiving water conditions.

A discharge with a greater difference in density to the receiving waters would experience greater mixing and hence dilution, as the difference in density causes the plume to fall or rise through the water column. A discharge with a density similar to the ambient conditions would experience less mixing, as mixing would occur mainly under tidal currents without buoyancy effects. The worst-case dilution is expected to occur when the density of the discharge is very similar to the ambient water, at a maximum discharge flow rate, a slack current speed and at low water level.

Method

The dispersion of the brine or mixed brine and treated wastewater discharge from the APLNG plant was modelled using the CORMIX model. CORMIX is a hydrodynamics model developed under steady state conditions which models the behaviour of point discharges in the near and far field, and is an analysis tool recommended by the US EPA (Doneker & Jirka, 2007). The nearfield, as referred to in this report, is defined as the area in which the discharge characteristics such as momentum flux, buoyancy flux, and outfall geometry, affect the jet trajectory and mixing. The end of the nearfield is where the plume either achieves neutral buoyancy or reaches the water surface or sea bed. Beyond the nearfield (far field), mixing mainly occurs through buoyant spreading and passive diffusion due to ambient turbulence.

The CORMIX model was used to predict distance from the point of discharge to dilution, and also the point at which a negatively buoyant plume reaches the sea bed or alternatively the point at which a positively buoyant plume reaches the water surface.

The CORMIX dispersion modelling was conducted separately for the construction outfall site and the operations outfall site. The geometry for each site was specified in the model. The construction site would be dredged to a depth of 5.6 m below LAT, and lies at a distance of 105 m from the shoreline. The operation site would be dredged to a depth of 13 m below LAT and lies at a distance of 138 m from the shoreline. A diffuser would be affixed to the construction and operation outlet at approximately 3 m below LAT. Given numerical restrictions in the CORMIX model, the diffuser could only be located in the top or bottom third of the water column, not in between. For water levels where the height of the diffuser was located in the middle third of the water column, its height was reduced to the top of the lower third, to ensure it still lies at least 3 m below LAT.

The dilution of the brine and treated wastewater plume was optimised based on a highly conservative scenario which would result in the poorest mixing conditions: the lowest water level (LAT), the slack tide current speed (0.04 m/s) and the combined discharge maximum flow rate of 265 m^3/hr for the operations site and 300 m^3/hr for the construction site.

3.4.4 Dilution Requirements

The dilution factor required to achieve a salinity of less than 1 ppt above the ambient conditions is summarised in Table 3-13. It shows that a dilution of 1 in 25 is required to achieve a salinity of 1 ppt above the ambient conditions in any particular month. A dilution factor of 1 in 50 would also be sufficient to reduce concentrations of other chemicals in the discharge water to below water quality guideline trigger levels, particularly total nitrogen (TN), total phosphorous (TP) and chlorine.

Table 3-13 Dilution Factors to achieve 1 ppt Salinity Above Ambient Conditions

	Ambient conditions			Discharge conditions			Dilution
Month	Min Temp (ºC)	Ave. Salinity (ppt)	Density (kg/m^3)	Salinity (ppt)	Brine Density (kg/m^3)	Combined Density (kg/m^3)	to achieve 1ppt change
JAN	26.9	36.1	1023.6	60.0	1041.7	1024.3	25.0
FEB	25.9	37.6	1025.0	60.0	1042.1	1025.7	25.0
MAR	24.8	36.2	1024.3	60.0	1042.5	1025.1	25.0
APR	24.6	39.5	1026.9	60.0	1042.5	1027.5	25.0
MAY	22.5	37.6	1026.1	60.0	1043.2	1026.8	25.0
JUN	18.4	37.3	1027.0	60.0	1044.5	1027.7	25.0
JUL	17.7	37.0	1026.8	60.0	1044.6	1027.6	25.0
AUG	19.9	37.0	1026.3	60.0	1044.0	1027.0	25.0
SEP	22.5	37.4	1025.9	60.0	1043.2	1026.6	25.0
OCT	24.3	37.8	1025.7	60.0	1042.6	1026.4	25.0
NOV	25.4	37.8	1025.3	60.0	1042.2	1026.0	25.0
DEC	25.2	37.9	1025.5	60.0	1042.3	1026.2	25.0
Worst case A	33.9	30.6	1017.1	60.0	1039.1	1017.8	32.0
Worst case B	17.7	30.6	1022.0	60.0	1044.7	1022.7	33.0

Note: dilution factor using the measured minimum monthly temperature and maximum salinity and a combined discharge of brine and treated wastewater. Two 'worst cases' are also given, i.e. maximum and minimum water temperature and minimum salinity.

3.4.5 Operations Scenarios

The various flow scenarios used in the modelling were presented in Table 3-12. For each of these flow scenarios a set of eight densities for the ambient water and discharge conditions, used in the model runs, are presented in Table 3-14. These subruns consider the brine salinity at 50 and 60 ppt, the ambient salinity at its minimum and maximum values of 30.6 ppt and 40.6 ppt and the ambient water temperature at its minimum and maximum values of 17.7 ºC and 33.9 ºC. These conditions were selected as providing the full range of density differences, aiming to find the most conservative scenario where mixing would be minimised. The ranges of water level conditions and current speeds used in the sensitivity modelling are given in Table 3-15.

Table 3-14 Modelled Discharge and Ambient Conditions for Operations Flow Scenarios

Subrun	Temp (°C)	Ambient Salinity (ppt)	Ambient Density (kg/m^3)	Brine Salinity (ppt)	Combined Discharge Density (kg/m^3) Flow Case						
					1	2	3	4	5	6	7
a	17.7	30.6	1022.0	60	1044.7	1044.7	1034.1	1024.6	1019.6	1037.3	1035.4
b	17.7	40.6	1029.6	60	1044.7	1044.7	1034.1	1024.6	1019.6	1037.3	1035.4
c	33.9	30.6	1017.1	60	1039.1	1039.1	1028.8	1019.6	1014.7	1031.9	1030.1
d	33.9	40.6	1024.5	60	1039.1	1039.1	1028.8	1019.6	1014.7	1031.9	1030.1
e	17.7	30.6	1022.0	50	1036.9	1036.9	1028.1	1020.3	1016.1	1030.8	1029.2
f	17.7	40.6	1029.6	50	1036.9	1036.9	1028.1	1020.3	1016.1	1030.8	1029.2
g	33.9	30.6	1017.1	50	1031.6	1031.6	1023.4	1015.4	1011.3	1025.6	1024.1
h	33.9	40.6	1024.5	50	1031.6	1031.6	1023.4	1015.4	1011.3	1025.6	1024.1

Notes: Flow cases 1 and 2 have the same discharge densities, as they are brine only discharges. Cases highlighted in yellow have positively buoyant discharge, the rest are negatively buoyant.

Table 3-15 Water Level and Current Speed Conditions used in the Sensitivity Modelling.

Water Level		Current Speed	
Low Water (LW)	0 m LAT	Slack	0.04 m/s
Mean Water Level (MWL)	2.4 m LAT	Mid	0.30 m/s
Approaching High Water (HW)	5.12 m LAT	High	0.77 m/s

3.4.6 Optimal Diffuser Design

The diffuser design proposed during modelling reported in the EIS documentation was further optimised using the CORMIX model, by varying the diffuser length, port size and number of ports along the diffuser (Table 3-16). The angle of discharge was fixed as parallel to the bed and perpendicular to the dominant flow direction. Angled ports were not considered given the variability in the buoyancy of the discharge relative to the ambient waters.

Table 3-16 Optimising Diffuser design.

Length of diffuser (m)	Port size (m)	No. of ports	Comment	Dilution at end of nearfield*
10	0.05	4		147.9*
20	0.05	6		240.1*
20	0.05	4		244.5*

Length of diffuser (m)	Port size (m)	No. of ports	Comment	Dilution at end of nearfield*
20	0.025	4		281.1*
10	0.05	6	fanned	93*
10	0.05	6	alternating	114*
10	0.05	6	twin risers	93*

*Note: The dilutions modeled during opimisation used a previous set of proposed discharge parameters and are not comparable to the other results in this section.

Alternating port direction, twin risers and fanned ports were considered and dismissed as producing lower dilutions. The reduced port opening of 0.025 m was also dismissed since this smaller opening would be prone to fouling and did not produce significantly improved dilution.

The diffuser design was optimized using a previous set of proposed discharge parameters. The dilutions given in Table 3-16 are therefore not directly comparable to the results of the final design modelling in this study, and only intended for comparison to each other. Dilutions were found to improve when the updated discharge parameters given in Table 3-11 were modelled.

Construction

The optimal diffuser design was 20 m long with four openings of 0.05 m diameter spaced evenly along the pipe, with the diffuser discharging horizontally to the bed and perpendicular to the current (and shore).

Operations

The optimal diffuser design was 20 m long with six openings of 0.10 m diameter spaced evenly along the pipe, with the diffuser discharging horizontally to the bed and perpendicular to the current (and shore). Six openings were found to provide a more stable flow than four, for which the model sometimes predicted unstable, recirculating flow.

3.4.7 Summary of Modelling Results

Construction

Figure 3-31 presents the dilution curves at the construction site for an average brine flow rate, and an average and maximum combined brine and treated wastewater flow rate for the low water slack. A dilution of 1 in 50 (exceeding the required dilution for salinity) is achieved with the optimised diffuser design within a distance of 2 m from the outfall pipe, for both the brine and combined average flow rates. For a maximum combined flow rate of 300 m^3/hr, a dilution of 1 in 50 is achieved within a distance of 12.8 m. It is expected that the maximum flow rate is an overestimation and so this is a conservative result. In addition, the slack tide current speed conditions would only last for approximately one hour, before increasing current speeds would enhance mixing. It must be noted that the discharge parameters used for the construction site do not match that at the operations site, where the brine is expected to vary in salinity from 50 to 60 ppt.

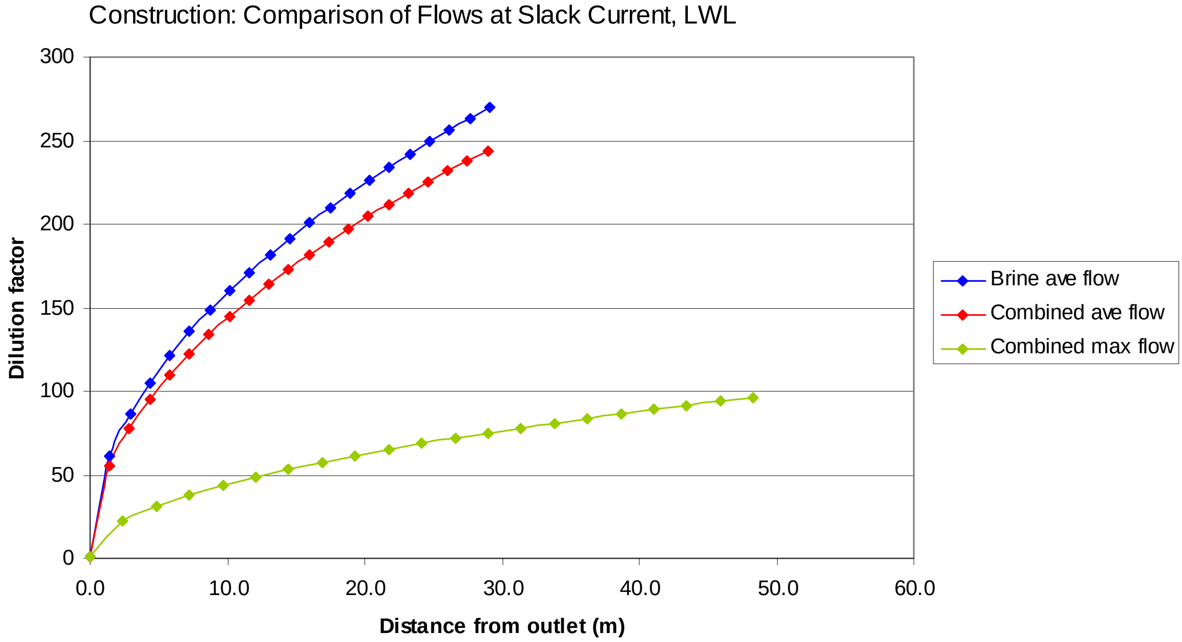

Figure 3-31 Comparison Site: Dilution Curves for a Range of Flow Rates at Low Water Slack

A sensitivity analysis of the dilution factor to the flow type, flow rate, water level and current speed was conducted. The distances to achieve dilutions of 1 in 50 and 1 in 100 across a range of flow rates, water levels and current speeds for the construction site are given in Table 3-17, along with the extent of the nearfield zone, i.e., the distance until the plume meets the bed. The distance to a dilution of 1 in 50 is below 2.0 m for all cases except for the maximum combined flow. The relationship between distance from the outfall and dilution was found to be more sensitive to current speed than water level.

Table 3-17 Construction Site: Sensitivity to Flow Type, Rate, Water Level and Current Speed

Flow Type	Flow Rate	Water Level	Current Speed	Distance to 1 in 50 Dilution (m)	Distance to 1 in 100 Dilution (m)	Extent of nearfield (m)
Brine	Average	LW	Slack	1.18	3.64	29.7
Brine	Average	LW	Mid	0.17	0.25	29.7
Brine	Average	LW	High	0.07	0.09	29.7
Brine	Average	MWL	Slack	1.18	3.50	40.9
Brine	Average	HW	Slack	1.18	3.40	49.8
Combined	Average	LW	Slack	1.31	4.05	29.0
Combined	Average	LW	Mid	0.19	0.32	29.7
Combined	Average	LW	High	0.07	0.15	29.7
Combined	Average	MWL	Slack	1.31	2.64	40.9
Combined	Average	HW	Slack	1.31	2.64	49.7
Combined	Max	LW	Slack	12.76	>48.3	48.3
Combined	Max	LW	Mid	0.79	1.76	29.5
Combined	Max	LW	High	0.31	0.63	29.7
Combined	Max	MWL	Slack	7.62	31.02	46.9
Combined	Max	MWL	Mid	0.77	1.56	41.1
Combined	Max	MWL	High	0.30	0.62	41.3

Flow Type	Flow Rate	Water Level	Current Speed	Distance to 1 in 50 Dilution (m)	Distance to 1 in 100 Dilution (m)	Extent of nearfield (m)
Combined	Max	HW	Slack	6.40	25.89	52.3
Combined	Max	HW	Mid	0.77	1.55	49.9
Combined	Max	HW	High	0.30	0.61	50.0

Operations

The results for the seven flow cases during operations and eight subruns per case are given in Table 3-8. Some results are the same between subruns of the same case, because the density difference between the ambient water and discharge is sufficiently low that buoyancy effects are neglected and the flow rate of discharge and current speed dominate.

The distances required to achieve dilutions of 1 in 50 are relatively low. The case with the greatest distance to a dilution of 1 in 50 is Case 4: Maximum Brine Flow (150 m^3/hrL) + Maximum Wastewater Flow (115 m^3/hrL), as this case has both the highest rate of discharge and densities close to the ambient conditions. The maximum distance to a dilution of 1 in 50 is 7.20 m and the maximum distance to a dilution of 1 in 100 is 28.55 m. This is a negatively buoyant case. Case 4c is the positively buoyant case with the maximum distance to a dilution of 1 in 50, being 7.01 m. These results are for the most conservative scenario: slack current conditions (current speed = 0.04 m/s) and low water level. Such conditions would not be expected to persist for more than an hour.

The different flow cases for sub-run (a) are compared in Figure 3-32. This figure shows that the lowest dilutions occur for cases with the higher flow rates and lower differences between the ambient and discharge densities caused by the dilution of brine with less saline treated wastewater.

Higher dilution could be achieved through separate outfalls for brine and treated wastewater discharges, but control of flows and hydraulic design would be more complex in this case. The present design produces adequate dilution (1 in 50) within a distance of 7.20 m. Separating the flows would reduce this distance to 5.05 m (as per Case 1h i.e., brine discharge only) under low water slack conditions. However, the addition of the treated wastewater discharges reduces the in pipe concentrations which has a more significant effect on reducing the near filed concentrations than the improved dilutions achieved by separating the flows. The dilution of brine in the nearfield zone is aided by the addition of treated wastewater by lowering initial concentrations.

Table 3-18 Operations Site: Distance to Achieve Dilutions and Extent of the Nearfield Zone

Flow Case	Sub-Run	Flow Type	Flow Rate (brine/wastewater)	Distance to 1 in 50 dilution (m)	Distance to 1 in 100 dilution (m)	Distance to end of nearfield (m)
1	a	Brine	ave	4.41	6.85	16.2
1	b	Brine	ave	4.65	7.49	18.2
1	c	Brine	ave	4.42	6.88	16.3
1	d	Brine	ave	4.66	7.26	18.4
1	e	Brine	ave	4.65	7.24	18.2
1	f	Brine	ave	5.03	8.19	24.1
1	g	Brine	ave	4.66	7.26	18.4
1	h	Brine	ave	5.05	8.23	24.4
2	a	Brine	max	2.85	5.85	24.8
2	b	Brine	max	3.27	6.73	27.0
2	c	Brine	max	2.88	5.91	24.9
2	d	Brine	max	3.30	6.79	27.2
2	e	Brine	max	3.27	6.74	27.1
2	f	Brine	max	4.14	8.64	32.2
2	g	Brine	max	3.29	6.79	27.2
2	h	Brine	max	4.18	8.71	32.4
3	a	Combined	ave + ave	3.12	6.53	29.6
3	b	Combined	ave + ave	2.39	7.08	66.4
3	c	Combined	ave + ave	3.15	6.59	29.8
3	d	Combined	ave + ave	2.39	7.08	66.4
3	e	Combined	ave + ave	3.94	8.34	35.5
3	f	Combined	ave + ave	2.88	6.90	65.0
3	g	Combined	ave + ave	3.94	8.34	35.5
3	h	Combined	ave + ave	2.88	6.90	65.0
4	a	Combined	max + max	7.01	28.55	66.1
4	b	Combined	max + max	7.20	29.31	66.1
4	c	Combined	max + max	7.01	28.55	66.1
4	d	Combined	max + max	7.20	29.31	66.1
4	e	Combined	max + max	7.20	29.31	66.1
4	f	Combined	max + max	7.20	29.31	66.1
4	g	Combined	max + max	7.20	29.31	66.1
4	h	Combined	max + max	7.20	29.31	66.1
5	a	Combined	ave + max	4.78	18.95	65.0
5	b	Combined	ave + max	4.78	18.95	65.0
5	c	Combined	ave + max	4.78	18.95	65.0
5	d	Combined	ave + max	4.78	18.95	65.0
5	e	Combined	ave + max	4.78	18.95	65.0
5	f	Combined	ave + max	4.02	8.00	5.9
5	g	Combined	ave + max	4.78	18.95	65.0
5	h	Combined	ave + max	4.04	8.1	5.9
6	a	Combined	max + ave	3.52	7.42	26.0
6	b	Combined	max + ave	3.48	14.13	66.3
6	c	Combined	max + ave	3.55	7.47	26.1
6	d	Combined	max + ave	3.48	14.13	66.3
6	e	Combined	max + ave	4.20	8.92	29.4
6	f	Combined	max + ave	3.48	14.13	66.3
6	g	Combined	max + ave	4.23	9.00	29.6
6	h	Combined	max + ave	3.48	14.13	66.3
7	a	Combined	80:20	2.95	6.15	29.2
7	b	Combined	80:20	2.31	6.56	66.4
7	c	Combined	80:20	2.31	6.56	66.4
7	d	Combined	80:20	2.31	6.56	66.4
7	e	Combined	80:20	3.64	7.69	34.2
7	f	Combined	80:20	2.26	6.42	65.0
7	g	Combined	80:20	3.67	7.76	34.4
7	h	Combined	80:20	2.26	6.42	65.0

Notes: this is for the seven flow cases and eight sub-runs for flow rates given in Table 3-3.

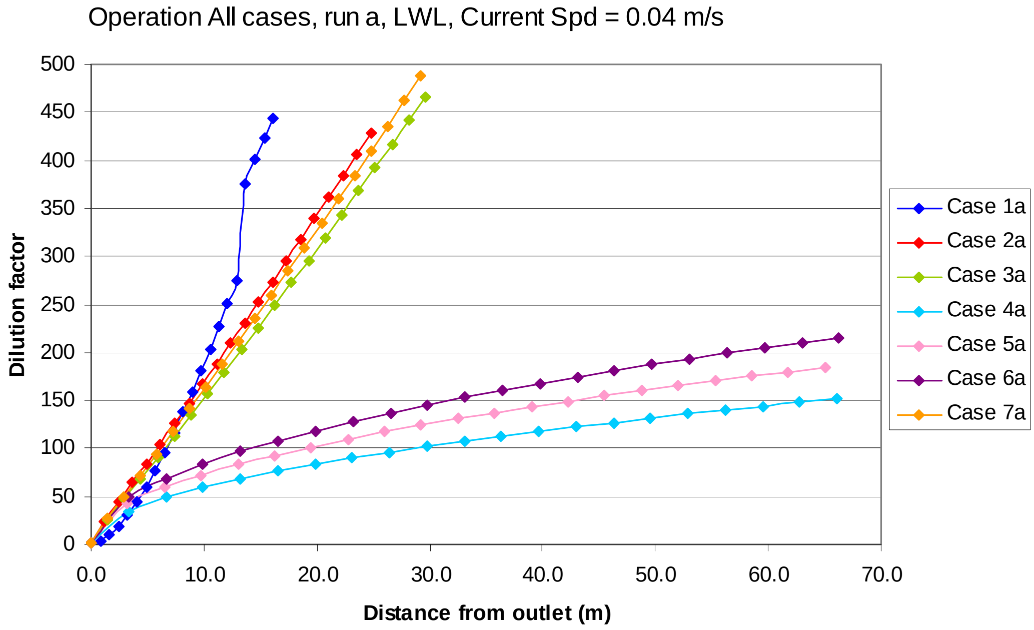

Figure 3-32 Operations Site: Dilution Curves for all Flow Cases Low Water Slack

Notes: Sub-run a: brine discharge salinity = 60 ppt, ambient salinity of 30.6 ppt and temperature of 17.7ºC. Lower dilutions are found for cases with higher flow rates and where the densities of the discharge and ambient water are similar (due to dilution of brine salinity by treated wastewater. Case 1a has a variable slope because there is a transition from the nearfield to the farfield and a different set of mixing processes exist. Accordingly, a different set of governing equations are applied by the CORMIX model and a transition zone exists.

The results imply that rapid dilution of brine is achieved for all cases. The discharge salinity level is greatest for Cases 2(a) to (d), where the discharge has a salinity of 60 ppt and the flow rate is maximum. A dilution of 1 in 50 is achieved within 3.3 m in these cases (Figure 3-33). Dilutions continue to improve beyond this.

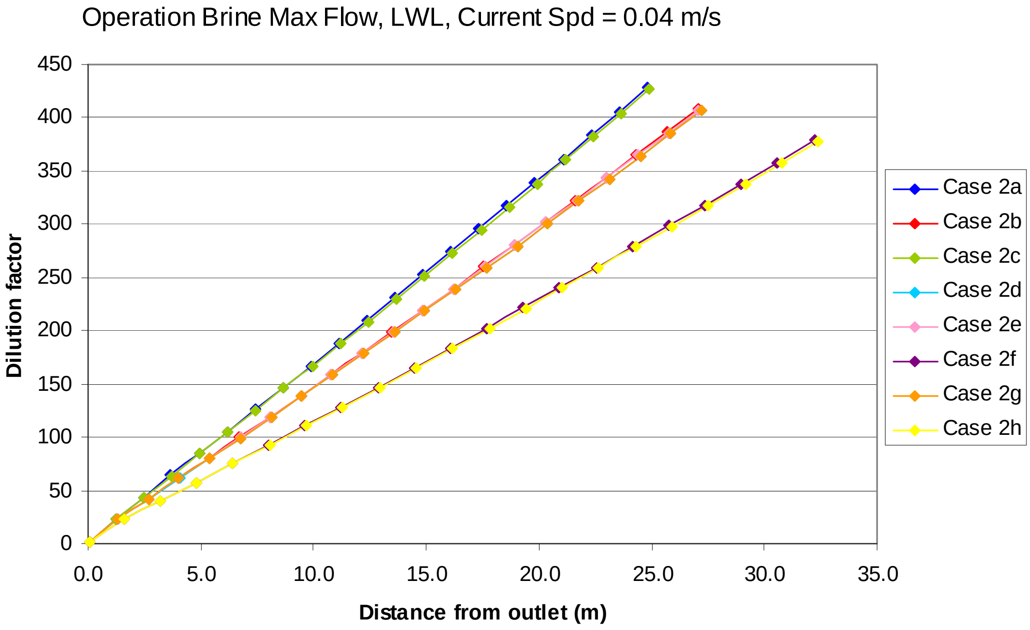

Figure 3-33 Operations Site: Dilution Curves for Brine Only Discharge

Note: lower dilutions are found for runs where the densities of the discharge and ambient water are similar.

Case 4(e) was used to test sensitivity to water levels and current speeds. As shown in Table 3-19, dilution is more sensitive to current speed than water level, and improves rapidly under high current speeds.

Table 3-19 Sensitivity Test for Water Levels and Current Speeds for Case 4(e)

Water Level	Current Speed	Distance to 1 in 50 Dilution (m)	Distance to 1 in 100 Dilution (m)	Distance to end of nearfield (m)
LWL	Slack	7.20	29.31	66.1
MWL	Slack	5.93	23.54	77.1
HWL	Slack	5.07	20.44	90.6
LWL	Mid	1.67	2.15	65.0
MWL	Mid	0.67	1.36	77.1
HWL	Mid	0.67	1.36	90.6
LWL	High	0.26	0.53	65.0
MWL	High	0.26	0.53	77.1
HWL	High	0.26	0.53	90.6

4. Discussion of Potential Impacts

4.1 Potential Water Quality and Ecological Impacts

4.1.1 Early Works Dredging

Total suspended solids (TSS) concentrations have been modelled for the following dredge scenarios incorporating the Australia Pacific LNG Early Works:

a) Construction Docks

b) MOF Construction Access

c) Embarkation Dock

d) Construction Docks dredging in addition to the Other dredging works scheduled to occur at the same time

Modelling of sediment plumes are consistent with assumptions used in the GPC WBDDP EIS. Modelled results indicate the TSS concentrations associated with dredging the early works areas are characterised by elevated levels on the eastern side for the Construction Docks and the MOF Construction Access with slightly elevated levels on the western side for the Embarkation Dock. The combined option is characterised by increased levels over the eastern side of the channel compared to the Construction Docks dredging only scenario. Over the durations associated with dredging the various early works areas; the mean, 99th percentile, and where relevant the 90th percentile TSS concentrations were extracted from the model at selected locations given in Table 3-4. A summary of modelled TSS concentration results at the selected locations for each dredging scenario has been presented in Table 3-5, Table 3-6, Table 3-8 and Table 3-10.

At the 90th percentile, modelled TSS concentrations at the selected locations do not exceed normal background concentrations.

The impact assessment on water quality and marine ecology associated with early works dredging is contained within the marine ecology supplementary report that has used the model predictions from this report. Additionally there is a potential impact on nearby sandy beaches from dredging on the Laird Point side of The Narrows. A coating of fine material (muds and silts) could appear on the beach as the plumes from the dredging follow the shoreline into Graham Creek. The quantity of material in suspension is not significant and could be mitigated via control measures described in the Dredge Management Plan such as regulating dredging activities to coincide with favourable tides in this location, or using some form of containment at low tides. Australia Pacific LNG will continue to consult with GPC on appropriate controls.

4.1.2 Combined Brine and Treated Wastewater Discharges

Given the location of and discharge conditions for the construction outfall, the diffuser design modelling has shown that a diffuser 20 m long with four port openings (diameter of 0.05 m) , with the ports discharging in the offshore direction, horizontal to the bed and perpendicular to the current direction, is optimal. Modelling indicated that this design would provide a dilution of 1 in 50 within 12.8 m of the diffuser in all cases including maximum flow rates, and within 2 m for average flow rates under the most conservative current, water level, salinity and temperature conditions.

For the operations phase, a diffuser design 20 m long with six port openings (diameter of 0.10 m) is optimal, with the ports discharging in the offshore direction, horizontal to the bed and perpendicular to the current direction. Modelling indicated that this design would provide a dilution of 1 in 50 within 7.20 m of the diffuser in all cases.

Modelling also indicated that dilution of brine in the nearfield zone is aided by the addition of treated wastewater. The impact assessment on water quality and marine ecology associated with early works dredging is contained within the marine ecology supplementary report. The model predictions from this report have been used for the marine ecology assessment.

Future coastal environment assessment will consider the location of the seawater intake in relation to the outfall, and the movement of vessels in the vicinity of the outfall. The CORMIX model used for this assessment is unable to model the effect of vessel movements or currents generated by the seawater intake.

5. References

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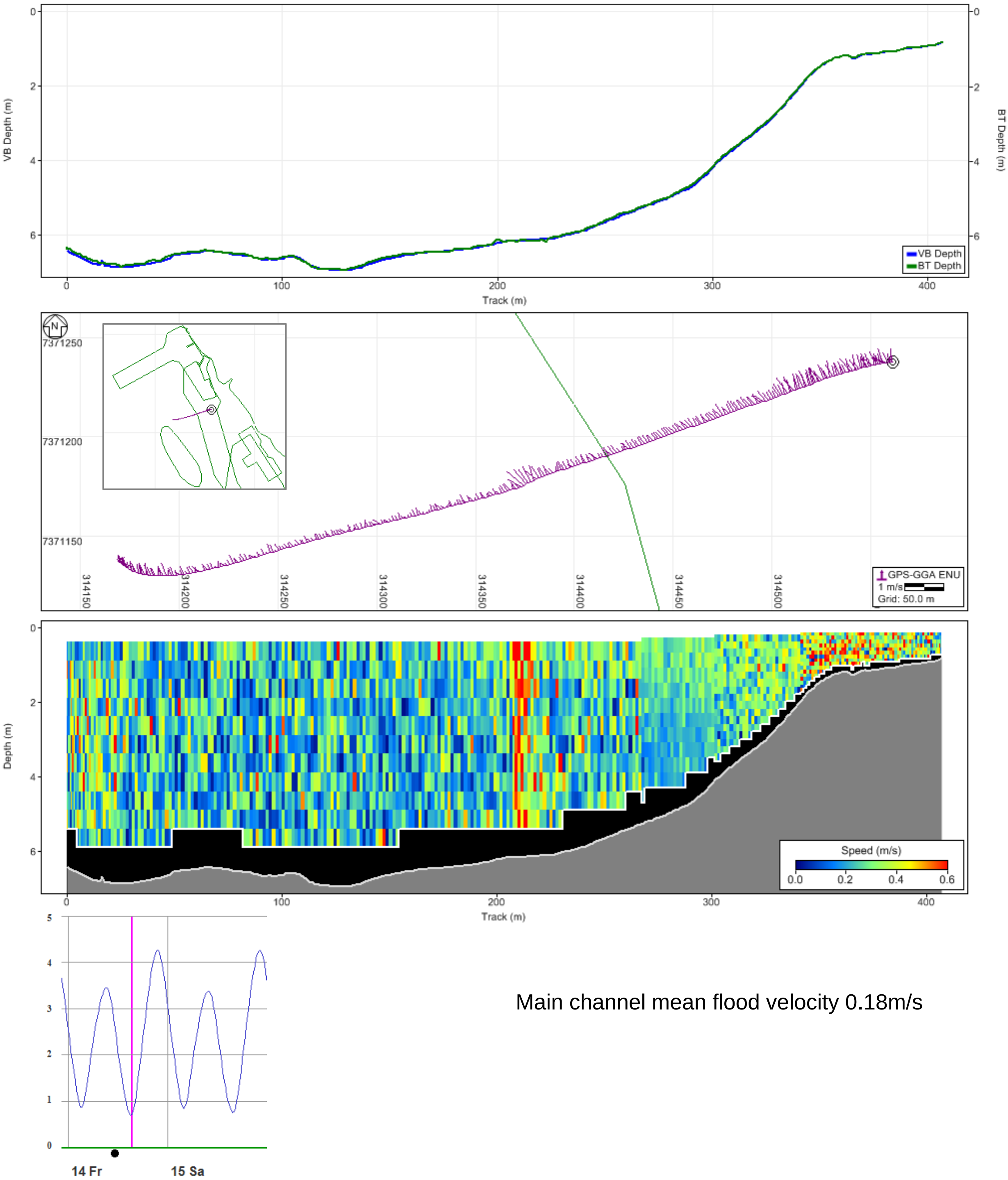
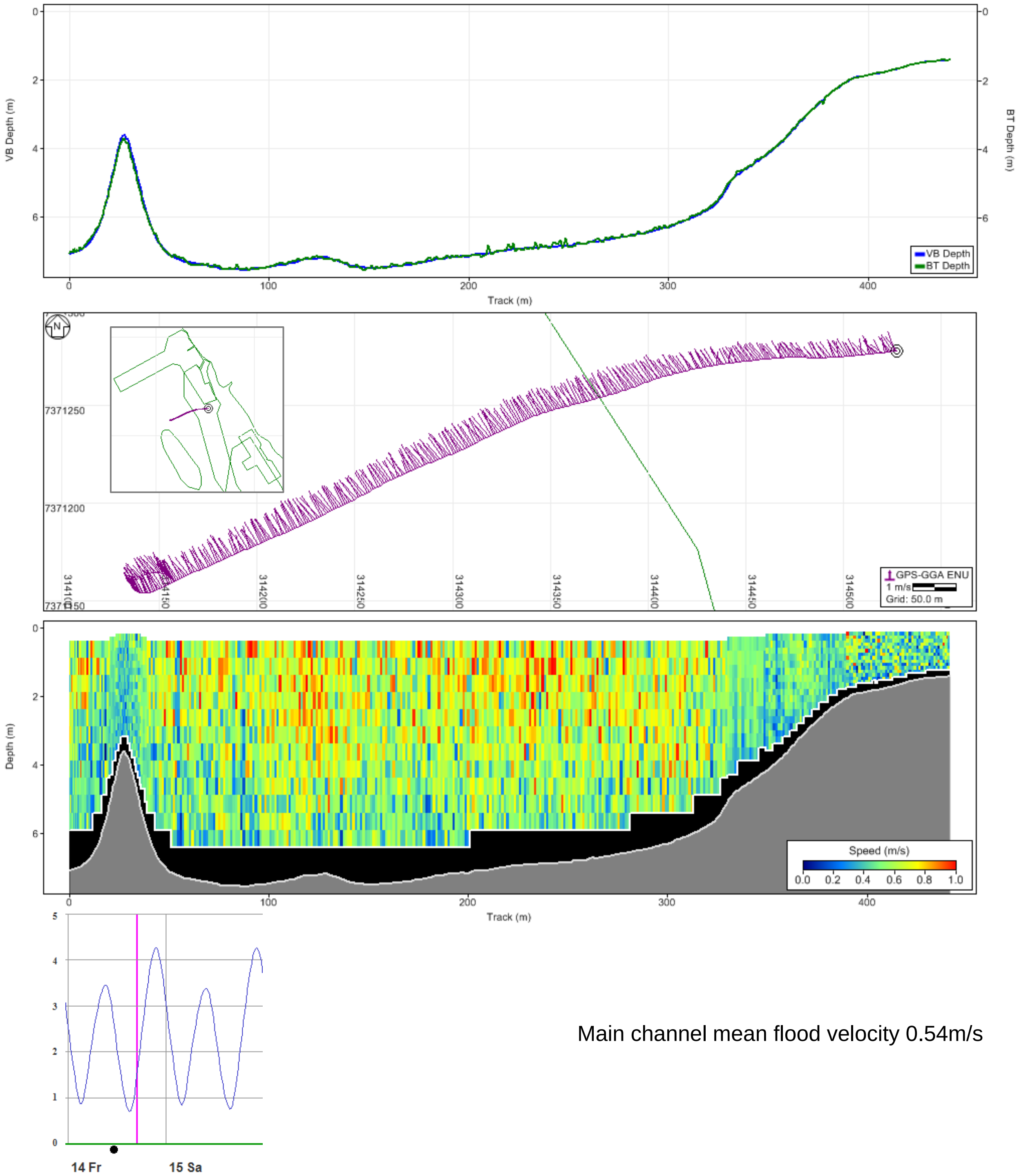
Appendix 1 - Current Measurements

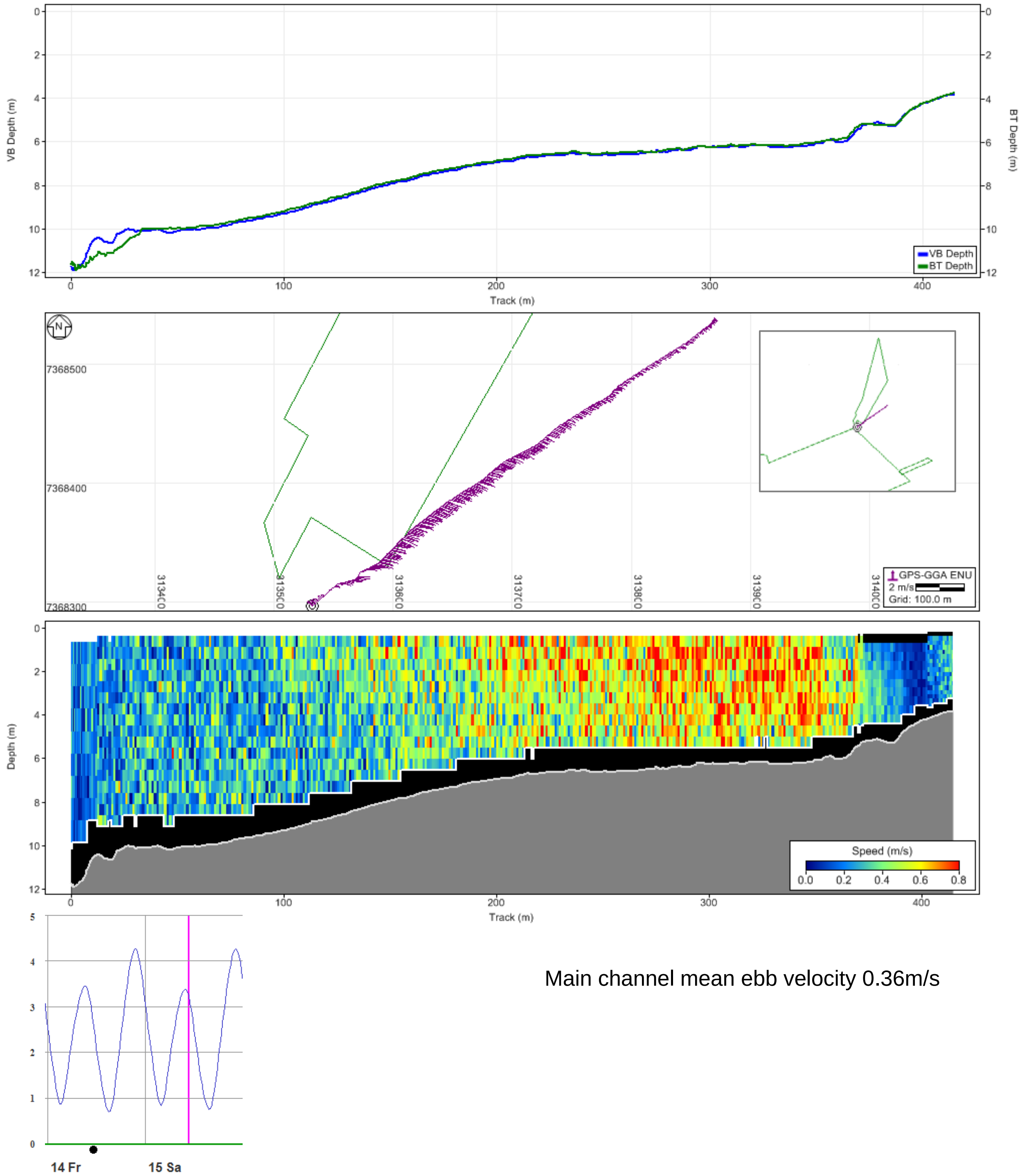


Appendix Figure 1 ADP transect - Proposed LNG Facility MOF (14 May 2010, 3:30PM)

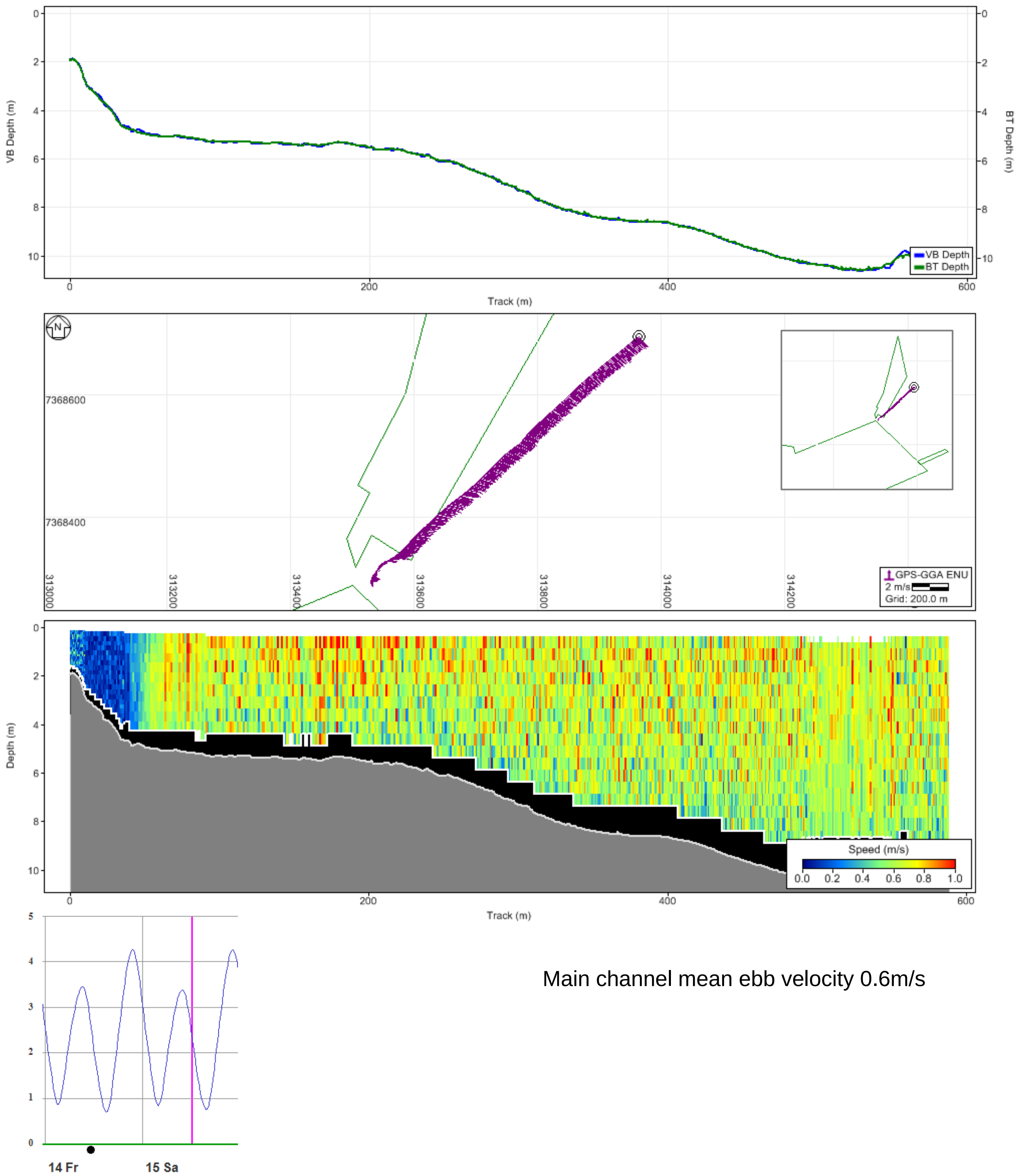


Main channel mean flood velocity 0.54m/s

Appendix Figure 2 ADP transect - Proposed LNG Facility MOF (14 May 2010, 4:55PM)



Appendix Figure 3 ADP transect - Proposed LNG Facility Embarkation Dock (15 May 2010, 10:43AM)



Appendix Figure 4 ADP transect - Proposed LNG Facility Embarkation Dock (15 May 2010, 12:11PM)