Australia Pacific LNG Project

Volume 5: Attachment

Attachment 26: Flooding, Drainage and Stormwater Management – LNG Facility

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Executive Summary

This report describes the investigation of surface waters issues for the proposed Liquefied Natural Gas (LNG) facility to be constructed by Australia Pacific LNG Pty Ltd (the Proponent) at Laird Point, on Curtis Island, Queensland. The investigations undertaken to assess the water quantity and quality impacts of the LNG facility included the following:

- Assessment of catchment, catchment hydrology, storm run-off flows and flood extents for existing conditions.
- Assessment of waterways and water bodies within the LNG facility site area.
- Water demand and source water for the LNG facility.
- Potential impacts of the proposed development
- Proposed mitigation measures and surface water quality management and monitoring requirements.

The investigations were undertaken to address section 3.4.1 of the Terms of Reference for the Project's EIS that relate to surface water environment, namely:

- Existing surface drainage and flows.
- Flooding.
- Water quality.
- Surface water management.
- Stormwater management

The methodology adopted for the investigations included the following:

- Description of the environmental values of the surface waterways on the site of the proposed LNG facility.
- Identification of potential impacts on surface water quality, quantity, drainage patterns and sediment movement.
- Formulation of management and monitoring strategies to ensure mitigation of potential impacts.

The site of the proposed LNG facility is traversed by a ephemeral creek system having three tributaries and flowing across an extensive area of tidal flats to an outlet through mangroves that drains a catchment that comprises timbered hills and valleys and tidal flats extending over an area of 284ha.

No recorded water quality and surface waterways information was available for the site and limited information was able to be obtained during site inspections due to the absence of flow in the creek system.

The extent of potential inundation of the LNG facility site has been determined using hydrologic and hydraulic modelling techniques. The modelling results indicated that existing flooding is generally confined to a 60m to 180m width along the main creek and the tributary branches across the site and spreads out over the broad tidal flats that extend to the creek entrance.

Additionally, the flats are subject to occasional tidal inundation during higher spring tides, with the maximum level for tidal inundation corresponding to Highest Astronomical Tide (HAT) level

(2.562mAHD). The maximum water levels for ocean inundation of the tidal flats are expected to occur in major ocean storm surge events, which may exceed HAT level.

The Laird Point site is located on the landward side of Curtis Island, approximately 12km from the ocean and is considered to be well protected from tsunamis, with the tsunami hazard generally considered to be low.

It is proposed that a portion of the tidal flats be filled to 6mAHD and runoff from the hills above the LNG facility site will be diverted around the of the site and discharged to Port Curtis to ensure that LNG facility will not be adversely impacted by floods and tidal fluctuations.

The site is not located within any area covered by a water resource plan, land and water management plan or declared wild river area.

The environmental values of the surface waterways were derived from values identified in the EPP (Water) and Queensland Water Quality Guidelines and relevant environmental values for the Port Curtis region.

The primary source of water for the LNG facility during the construction period, as well as the operation period, is expected be desalinated seawater, with supplementary supply from stormwater runoff stored in the hydro-test pond and sediment basin. A water balance has been undertaken to assess the yield that can be supplied from stormwater runoff from the LNG facility.

Surface runoff from the site will be collected and conveyed to sediment ponds via vegetated swales, which will include rock check dams to reduce velocity and facilitate sediment deposition during the construction and operation phases of the LNG facility.

Potentially contaminated stormwater runoff containing fuels, oils or chemicals from the plant process areas will be collected and directed to a coalescing plate interceptor (CPI) treatment process and disposed by irrigation with the sewage effluent in order to prevent fuels and chemicals being discharged to Port Curtis in stormwater runoff.

A stormwater management plan (Section 7) has been prepared that outlines objectives, key pollutant risks, management actions, monitoring requirements, corrective actions and responsibilities for the construction and operation periods of the LNG facility. The stormwater management plan will be incorporated into the Environmental Management Plan (EMPlan) for the LNG facility.

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1. Introduction

This report describes the investigations of the existing surface water environment and potential impacts from the proposed Liquefied Natural Gas (LNG) facility to be constructed by Australia Pacific LNG Pty Ltd (the Proponent) at Laird Point, on Curtis Island, Queensland. The investigations included:

- An assessment of waterways and water bodies within the LNG facility site area including determining the existing hydrologic and water quality conditions..
- A summary of the LNG facility's water demand and potential sources of supply.
- A review of potential impacts of the proposed development.
- Potential mitigation measures for stormwater flow and quality management during both the construction and operational phases of the LNG facility.
- Surface water quality management and monitoring requirements.

The investigations were undertaken to address section 3.4.1 of the Terms of Reference for the Project's EIS that relate to surface water environment. The Terms of Reference and the locations of the responses are summarised within Table 1.1.

Subsequent to the above investigations, a stormwater management plan was prepared that outlines objectives, key pollutant risks, management actions, monitoring requirements, corrective actions and responsibilities for the construction and operation phases of the LNG facility (Section 7 of this report).

Table 1.1 Terms of reference and response locations

Terms of Reference	Response
Description of environmental values	
The EIS should describe the environmental values of the surface waterways of the affected area in terms of: • Values identified in the EPP (Water) and Australian and New Zealand Environment and Conservation Council, State of the Environment Reporting Taskforce 2000 (ANZECC 2000) • Sustainability, including both quality and quantity • Physical integrity, fluvial processes and morphology of watercourses, including riparian zone vegetation and form any water resource plans, land and water management plans, declared or proposed wild river areas relevant to the affected catchment.	Section 3
A description should be given of the surface watercourses and their quality and quantity in the area affected by the project with an outline of the significance of these waters to the river catchment system in which they occur.	Section 3
Details provided should include a description of existing surface drainage patterns and existing and historical flow regimes in major streams and wetlands and a description of present and potential water uses downstream of the areas affected by the project.	Section 3

Terms of Reference	Response
Details should be provided on the likelihood of flooding, history of flooding (including extent, levels and frequency). Flood studies should include a range of annual exceedance probabilities for affected waterways, based on observed data if available, or use appropriate modelling techniques and conservative assumptions if there are no suitable observations. The flood modelling should include local flooding due to short duration events from contributing catchments on site, as well as larger scale regional flooding including waterways downstream.	Section 3
The EIS should provide a description, with photographic evidence where appropriate, of the geomorphic condition of any watercourses likely to be affected by project works and operations. The results of this description should form the basis for the planning and subsequent monitoring of rehabilitation of the affected watercourses.	Appendix D
An assessment is required of existing water quality in surface waters and wetlands likely to be affected by the proposal. The basis for this assessment should be a monitoring program, with sampling stations located upstream and downstream of the project areas. The water quality monitoring should capture seasonal variations or variations with flow where applicable. A relevant range of physical, chemical and biological parameters should be measured to provide a baseline for affected creek or wetland systems.	Section 4
Potential impacts and mitigation measures	Section 6
The water management systems for all project elements should be described, addressing surface water quality, quantity, drainage patterns and sediment movements.	
The beneficial (environmental, production and recreational) use of nearby surface water should be discussed. An analysis of potential impacts on affected creeks should be carried out. This analysis should identify any likely inundation and duration, as this may affect emergency vehicle access.	Section 6
Monitoring programs should be described which will assess the effectiveness of management strategies for protecting water quality during the construction, operation and decommissioning of the project. Monitoring programs should also be designed to evaluate changes in the physical integrity and geomorphic processes associated with changed flow regimes in affected water courses.	Section 7
Where on-site storage of water sourced from waste water treatment plants is proposed, the EIS should detail how this water would be managed to ensure environmental harm is avoided. The EIS should also describe the design features of any such storages to effectively contain saline water and other harmful constituents.	Section 5
Key water management strategy objectives include: • Maintenance of sufficient quantity and quality of surface waters to protect existing beneficial downstream uses of those waters (including maintenance of in-stream biota) • Maintenance or replication of the existing geomorphic conditions of local watercourses • Minimisation of impacts on flooding levels and frequencies both upstream and downstream of the project.	Section 6

Terms of Reference	Response
The EIS should include a risk assessment for uncontrolled emissions to water due to system or catastrophic failure, implications of such emissions for human health and natural ecosystems, and strategies to prevent, minimise and contain impacts.	Section 6
The EIS should describe the proposed project component stormwater drainage systems and the proposed disposal arrangements, including any off-site services and downstream impacts.	Section 6
Where dams, weirs, or ponds are proposed, the EIS should investigate the effects of predictable climatic extremes (droughts, floods) upon the structural integrity of the containing walls, and the quality of water contained, and flows and quality of water discharged.	Section 6
A dam failure impact assessment should be carried out for any proposed dams that, due to their size, trigger the need for such an assessment under the *Water Act 2000*. Any dams that are likely to be referrable under the *Water Act 2000* should be noted and emergency response procedures incorporated into the project's environmental management plan (EMP).	Section 6
The need, or otherwise, for licensing of any dams (including referable dams) or creek diversions, under the *Water Act 2000* or the *Fisheries Act 1994* or the construction or raising of any waterway barrier works under the *Fisheries Act 1994* should be discussed. The process for water allocation and water discharge should be established in consultation with DERM. Consideration should also be given to any water allocation and management plans.	Section 5
The environmental values of the surface waters potentially affected by the project should be identified in accordance with the EPP (Water). Surface water quality objectives should be determined after consideration of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality.	Section 4
Risks to farmland from potentially contaminated surface water flow, particularly during flood events should be assessed.	Not Applicable
Options for flood mitigation and the effectiveness of mitigation measures should be discussed with particular reference to sediment, salinity and other emissions of a hazardous or toxic nature to human health, flora or fauna.	Section 6
Waste management	
Stormwater management should also address: • Nominated stormwater discharge points and discharge criteria • Design criteria, diversions, volume and capacity of any retention ponds, process tanks or bunded areas, as well as those reasonable and practicable measures proposed to prevent the likely release of contaminated stormwater to any drain or waters • Potential impacts during extreme rainfall events • Information on the collection, treatment and disposal of contaminated stormwater runoff from plant and associated materials handling facilities • details of expected contaminants (e.g. chemical composition, particulates, metals, effluent temperature and pH) in controlled discharges of proposed wastewater and stormwater	Section 6

Terms of Reference	Response
management systems • Impacts of discharges on potential receiving waters, particularly effects on the downstream environment of stormwater releases (i.e. water – salt balance) • An outline the expected disposal strategies, where solid or liquid wastes are to be disposed of off-site.	

2. Project description

The Project's LNG facility is proposed to be developed in stages to a maximum ultimate capacity of approximately 18 million tonnes per annum (Mtpa) of LNG. It is expected that the ultimate configuration of the LNG facility will comprise up to four LNG trains, each producing up to 4.5 Mtpa of LNG. To produce 4.5 MTPA of LNG, each train will require approximately 270 Petajoules (PJ) of Coal Seam Gas (CSG) per annum which is roughly equivalent to 11 million m3 of LNG per annum. The LNG facility is expected to operate 24 hours per day, seven days a week.

It is anticipated that the LNG facility will consist of the following major components:

- LNG trains for processing incoming gas to LNG
- LNG and LPG storage tanks
- Process gas wet and dry ground flares
- Wastewater treatment
- Desalination plant
- Plant infrastructure
- Loading jetties to transfer LNG to ships for export to market and receive shipments of LPG
- A Material Off-loading Facility (MOF) for the transfer of building materials and heavy equipment to the LNG facility site
- Ferry terminal
- Construction workforce accommodation, offices and related facilities.

The LNG facility site area is located on Curtis Island within the Curtis Island Industry Precinct of the Gladstone State Development Area (GSDA) and the adjacent areas of Port Curtis. Curtis Island is approximately 10km north of Gladstone on the central Queensland coast.

The facility site is described as Lot 3 on SP225924 and is situated within the mid-west corner of Curtis Island adjacent to Laird Point. The site is bound by Graham Creek to the north and Targinie Passage to the west. The location is referred to as Laird Point. The LNG facility site will cover approximately 270 hectares (ha), which includes approximately 39ha of tidal flats that are to be reclaimed for LNG facility infrastructure and the MOF. The LNG facility footprint covers approximately 156ha or 58% of the LNG facility site area.

3. Existing conditions

3.1 Catchment characteristics

The proposed LNG facility site is located on the west coast of Curtis Island, approximately 1km south of Laird Point and Graham Creek, as shown on Figure 3.1.

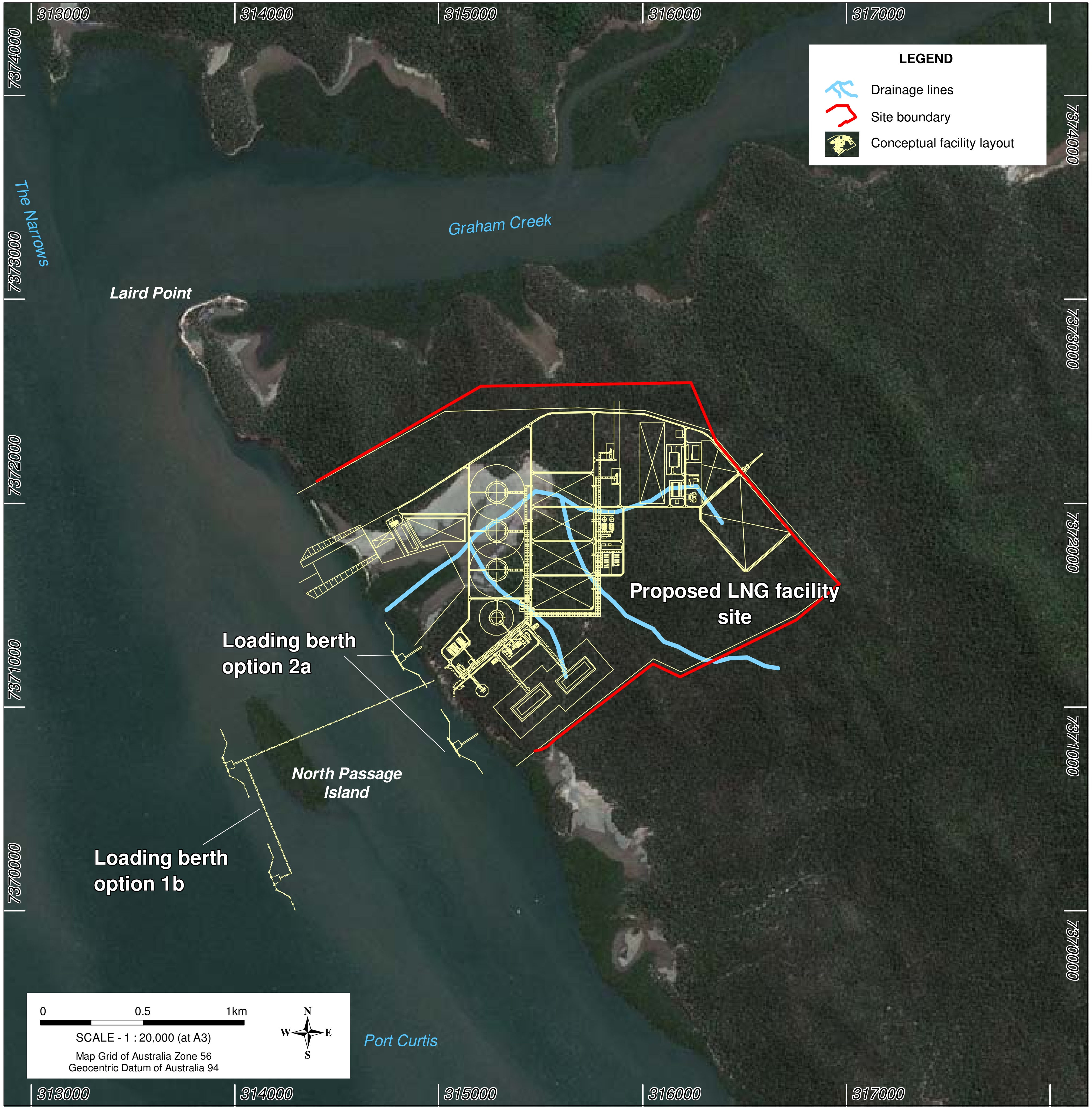
The site is traversed by an ephemeral creek system having three tributaries and flowing across an extensive area of tidal flats and through mangroves to an outlet into Port Curtis approximately 1.3km south of Laird Point.

The local creek catchment covers the LNG facility site and extends to the south-east, covering a total area of 284ha. The central and upper reaches of the catchment comprise steeply graded (up to 30% slope) timbered hills and valleys, while the lower catchment comprises approximately 50ha of grassed tidal flats and mangroves at the creek entrance. Natural ground levels on the site range from approximately 1.5mAHD within the intertidal area to 62mAHD towards the south-east corner.

The soils on the site and in the catchment are gravelly sandy loams on the hillsides, having dispersive nature and a medium runoff potential. Initial site investigations indicated the presence of actual Acid Sulphate Soils (ASS) and potential acid sulphate soils (PASS) on the site. The assessment of the soils on the site is presented in Volume 4, Chapter 5 of this EIS.

Reconnaissance surveys of the site were carried out in order to obtain some qualitative assessment of the condition of the natural drainage on site. During these surveys, a natural melaleuca wetland and a small farm dam were located on the site. Both features are degraded and were considered to posses few environmental values, due to the lack of diversity and habitat present, as well as the damage made by cattle and horses. The dam was supplied by groundwater from a nearby bore as catchment runoff into the dam is insufficient to provide a continuous supply. The aquatic ecology and habitat values of the waterways throughout the site are explained in detail in Volume 4, Chapter 9 of the EIS.

The site has been used previously for cattle grazing and runoff quality is expected to be similar to that for low intensity grazing. Contamination of runoff is considered unlikely as no disused cattle dip or other potential sources of contamination were found on the LNG facility site. The site is no longer used for cattle grazing, however wild horses roam over the site.



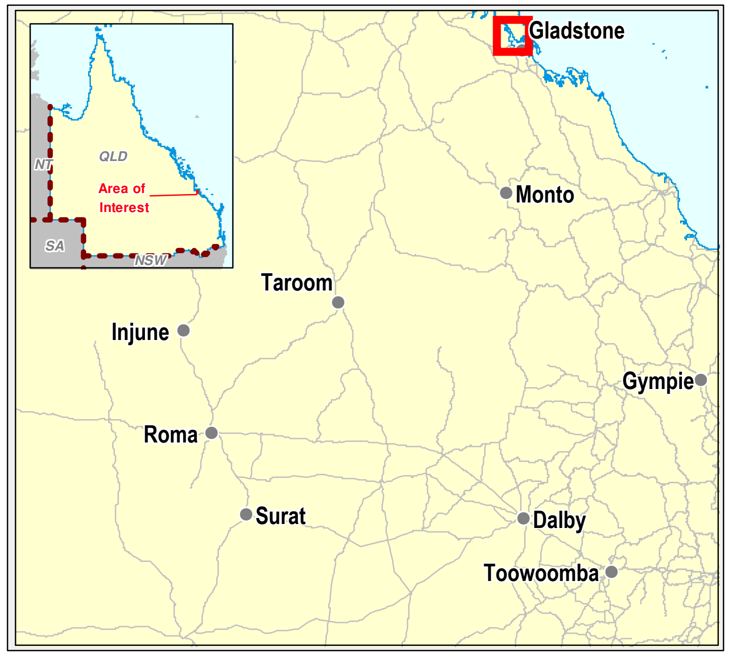


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Figure 3.1 Site Location

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The nearest long-term rainfall gauges to the site are located in Gladstone, where the long-term mean annual rainfall is 965mm based on the composite Gladstone rainfall data for the period 1872 to 2009 for the Post Office and Radar Hill stations.

The monthly average rainfall, evaporation and temperature data for the Radar Hill station for the period 1957 to 2009 are summarised in Table 3.1.

Table 3.1 Climate data at Radar Hill (Source: Bureau of Meteorology Climate Averages)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total year
Rainfall (mm)	143.4	143.4	82.6	46.4	59.6	38.9	34.4	31.2	26.2	61.3	73.2	128.8	869.7
Days rain ≥10mm	4	4	2	1	1	1	1	1	1	2	2	3	23
Potential Evaporation (mm)	195	165	164	132	105	90	96	109	132	170	183	195	1736
Temperature (°C)	22.5-31.2	22.4-30.9	21.5-30.2	19.6-28.4	17.0-25.7	14.3-23.2	13.4-22.8	14.3-24.1	16.4-26.5	18.7-28.4	20.5-29.9	21.9-31.0	18.5-27.7

The climate data exhibits high seasonality with the highest rainfall occurring between December and February, during which period approximately 48% of the annual rainfall occurs. The higher evaporation begins in October and extends through to March, reflecting the higher temperatures during those months.

The average annual rainfall recorded at the Radar Hill station is approximately 10% less than the long-term average annual rainfall obtained for the period 1872-2009 using the composite records for the Post Office and Radar Hill gauges. The lower annual rainfall reflects the influence of the prolonged drought from the mid 1990s to 2008 when rainfall was 25% less than for the preceding 120 years.

3.2 Streamflow

There are no known streamflow records for the drainage lines within the site or other watercourses on Curtis Island.

The nearest DERM streamflow gauging stations to Curtis Island are located at Castlehope on the Calliope River, approximately 20km south-west of Gladstone and at Old Station on Raglan Creek, approximately 45km west of Gladstone. The mean annual depths of runoff at the two stations are 117mm and 89mm respectively and are equivalent to approximately 10-14% of the average annual rainfall for the catchments.

The catchment and rainfall characteristics for the gauged catchments are similar to those on Curtis Island. Therefore, the average depth of runoff on Curtis Island is estimated to be approximately 140mm, based on a volumetric runoff factor of 15% and the long-term average rainfall, yielding an estimated volume of runoff from the local creek catchment at the site of approximately 400ML/yr.

Based on the rainfall data presented in Table 3.1, runoff would be effectively concentrated to the period between December and March, with negligible stream flow during the remaining months.

3.3 Stormwater flows

Storm runoff hydrographs were calculated at the catchment outlet (downstream extent of the site) and a number of locations within the LNG facility site using the RAFTS hydrologic model. RAFTS is a non-linear run-off routing model that calculates run-off hydrographs from excess rainfall for rural and urban catchments ranging in area from less than 1ha to over 1000km^2.

The RAFTS model comprised nine sub-areas covering the site and the upstream areas. The delineation of the sub-areas was based on topography and the natural drainage layout. The RAFTS model layout is presented on Figure 3.2.

Design rainfall intensity-frequency-duration data was determined for the Curtis Island locality in accordance with Australian Rainfall and Runoff (AR&R 2001). The design rainfall intensity-frequency-duration (IFD) data is presented in Appendix A.

An initial loss of 25mm and continuing loss of 2.5mm/hour were adopted for the RAFTS model. The adopted rainfall losses were based on the volumetric run-off co-efficients for a typical single storm for soils having a moderate to high infiltration capacity, similar to the soils on the site.

The RAFTS model produced peak flows for a critical storm duration of 120 minutes for the 100 and 50 years ARI events and for a critical storm duration of 180 minutes for the lesser design storm events. The longer critical storm duration for the lesser events reflects the influence of initial loss on excess rainfall and resultant run-off. This effect is particularly evident in the 1 and 2 Year ARI events, where the adopted initial loss represents 40-50% of the rainfall in the critical duration design storm events.

The peak flows at the downstream extent of the site are listed in Table 3.2 and a summary of peak flows for the model sub-areas are listed in Appendix B.

Table 3.2 RAFTS model peak flows at downstream extent of the site

Average Recurrence Interval (yrs)	Peak flow (m3/s)
100	47.4
50	42.2
20	34.4
10	27.4
5	22.4
2	14.5
1	9.0

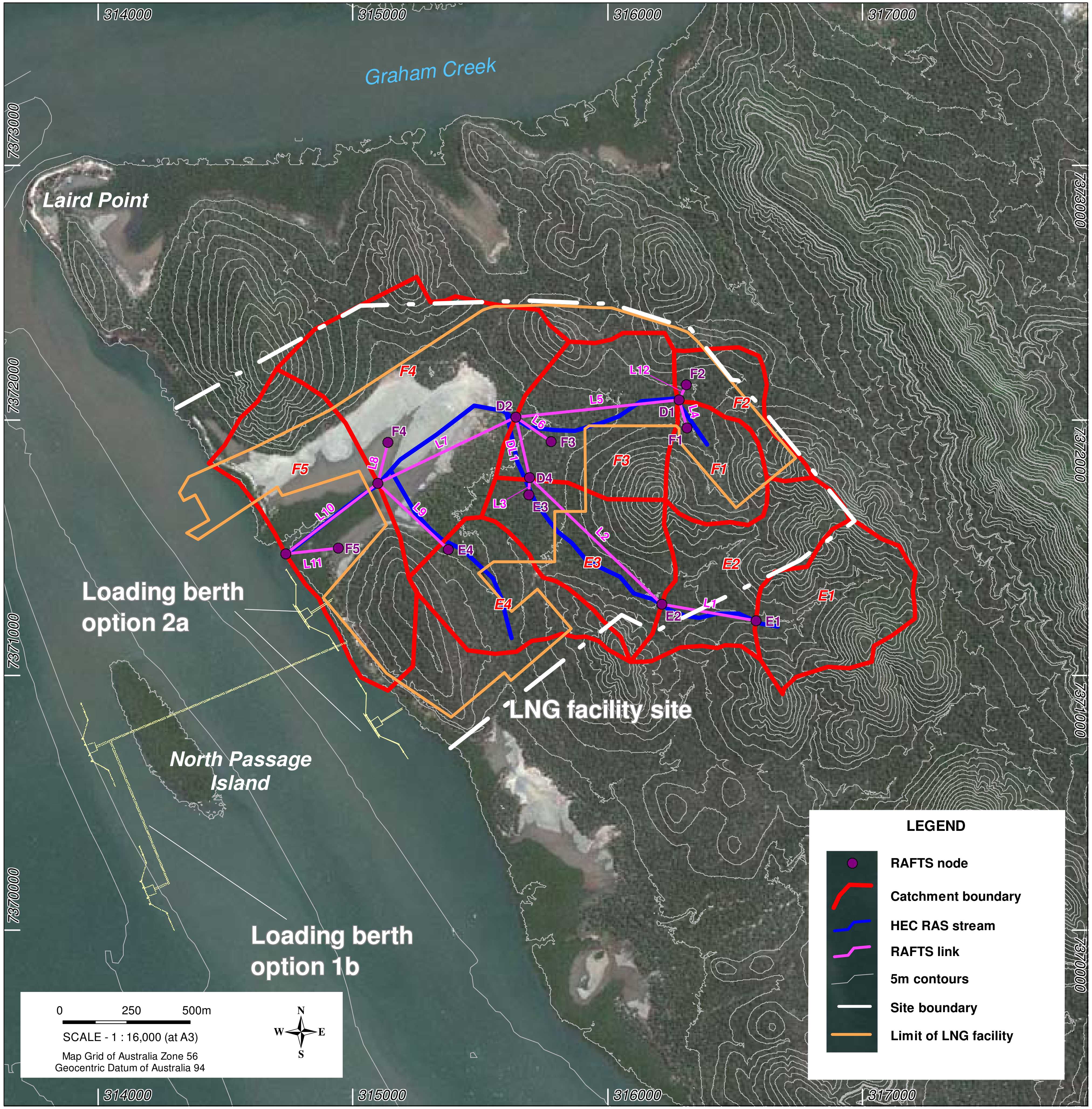

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Figure 3.2 Catchments and RAFTS Model - Existing

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Peak flows for design storm events were also estimated for existing catchment conditions using the Rational Method in order to validate the RAFTS modelling. The time of concentration for the catchment was estimated to be 90 minutes, as per the Bransbury-Williams formula for rural catchments.

The Rational Method peak flow estimates for design storm events having an Average Recurrence Interval (ARI) for up to 100 years are presented in Table 3.3.

Table 3.3 Rational Method peak flows - existing

Average Recurrence Interval (yrs)	Peak flow (m3/s)
100	51.5
50	43.3
20	33.5
10	27.2
5	22.9
2	16.0
1	11.7

The peak flows predicted by the RAFTS model are comparable to the peak flow estimates obtained from the Rational Method for moderate and major design storm events. As stated above, the adopted initial loss has a significant influence for the minor storm events, resulting in marginally lower peak flows for those events than the Rational Method estimates for the 1 and 2 Year ARI design storms.

The principal purpose of the RAFTS modelling was to determine peak flows at selected locations along the natural drainage network for input to the hydraulic model to estimate the extent of inundation in the 100 years ARI design event, as discussed below.

3.4 Existing Conditions Flood Extent

The approximate extent of inundation of the proposed site in the 100 years ARI design event was determined using a HEC-RAS hydraulic model, with peak flows obtained from the RAFTS hydrologic model.

HEC-RAS is a one-dimensional hydraulic model that was developed at the Hydrologic Engineering Center by the US Army Corps of Engineers. The model is designed to perform one-dimensional hydraulic calculations for natural and constructed channel networks. The model can simulate branched networks and hydraulic structures, including weirs, bridges and culverts.

The HEC-RAS model of the study area included the main creek and two tributary branches, with peak flows input for seven reaches. The cross-sections for the model were extracted from the contour survey information for the site. The cross-section locations are depicted in Figure 3.3.

A tail-water level at 1.64mAHD, corresponding to Mean High Water Springs (MHWS) at the Gladstone Port gauge was adopted for the HEC-RAS model. The natural ground level at the lowest portion of the site adjacent to the mangroves at the mouth of Graham Creek is approximately 150mm below MHWS level.

The approximate extent of inundation in the 100 years ARI design storm event is plotted in Figure 3.3 and peak flood levels are summarised in Appendix A.

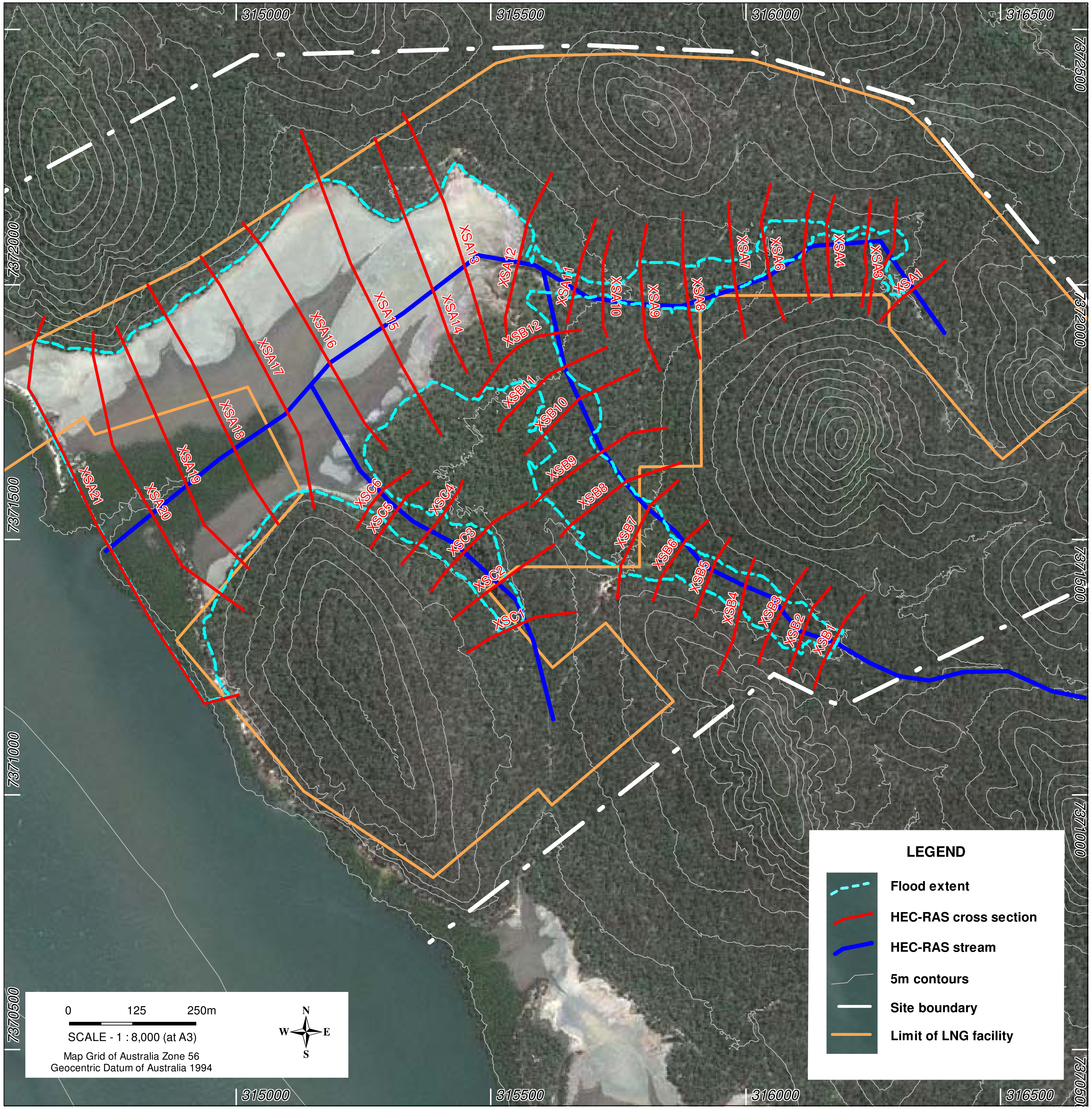

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Figure 3.3 100 Years ARI
Flood Extent - Existing

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The HEC-RAS modelling results indicate that floodwaters are generally confined to a 60-180m width along the main creek and the tributary branches across the site. The floodwaters spread out over the broad tidal flats that extend to the creek entrance.

The extent of inundation in the 100 years ARI design storm event for existing conditions covers a significant proportion of the proposed LNG facility site. The LNG facility site is to be filled and runoff from external areas is to be diverted around the LNG facility as discussed in Section 6.1.

3.5 Ocean inundation

The proposed LNG facility site extends onto tidal flats within an area of approximately 24ha between the mangroves at the mouth of the creek to near the bases of the hills. The flats are subject to occasional tidal inundation during higher spring tides. The maximum level for tidal inundation corresponds to Highest Astronomical Tide (HAT) level and is 2.562mAHD. This is approximately 1m higher than the lowest portion of the site and adjacent to the mangroves at the mouth of Graham Creek.

The location of the HAT level contour on the site is plotted on the survey plan for the reclamation area presented on. The extent of the proposed reclamation areas for the LNG facility and MOF are also shown on Table 3.4. The reclamation areas are to be filled to 6.0mAHD as discussed in Section 6.1.

The tidal plane data for Gladstone is listed in Table 3.4. This data was adopted for defining the tidal water level data for the Laird Point site.

Table 3.4 Gladstone tidal plane data

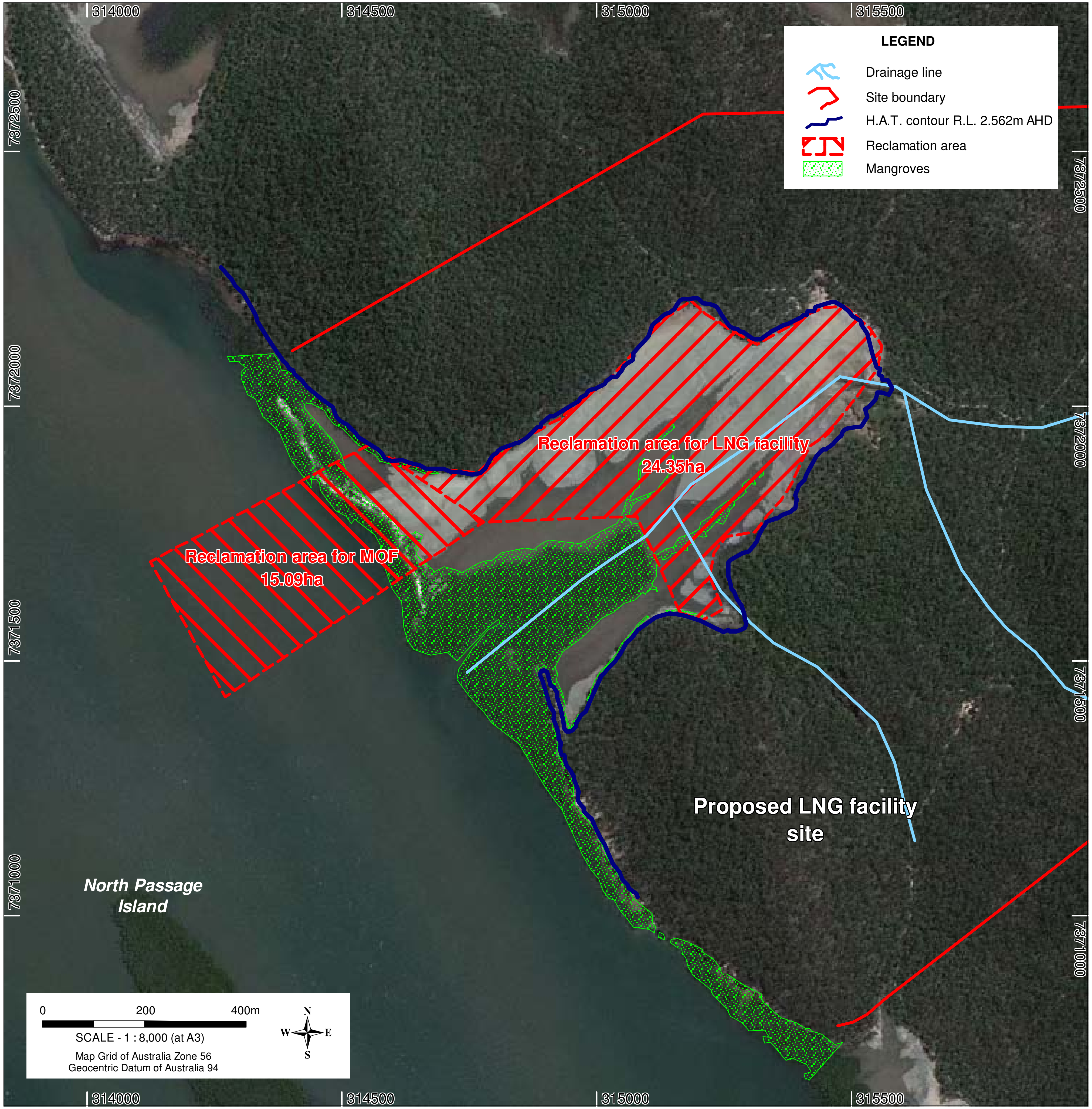
Tidal plane	Height above LAT (m)	Level (mAHD)
Highest Astronomical Tide (HAT)	4.83	2.562
Mean High Water Springs (MHWS)	3.96	1.692
Mean High Water Neaps (MHWN)	3.11	0.842
Mean Sea Level (MSL)	2.34	0.072
Australian Height Datum (AHD)	2.268	0.000
Mean Low Water Neaps (MLWN)	1.57	-0.698
Mean Low Water Springs (MLWS)	0.72	-1.548
Lowest Astronomical Tide (LAT)	0.00	-2.268

Source: Maritime Safety Queensland, 2009

The estimated 100 years ARI storm tide water level at Gladstone (Harper 1998) is 0.8m above HAT level, resulting in a maximum inundation level at 3.362mAHD.

The tsunami hazard along the Queensland east coast is generally considered to be low (WLA 2009). In general, sites exposed to the ocean are most vulnerable to tsunami hazard. The Laird Point site is located on the landward side of Curtis Island, approximately 12km from the ocean and is considered to be well protected from tsunamis.

Therefore, the maximum water levels for ocean inundation of the tidal flats are expected to occur in major ocean storm surge events.



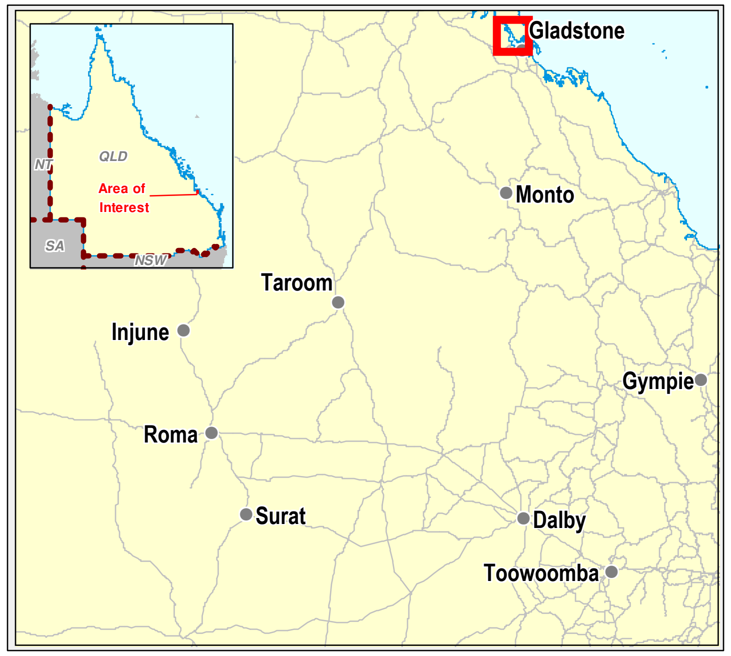


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Figure 3.4 Extent of Tidal Inundation

Project No: 301001-00752	Figure: 00752-00-EN-DAL-0091	Rev: 0

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3.6 Existing water quality

No information is available from DERM databases with regard to water quality and condition of the natural drainage lines for the Laird Point study area. Two reconnaissance surveys of the site were carried out in order to obtain some qualitative assessment of the condition of the natural drainage on site. A small farm dam was located on the site during the first site visit. The dam was supplied by groundwater from a nearby bore as runoff into the dam was insufficient to provide a continuous supply. The dam and nearby bore are no longer being used.

During a later site visit undertaken to assess ASS conditions on the site, a melaleuca wetland was located approximately 200m to the north-east of the dam located previously. Both the dam and wetland were quite degraded and are considered to have limited environmental values. The locations of the dam and melaleuca wetland are shown on Figure 3.5.

The site has been used previously for cattle grazing and run-off quality is expected to be similar to that for low intensity grazing. The site is no longer used for cattle grazing, but wild horses roam over the site. Contamination of run-off is considered unlikely as no disused cattle dip or other potential sources of contamination were found on the site. The contaminated land investigations are presented in the Land Contamination technical report included in Appendix 5 of this EIS.

Two waterway-focussed site investigations to Laird Point were conducted; a reconnaissance survey was carried out on the 16 June 2009, with a second investigation held on the 7 October 2009.

The first reconnaissance survey in June was conducted during the dry season and from background research, no water was expected to be found within the study area. The Bureau of Meteorology had recorded no rainfall for Gladstone or South End (on Curtis Island) for at least three weeks prior to the reconnaissance survey.

The water in the dam was sampled and analysed and the water quality results are presented in Table 3.5. It should be noted that the water quality is not representative of the surrounding surface environment due to the water in the dam being sourced from groundwater.

Table 3.5 Water quality results from Laird Point farm dam, 16 June 2009

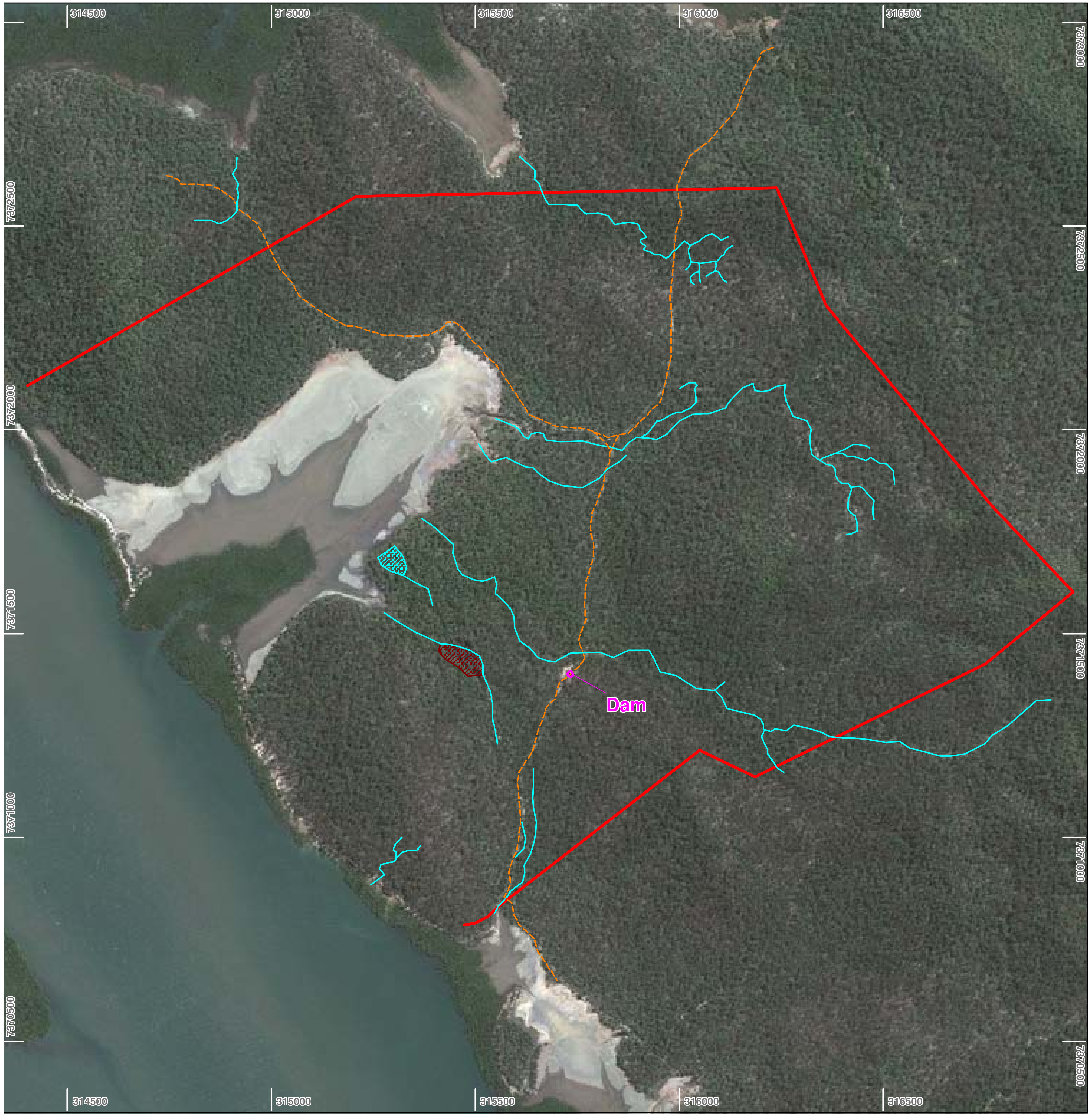
Parameter	Units	Value
Physical and Nutrient Parameters		
pH	-	6.66
Dissolved Oxygen	mg/L	10.86
Conductivity	µS/cm @ 25°C	493
Water Temperature	°C	18.4
Total Dissolved Solids	mg/L	419
Suspended Solids	mg/L	62
Ammonia	mg/L	<0.01
Nitrite	mg/L	<0.01
Nitrate	mg/L	<0.01

Parameter	Units	Value
Total Kjeldahl Nitrogen	mg/L	0.7
Total Nitrogen	mg/L	0.7
Total Phosphorus	mg/L	0.08
Cations and Anions		
CaCO3	mg/L	24
Sulfate as SO4	mg/L	6
Chloride	mg/L	158
Calcium	mg/L	4
Magnesium	mg/L	11
Sodium	mg/L	76
Potassium	mg/L	4
Total Metals		
Arsenic (II and V)	mg/L	0.003
Cadmium	mg/L	<0.0001
Chromium (III and VI)	mg/L	<0.001
Copper	mg/L	0.004
Lead	mg/L	<0.001
Mercury (II and III)	mg/L	<0.0001
Nickel	mg/L	0.001
Zinc	mg/L	0.015
Hydrocarbons		
C6 – C9 Fraction	µg/L	<20
Benzene	µg/L	<1
Toluene	µg/L	<2
Ethylbenzene	µg/L	<2
meta- & para-Xylene	µg/L	<2
ortho-Xylene	µg/L	<2

The farm dam was experiencing an algae bloom at the time of sampling, which would contribute to the organic speciation of nitrogen found within the water column. Additionally, the elevated chloride and sodium levels reflect the origin of the water, being from the groundwater bore.

The second site visit also followed a prolonged dry period with the only noteworthy rainfall being 8mm over 4 days in early September 2009, four weeks earlier. It was not possible to obtain samples of the surface water during the second due to the complete absence of water on the site.

Details of the observations made during the site investigations are included in Appendix D.



LEGEND

- Photo location
- Existing track
- Identified drainage line/creek
- Site boundary
- Melaleuca wetland
- Farm dam
- Melaleuca soak

Satellite imagery captured by GeoEye-1 on 24 March 2009

0 200 400m

SCALE - 1 : 10,000 (at A3)

Map Grid of Australia Zone 56
Geocentric Datum of Australia 94

N W E S

Rev	Date	Revision Description	ORIG	CHK	ENG	APPD
0	17/02/2010	Issued for use	KM	DH		RB

WorleyParsons resources & energy

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Figure 3.5 Laird Point Waterways and Photo Locations

Project No: 301001-00752	Figure: 00752-00-EN-DAL-0125	Rev: 0

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4. Water quality

No information is available from desktop research for the water quality of the natural drainage lines that exist on the site. These natural drainage lines are ephemeral and only flow for a relatively short time following heavy rainfall, and as such it was expected that limited opportunity would exist to obtain water quality samples while on site, as sampling is only possible during or immediately after rainfall events.

The site has previously been used for cattle grazing and run-off quality is expected to be similar to that for low intensity grazing. There are currently no cattle grazing on site. Contamination of run-off is considered unlikely as no disused cattle dip or other potential sources of contamination were found on the site (refer to Volume 4, Chapter 5).

4.1 Water Quality Guidelines

The Queensland Water Quality Guidelines (2009) have established water quality targets for some areas of Queensland. Where these site-specific targets do not exist, the ANZECC/ARMCANZ (2000) Guidelines are used as a general target based on regions throughout the state. Both the ANZECC/ARMCANZ Guidelines and Queensland Water Quality Guidelines were established mainly for flowing waters within streams, estuaries and marine waters, or standing water bodies within wetlands and lakes. Given that ephemeral and intermittent water bodies experience natural seasonal changes in chemical and physical status, an accurate comparison of sampling data to the relevant national and state water quality guidelines, which are based on permanent and flowing waters, is not possible.

4.2 Environmental Values

Environmental Values (EVs) are the qualities of waterways that need to be protected from the effects of pollution, waste discharges and deposits to ensure healthy aquatic ecosystems and waterways that are safe and suitable for community use (DERM, 2008). These range from the maintenance and protection of healthy aquatic ecosystems, health and safety, commercial and cultural heritage values.

Environmental Protection (Water) Policy 2009 (EPP Water) was established to achieve the objectives of the *Environmental Protection Act 1994* (EP Act) in relation to Queensland waters and provides the framework for establishing EVs and Water Quality Objectives (WQOs) for Queensland waters. Table 4.1 provides the EVs scheduled under EPP Water and the respective EVs applicable to Port Curtis.

Table 4.1 EPP Water Environmental Values

EPP Water EVs	Port Curtis EVs
Aquatic ecosystems	Local – aquatic ecosystems within Port Curtis. Regional – GBRMP.
Aquaculture use	Commercial fishing.
Primary recreation	Swimming, water sports and recreational fishing
Secondary recreation	Wading, boating.
Drinking water	NA
Industrial purposes	LNG facility site water usage, cooling water for other industries, export of resources from Central Queensland.

EPP Water EVs	Port Curtis EVs
Cultural and spiritual values	Cultural significance of Port Curtis and Graham Creek, Indigenous Traditional Owners (Gurang, Gooreng Gooreng and Bailai).

Furthermore, no additional environmental values have been established for the Port Curtis area within the Queensland Water Quality Guidelines (2009).

4.3 Receiving Environment Monitoring Program

The Port Curtis Integrated Monitoring Program (PCIMP) is an existing program that aims to assess the ongoing health of the Port Curtis region, and manage the area to either maintain or improve ecosystem health. Australia Pacific LNG is a contributing member of PCIMP. The PCIMP establishes ecosystem health guidelines for water chemistry, bio-available metals in water and Polycyclic Aromatic Hydrocarbons (PAHs) in sediments which have been derived from the ANZECC / ARMCANZ (2000) guidelines. Australia Pacific LNG will continue to work collaboratively with PCIMP for the monitoring of cumulative impacts to water quality. PCIMP was officially launched in 2005 and currently monitors four themes:

- Water Quality (including bio-monitoring)
- Intertidal Monitoring
- Seagrass Health
- Oil Spill Assessment.

The annual PCIMP Report Card provides an overall rating of the environmental health within Port Curtis, based on the above four themes. The PCIMP divides Port Curtis into nine separate zones. Zone Two – Inner Harbour Fisherman's includes Port Curtis and Graham Creek.

The monitoring of water quality in Port Curtis is discussed in Volume 4, Chapter 11.

5. Proposed water management

The investigation to determine the appropriate water source and treatment requirements for the proposed LNG facility (Bechtel 2009b) concluded that stormwater runoff could not feasibly meet all the water demands of the LNG facility are due to:

- Extreme seasonal variability of rainfall.
- Large storage facilities being required to capture adequate run-off.
- High probability that the reliable yield of the system would not be sufficient to satisfy the demands of LNG facility.

Therefore, it is proposed that a desalination plant with a capacity of 40kL/hr (0.96ML/day) will be constructed with water feed from Port Curtis to provide a supplementary supply of water required during construction and operations with additional water drawn from the stormwater drainage sediment basin and hydrotest pond, following appropriate pre-treatment.

As stated in Section 3.2, the estimated average annual volume of runoff from the local creek catchment is approximately 400ML/yr and is effectively concentrated to the period between December and March, with negligible stream flow during the remaining months.

The estimated LNG facility demand for water during the operational period is approximately 1.3ML/day at the maximum LNG facility production of 18Mtpa. Therefore, it will be necessary to obtain 0.34ML/day from stored stormwater runoff in order to satisfy the shortfall between desalination plant capacity and forecast demand at maximum LNG facility operation.

5.1 Construction

Separate desalination plants will be provided either by rental or construction to supply all water requirements during the construction phase. Water will be drawn from the desalinated water and treated further for potable consumption. Initially, potable water for drinking will be transported to the site until the desalination plant becomes operational.

The estimated potable and service water requirements during the construction period are set-out in Table 5.1.

Table 5.1 Estimated total water demand for construction

Demand	Total (kL)	Peak rate (kL/hr)
Hydrotest water	160,000	
LNG facility concrete work	31,500	
Site preparation/dust control/wash down	6,000	
Potable water	433,000	1 to35

Source: Bechtel 2009a

Potable water will be sourced from the desalination plant after pH adjustment, sodium hypochlorite dosing (to control microbial growth) and Ultra-Violet disinfection has been undertaken. Furthermore, demineralised water will be sourced from the desalination plant after further processing through brackish water RO and electrodeionisation units.

Hydrotest water will be sourced from on-site stormwater and desalination water and will be treated to comply with the quality requirements of American Petroleum Institute (API) 620, which state:

- Water will be substantially clean and clear.
- Water will have no objectionable odour (that is, no hydrogen sulfide).
- Water pH will be 6 to 8.3.
- Water temperature will be below 49ºC.
- For austenitic stainless steel tanks, the chloride content of water will be below 50ppm.
- For aluminium tanks, the mercury content of the water will be less than 0.005ppm and the copper content will be less than 0.02ppm.
- If the water quality outlined above cannot be achieved, use suitable inhibitors as agreed by tank supplier and buyer.

Utility water and fire water will be sourced from the desalination plant product water after pH adjustment and sodium hypochlorite dosing (to control microbial growth) stored in the hydrotest pond. For the most part, this water will be used onsite for irrigation and dust suppression purposes.

The water to be used for hydrotest water and flushing water will be routed to the hydrotest pond and re-used for future testing purposes. The peak demand (flowrate) for water is for the hydrotesting, where water will be required to fill the LNG storage tank over a period of approximately 30 days to ensure its integrity.

5.2 Operations

The projected water demands for the LNG facility for the operational phase are set out in Table 5.2.

Table 5.2 Projected water demand (kL/hr)

LNG facility capacity	9Mtpa (two-trains)	18Mtpa (four-trains)
Treated water	0.80	1.6
Potable water	8.30	13.3
Laboratory use	1.20	2.4
Clinical use	1.00	2.0
Demineralised water	13.34	26.7
Safety showers	3.00	6.0
Fire water flush	0.80	1.6
Total water demand	28.50	53.6

Source: Bechtel 2009a

The estimated LNG facility demand for water during the operational period is approximately 1.3ML/day at the maximum LNG facility production of 18Mtpa. Therefore, it will be necessary to obtain 0.34ML/day from stored stormwater runoff in order to satisfy the shortfall between desalination plant capacity and forecast demand at maximum LNG facility operation.

Process wastewater and contaminated stormwater run-off from the plant process areas will be routed to the coalescing plate interceptors (CPI) separator for treatment. The effluent from the CPI separator will pass through a Dissolved Air Flotation (DAF) unit and tertiary filter and be mixed with treated sewage effluent and disposed by irrigation.

Sewage will be conveyed by gravity sewers and rising mains to the extended aeration activated sludge sewage treatment plant. The effluent from the sewage treatment plant will be further processed in tertiary filters and disinfected with chlorine and disposed by irrigation. The predicted treated sewage effluent characteristics are set-out in Table 5.3. The digested sewage sludge will be transported by a licensed contractor for off-site disposal at a licensed waste management facility on the mainland.

Table 5.3 Predicted sewage treatment plant effluent quality

Parameter	Concentration
pH	6.5 - 7.5
BOD_5	10 - 20 mg/L
Oil	5 - 10 mg/L
Total nitrogen	4 mg/L as N
Total kjeldahl nitrogen	1 – 4 mg/L
Ammonia nitrogen	1 - 4 mg/L
Total phosphorus	1 mg/L
Chlorine	1 - 2 mg/L
TDS	250 mg/L

Source: Bechtel 2009b

It is estimated that the maximum volume of effluent to be irrigated during the LNG facility operations period will be approximately 84kL/d (Bechtel 2009b) based on an average facility population of 150 persons, including visitors and transient workers and a maximum population of 250 persons. A minimum irrigation disposal area of 5ha would be required, based on an application rate of 3mm/day, equivalent to the minimum monthly average evaporation rate. A suitable disposal area could be developed on the northern side of the LNG facility where the saddle between the hills is to be filled and re-profiled. A sewage effluent holding pond having a minimum storage capacity of 4,800kL would be required to store effluent over the wet season, when irrigation is not possible due to saturated soil conditions.

Prior to the camp becoming operational, sewage will be transported back to the mainland for suitable disposal into the existing waste water infrastructure. Package sewage treatment facilities are proposed for the site, following the establishment of the construction camp.

The estimated total volume of sewage generated during the construction period is 412,700kL and the estimated maximum daily volume of sewage generated during the construction period is approximately 550kL/day.

It is anticipated that some of the treated sewage effluent will be disposed by irrigation and used for dust suppression during the construction period, with the balance of the effluent to be discharged to Port Curtis with the desalination plant reject water via the seawater outfall diffuser system.

5.3 Water balance

A water balance simulation has been undertaken in order to assess the reliability of the stormwater runoff from the LNG facility site as a supplementary source of supply for the operation period. The simulation was undertaken using the composite rainfall records for Gladstone Post Office and Radar Hill rainfall stations for the period 1889 to 2008.

The results of the water balance calculations indicated that the average volume of runoff from the LNG facility site into the hydrotest basin is approximately 450ML/year, of which approximately 30ML/year is lost as evaporation and the balance that is not extracted for use overflows from the pond. The water balance results are summarised in Table 5.4.

Table 5.4 Water balance results

Demand		Supply	Reliability		Overflows
kL/day	ML/yr	ML/yr	%	Days/yr	ML/yr
250	91.25	90.9	99	363	353
375	136.88	135.9	99	362	309
500	182.5	180.2	99	360	265
750	273.75	256.1	94	341	191
1000	365.0	305.0	84	305	144
1250	456.25	332.6	73	266	118
1500	547.5	349.9	64	233	101

The water balance calculations indicate that the 340kL/d estimated shortfall between desalination plant capacity and LNG facility demand at maximum output should be able to be supplied from captured stormwater runoff with 99% reliability. The calculations confirmed that it is unlikely that a stormwater runoff will provide an adequate source of supply to meet all the LNG facility operation requirements.

6. Stormwater management

6.1 Proposed drainage strategy

The LNG facility is to be constructed in stages and will extend across an area of approximately 159ha. It is proposed that the tidal flats be filled to 6mAHD and a number of benches be constructed between 8mAHD and 35mAHD, as illustrated within the bulk earthworks plan presented on Figure 6.1. The proposed development will result in significant changes to the local drainage through and adjoining the LNG facility site.

The proposed reclamation and filling of the tidal flats will provide a building platform for the LNG facility that is located above peak water levels for flooding resulting from local catchment runoff and inundation under normal tidal conditions as well as ocean storm surge events. As stated in Section 3.5, the site is considered to have a low exposure to tsunami hazards, with the result that the maximum water levels on the tidal flats due to ocean inundation are expected to result from major ocean storm surge events.

The estimated peak water level in the 100 years ARI storm surge event is 3.326mAHD, which is approximately 0.9m above the estimated 100 years ARI flood level for local catchment runoff. Therefore, the LNG facility will be located with greater than 2.5m freeboard above the estimated highest 100 years ARI water level.

Runoff from the hills to the south-east of the LNG facility site will be diverted around the southern side of the site and discharged to Port Curtis approximately 600m to the south of the mangrove flats. Run-off from the slopes along the northern side of the LNG facility will be diverted along the northern boundary of the site and discharged approximately 300m to the north of the mangrove flats. The proposed drainage strategy for the developed site is illustrated on Figure 6.2.

All runoff from the LNG facility is to be conveyed by shallow drains to the hydrotest pond or sediment basin in order to reduce the suspended sediments prior to discharge from the site. The proposed drainage layout will divide the LNG facility into two drainage catchments that will be further subdivided into sub-areas based on drainage layout and the constructed landform.

Run-off from the LNG train and storage tank areas and from the southern sector of the facility is to be directed to the hydrotest pond via constructed drainage lines, which will have an outlet that discharges to the mangrove area at the entrance to the existing drainage line. The outlet from the hydrotest pond will be designed and constructed to minimise the potential for high velocity flows and resultant erosion or damage to vegetation in the mangrove area.

Runoff from the administration and maintenance facilities areas, and the construction camp area at the eastern end of the site is to be directed to a smaller sediment basin prior to discharge to the southern bypass channel.

The minimum volumes required for the hydrotest pond and sediment basin were calculated to be 6900m^3 and 6700m^3 respectively, based on the Brisbane City Council guidelines for Type C basins as the suspended sediment is expected to be gravelly silts with some clays, as described in Volume 4 Chapter 5 Soil, geology and topography assessment.

The BCC guidelines recommend a minimum settling zone depth of 0.6m and sediment storage volume equal to the settling volume and a minimum length to width ratio of three.

Figure 6.1 Bulk earthworks

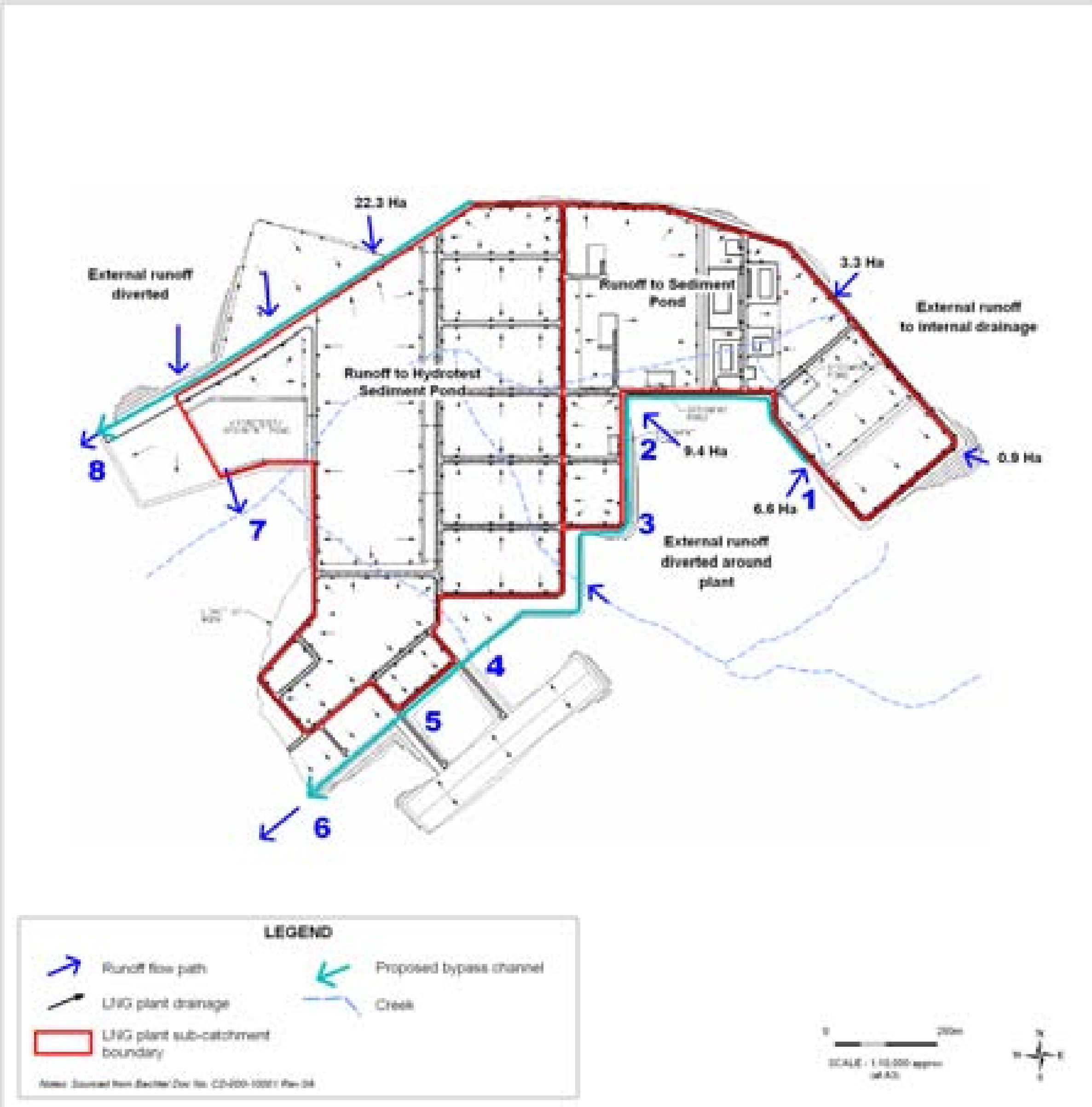

Figure 6.2 Proposed drainage

The initial hydrotest pond design had a total volume of 160,000m^3 and a maximum depth of approximately 3.75m which is significantly larger than the required volume for sedimentation of suspended solids. It is understood that the volume of the hydrotest pond is now likely to be 100,000m^3, based on hydrotest water requirements.

The sediment basins are to capture the first 25mm of runoff for sediment removal, yielding a total volume of 41,100m^3 or more than 3 times the minimum volume required by the BCC guidelines.

6.2 Stormwater flows

Storm run-off flows for base case were calculated using the RAFTS hydrologic model for the 100 years ARI design storm events to determine the outlet capacities for the two sediment ponds and design flows for the bypass channel.

The RAFTS model comprised 48 sub-areas representing the proposed drainage sub-catchments as presented within the conceptual drainage plan presented on Figure 6.2. An initial loss of 25mm and continuing loss of 2.5mm/hr were adopted for the pervious areas as for the existing conditions modelling undertaken previously, with an initial loss of 1mm and zero continuing loss for the impervious areas.

The impervious area fraction was assumed to be 80% over the bulk of the LNG facility site except for the large open areas near the hydrotest pond and at the northern end of the LNG storage tanks for which 10% impervious area fraction was adopted for roadways and minor paved areas.

The RAFTS model peak flows generally occur at durations between 30 minutes and 90 minutes, depending upon the catchment area above the location of interest. The peak flows at selected locations along the bypass channel and at selected culvert sites within the LNG facility indicated on Figure 6.2 are listed in Table 6.1.

Table 6.1 Post-development peak flows 100 years ARI

ID	Location	Peak flow (m^3/s)
1	Upstream of site	3.29
2	Top of bypass channel	16.18
3	Bypass channel at power plant	17.91
4	Upstream of Flare #2 access road	35.14
5	Upstream of Flare #1 access road	37.15
6	South bypass channel outlet	37.27
7	Hydrotest pond outlet	10.76
8	North bypass channel outlet	7.96

The RAFTS model results for post-development conditions are summarised in Appendix B.

The hydrotest pond has the potential to reduce the peak flow discharged to the mangroves due to the large volume of the pond, depending on the design of the outlet works. The flow attenuation through the pond will be minimised if the water level in the pond is maintained at maximum storage for water supply purposes, as discussed in Section 5.3.

As the site is located at the outlet of the local drainage catchment with no properties downstream, there is no requirement to maintain existing peak flows for runoff discharged from the site. The primary function of the sediment basins will be the reduction in suspended solids, with the result that only minor reductions of peak flows will be achieved.

6.3 Bypass channels

As stated above, run-off from the hills to the east of the LNG facility site is to be diverted around the southern side of the site and discharged to Port Curtis approximately 600m to the south of the mangrove flats. Drainage of the northern hillside adjoining the LNG facility is to be diverted along the northern boundary of the site and discharged approximately 300m to the north of the mangrove flats.

The preliminary design for the southern bypass channel comprises a trapezoidal cross-section, having a minimum longitudinal slope of 0.4% with 1:3 sideslopes and minimum depth of 1.5m with a 15m wide invert from the confluence with the existing creek near the south-east corner of the site through to the outlet and a 10m-wide invert upstream of the existing drainage line.

The hydraulic performance of the bypass drain was assessed using HEC-RAS modelling with variable peak flows along the drain determined using the RAFTS model. The HEC-RAS model included 5 cells 3000mm x1500mm box culverts under the access roads to the ground flares. The maximum depth of flow was calculated to be 1.5m immediately upstream of the culvert under the downstream flare access road.

The HEC-RAS model results for the southern bypass drain are summarised in Appendix C.

The northern bypass channel will convey run-off from the hillsides and batter slope adjoining the LNG facility site. The preliminary design for the northern bypass channel comprises a trapezoidal cross-section having a 5m wide invert with 1:3 sideslopes and minimum depth of 1.5m, with a minimum longitudinal slope of 0.4%. The maximum depth of flow was calculated to be 1.15m.

The outlets on the bypass channels are to be located above HAT level at 3.0mAHD in order to prevent mangrove intrusion into the lowest sections. The outlets are to include rock energy dissipation works to prevent scour and erosion downstream of the outlets. The conceptual design for the outlets is illustrated on Figure 6.3 which has been extracted from Brisbane City Council (BCC) creek erosion control guidelines (BCC 2004).

The BCC guidelines have been derived from a design developed by McLaughlin Water Engineers Ltd for the Denver, Colorado, Urban Drainage and Flood Control District in 1986, which have been used throughout the world since that date.

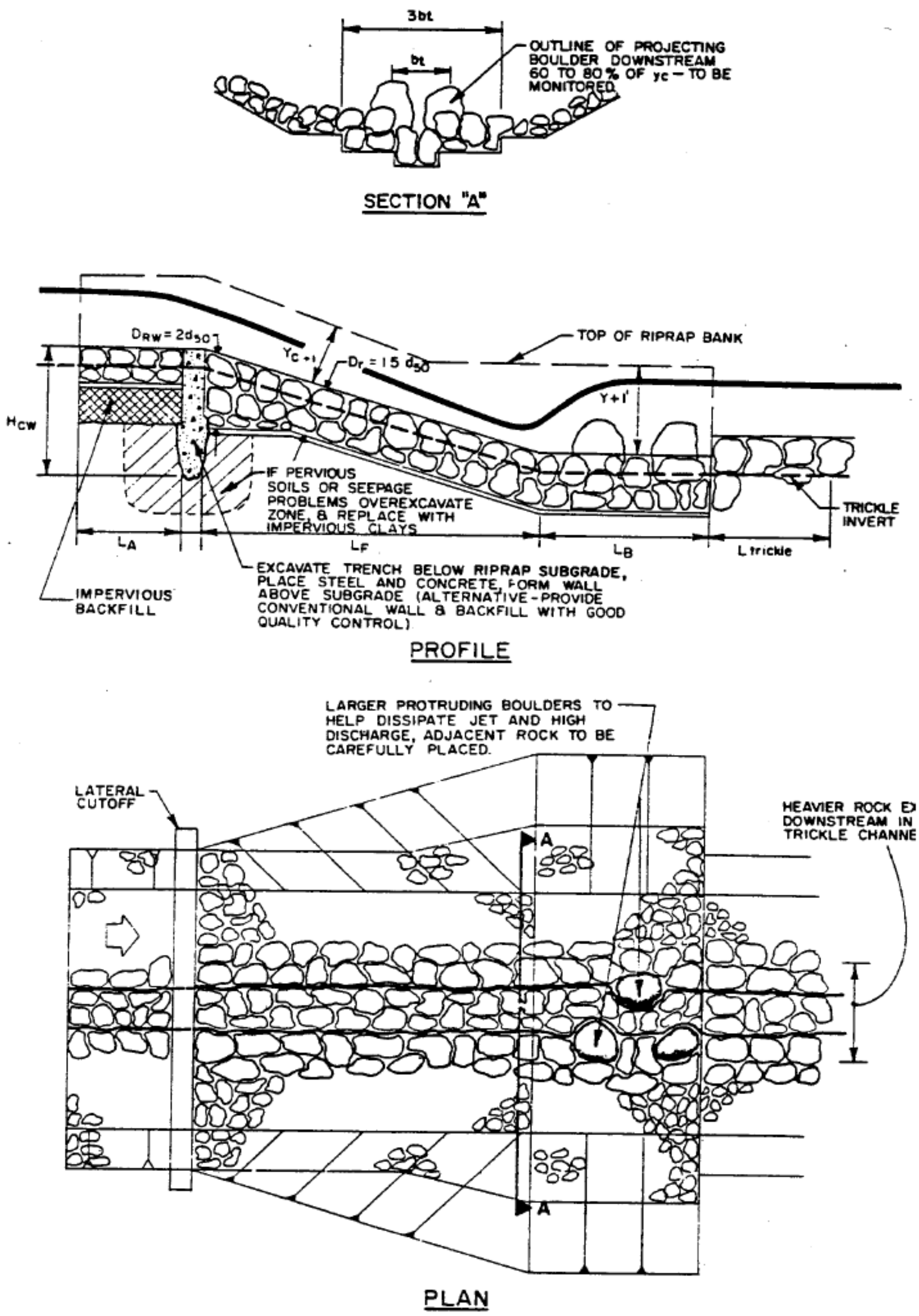

Figure 6.3 Conceptual design of diversion channel outlets

6.4 Climate extremes

As stated in Section 6.2, the spillways on the hydrotest pond and sediment basin will be designed to discharge the runoff from the 100 years ARI design storm events without overtopping. The 100 years ARI design event is not the largest event that is likely to occur and could be exceeded as a result of climatic changes, including potential Global Warming resultant increases in rainfall intensities, or by the occurrence of very large and rare storm events that result from significantly greater rainfall than the adopted 100 years ARI design event.

The embankments for the hydrotest pond and sediment basin will be designed with a minimum freeboard of 300mm above the 100 years ARI design water level and to withstand overtopping.

There are no properties downstream of the LNG facility so the hazard associated with a catastrophic failure of the embankments is classified 'low'. Therefore, a dambreak failure assessment has not been undertaken.

6.5 Stormwater quality management

6.5.1 Water Quality Objectives

The Queensland Water Quality Guidelines (2009) have established water quality targets for some areas of Queensland. Where these site-specific targets do not exist, the ANZECC/ARMCANZ (2000) Guidelines are used as a general target based on regions throughout the state. Both the ANZECC/ARMCANZ Guidelines and Queensland Water Quality Guidelines were established mainly for flowing waters within streams, estuaries and marine waters, or standing water bodies within wetlands and lakes.

Environmental Protection (Water) Policy 2009 (EPP Water) was established under the EP Act, to achieve water quality objectives and environmental values for Queensland waters. For the Port Curtis area, the WQO are listed in Table 6.2. The listed parameters are water quality parameters for receiving waterways.

Table 6.2 Ecosystem Health Guidelines (from Storey *et al.*, 2007)

Indicator	Ecosystem Health Guideline
pH	7.0 – 8.5
DO (%)	80
Turbidity NTU	20
Total N (g/L)	250
Total P (g/L)	20
Aluminium (g/L)	1.5
Copper (g/L)	0.3
Cobalt (g/L)	0.07
Cadmium (g/L)	0.7
Lead (g/L)	2.2
Chromium III (g/L)	7.7
Manganese (g/L)	2.9
Nickel (g/L)	7.0

The Healthy Waterways Water Sensitive Urban Design (WSUD) Technical Guidelines (2009) notes that many regions around Australia are adopting load-based objectives instead of concentration-based objectives because of the ongoing issues that many areas have found with using concentration-based receiving water targets as discharge criteria. The objectives adopted by Healthy Waterways for south-east Queensland are:

- 80% reduction in total suspended solids load
- 60% reduction in total phosphorus load
- 45% reduction on total nitrogen load, and
- 90% reduction in gross pollutant load.

The objective of the stormwater quality management strategies developed for the proposed LNG facility is the compliance with the load reduction targets recommended in the Healthy Waterways guidelines in recognition of the ongoing issues that many areas have found with using concentration-based receiving water targets as discharge criteria.

The water quality within Port Curtis has been discussed in the Marine Ecology technical report included in Volume 4, Chapter 10.

6.5.2 Construction period

There will be high erosion potential during the construction period during rain events due to the removal of vegetation and associated earthworks. There is also the potential release of contaminants that may be attached to the soils that enter drainage lines and subsequently flow into Port Curtis. The capture of sediment laden water within the sediment control devices, and ultimately the settlement basins, will mitigate potential impacts to water quality in Port Curtis.

It is proposed to construct the sediment basin and hydrotest pond and internal swale drains during the initial bulk earthworks activities. All runoff from the site during the construction period will be directed to the sediment basin and hydrotest pond via the swale drains in order to minimise the sediment load in run-off discharged from the site.

An Erosion and Sediment Control Plan (ESCP) will be prepared in accordance with relevant guidelines (Engineers Australia, 1996) for the construction period. The ESCP will include additional temporary sediment control devices including the installation of silt fences, vegetated buffer strips and diversion bunds, as appropriate.

Earthworks may have the potential to disturb acid sulfate soils (ASS) which could impact the pH of waters in the receiving environment. Detailed acid sulphate and geotechnical investigations will be undertaken to determine the level of risk and ASS and leachate management required. General information regarding ASS and leachate management is discussed in Volume 4, Chapter XX.

There is also the potential for contaminated stormwater to run-off from fuel/chemical storage areas and plant equipment storage areas if located near drainage lines. Appropriate bunding in accordance with Australian standards will be required around fuel/chemical storage areas to reduce this potential risk.

The hydrotest pond will have a capacity of 160,000m^3 and will initially provide water for testing of the LNG storage tanks during construction. The hydrotest water will be sourced from impounded stormwater run-off supplemented with desalinated seawater. The water in the hydrotest pond will be screened, dosed and treated to make it acceptable for use as hydrotesting water. Following completion of the construction phase, the hydrotest pond will function primarily as a sediment pond.

6.5.3 Operation period

The primary pollutants of concern in stormwater run-off from the LNG facility will be suspended solids and fuels/chemicals. The removal of suspended sediments and fuels/chemicals is to be the focus of the stormwater treatment system for the operational phase.

All drainage swales will be grassed and will include rock check dams to reduce velocity and facilitate sediment deposition. The bulk of the sediment removal will occur in the hydrotest pond and sediment basin which will have been constructed during the initial site clearing and bulk earthworks.

Stormwater that may be contaminated by process chemicals or other hazardous or toxic materials from process areas will be collected in a separate drainage system and directed to a dedicated treatment facility comprising the CPI separator followed by DAF and tertiary filtration and disposal by irrigation. This will remove fuels and oil from stormwater.

It is proposed to connect the sediment basin to the hydrotest pond by pressure main to enable water to be transferred from the sediment basin to the hydrotest pond. The hydrotest pond will also provide a supplementary source of water.

6.6 Stormwater quality modelling

The performance of the proposed stormwater quality management strategy was assessed using the MUSIC (Model for Urban Stormwater Improvement Conceptualisation) stormwater run-off and quality model. MUSIC was developed by the Co-operative Research Centre for Catchment Hydrology (CRCCH 2005) and simulates the hydrologic and water quality performance of stormwater systems at a range of temporal and spatial scales suitable for catchment areas from 1ha up to 100km^2, using time-steps of six minutes up to one day. The modelling is normally undertaken on a continuous simulation basis in order to simulate cumulative pollutant loadings and treatment.

MUSIC comprises a conceptual rainfall-runoff model that is coupled with a pollutant model to generate run-off and pollutant loads. The removal of pollutants through treatment devices is simulated using a range of device-dependent conceptual models.

The MUSIC modelling was undertaken using a time-step of six minutes, with rainfall and evaporation data for Rockhampton for the period 1950-59 Rockhampton rainfall and evaporation were adopted for the modelling as Rockhampton is the nearest station in the MUSIC database. The mean annual rainfall for the Rockhampton simulation period is 999mm and is the closest to the long-term average rainfall at Gladstone of 965mm for the period 1872-2009.

Stormwater quality data for LNG facilities were not available for input to the MUSIC model, therefore, the estimation of stormwater run-off and quality was undertaken using parameters recommended in BCC guidelines (BCC, 2003) for industrial developments and urban residential catchments. Run-off and quality for existing conditions on the site was estimated using BCC parameters for details relating to ‘forest’. The BCC data were considered appropriate and used in this case because it was obtained by monitoring actual stormwater run-off quality and the data have been adopted by numerous Councils throughout Queensland.

The MUSIC model ‘effective impervious area’ and median concentrations of suspended solids (TSS_{50}) and nutrients (TP_{50} and TN_{50}) inputs are summarised in Table 6.3. The complete listing of parameters is included in Appendix E.

The runoff generation in the MUSIC model is highly sensitive to the ‘effective impervious area’ factor adopted for model catchments The BCC guidelines recommend that the ‘effective impervious area’ factor adopted for industrial areas in the MUSIC model is equivalent to 76% of the actual impervious area. Therefore, an ‘effective impervious area’ factor of 61% was adopted for the LNG plant area, based on an estimated actual impervious area fraction of 80%.

Table 6.3 MUSIC Model Parameters

Parameter	LNG facility	Camp	Existing site
Effective Impervious Area (%)	61	30	0
TSS_{50} (log_{10}mg/L) (Storm/Base)	1.92 / 0.78	2.18 / 1.00	1.90 / 0.51
TP_{50} (log_{10}mg/L) (Storm/Base)	-0.59 / -1.11	-0.47 / -0.97	-1.10 / -1.79
TN_{50} (log_{10}mg/L) (Storm/Base)	0.25 / 0.14	0.26 / 0.20	0.075 / -0.59

The predicted stormwater run-off quality determined using the MUSIC model is summarised in Table 6.4.

Table 6.4 Predicted stormwater quality

Location	Parameter	Run-off (ML/yr)	TSS (T/yr)	Total-P (kg/yr)	Total-N (kg/yr)
Hydrotest pond outlet	Generated	489	60.8	160	1070
	Discharged	432	15.1	68.7	654
	Removed	N/A	75%	57%	39%
South bypass channel outlet	Generated	283	39.9	99.4	630
	Discharged	276	5.6	38.3	428
	Removed	N/A	86%	62%	32%
Total site runoff	Generated	772	100.7	259	1700
	Discharged	708	20.7	107	1080
	Removed	N/A	79%	59%	36%

The MUSIC model predicts that the proposed stormwater quality management strategy will provide comparable reductions in suspended solids and total phosphorus pollutant loads to the load reduction targets recommended for south-east Queensland. The Healthy Waterways load reduction targets for south-east Queensland have been derived from similar guidelines developed in other States and it is generally accepted that the targets have been adopted throughout Queensland and hence used for this assessment.

The predicted removal of total nitrogen is less than the recommended target reduction. The nitrogen export loads adopted for the model were based on BCC data for industrial developments and may not be representative of the actual load exported from the LNG facility.

Stormwater run-off from LNG plant process areas will be routed to a treatment process comprising CPI separator followed by DAF and sand filtration prior to disposal by irrigation with the treated sewage effluent. This strategy will prevent fuels and chemicals being discharged to Port Curtis in stormwater runoff.

6.7 Water quality monitoring

Sampling and analysis of water at the outlets from the hydrotest pond and sediment basin will be undertaken during both construction and operation phases. The water quality will be compared to the WQO for the receiving waterways as listed in Table 6.2. In addition, the hydrotest pond and sedimentation basin will be inspected to assess overall condition and visual appearance, colour, turbidity, odour, surface crusts, films or floating material, algae, etc. will be noted. Other relevant observations such as surface rubbish, spills, etc. will also be recorded.

The water quality monitoring will focus on stormwater run-off discharged from the LNG facility site, as recommended below:

- Stormwater collected within the sediment basin and hydrotest pond will be monitored prior to discharge, on a monthly basis during the construction period and within 24 hours of a rainfall event that exceeds 25mm depth of rainfall, to confirm that sediments have settled from within the water column and that the discharged water will not impact significantly on the receiving harbour. Refer to Section 7.4 for the parameters to be monitored and frequency.
- Monitoring of water quality of stormwater run-off and other discharges from the LNG facility during the operational phase will be undertaken prior to discharge, on a quarterly basis during the operational phase and within 24 hours of a rainfall event that exceeds 25mm depth of rainfall, to confirm that sediments have settled from within the water column and that the discharged water will not impact significantly on the receiving harbour. Refer to Section 7.4 for the parameters to be monitored and frequency.
- Stormwater run-off and other discharges into Port Curtis will be monitored through the marine waters monitoring program as outlined in the marine ecology discussion in Volume 4, Chapter 10.

7. Stormwater management plan

The provisions of this site-based stormwater quality management plan are to be incorporated into the Environmental Management Plan (EMPlan) for the LNG facility (Volume 4, Chapter 24).

7.1 Objectives

The key objectives for stormwater quality management are to:

- Restrict soil erosion and mobilisation of sediments and contaminants downstream of the site.
- Minimise contaminants exported from the site in stormwater run-off.
- Ensure stormwater does not adversely impact the aesthetic or environmental values of receiving waters.

7.2 Construction period

The pollutants commonly contained in stormwater discharged from construction sites are listed in Table 7.1.

Table 7.1 Typical contaminants in run-off from construction sites

Pollutant	Sources
Litter	Paper, packaging, , off-cuts
Sediment	Exposed soils and stockpiles
Hydrocarbons	Fuel and oil spills, leaks from construction equipment
Toxic materials	Cement slurry, asphalt prime, solvents, cleaning agents, washdown water
pH altering substances	Acid sulphate soils, cement slurry, washdown water

The management measures to be implemented during the construction period to minimise the export of pollutants from the site include:

- Employees and contractors will undertake a detailed environmental site induction.
- Vehicular access to the site will be limited to authorised vehicles (i.e. regularly maintained and appropriate for local conditions) through a controlled access point.
- Wash down areas will be a sufficient distance from drainage lines.
- Loads will be covered to prevent spillage or wind-borne escape of litter.
- Litter and rubbish will be routinely picked-up and deposited within secure storage bins for disposal by appropriate means.
- Contaminants or other materials will be cleaned-up as quickly as practicable using procedures that prevent contaminants or material being transferred to the stormwater drainage system.
- Chemical storage and handling areas will be bunded and will have drainage lines separate from the stormwater drainage, to reduce the likelihood of chemical contamination of stormwater.

- An ESCP will be prepared in accordance with Soil Erosion and Sediment Control Engineering Guidelines for Queensland Construction Sites (Engineers Australia 1996). The ESCP will include additional temporary sediment control devices including the installation of silt fences, vegetated buffer strips and diversion bunds, as appropriate.
- The stormwater system for the site will be inspected regularly to identify any failures and, if necessary, repairs will be undertaken.
- Trapped sediment will be removed from the erosion and sediment control devises and sediment basins as required and relocated to a stabilised stockpile, either onsite or taken to an appropriately licensed landfill.

7.3 Operation period

Stormwater run-off from the proposed LNG facility may contain suspended solids and fuels/chemicals and minor amounts of nutrients. The proposed stormwater treatment system for the operation period comprises vegetated swales, hydrotest pond and sediment basin to reduce suspended sediments, nutrients and litter/gross solids from stormwater run-off.

Stormwater that may be contaminated by process chemicals or other hazardous or toxic materials from process areas will be collected in a separate drainage system and directed to a dedicated treatment facility. Appropriate bunding in accordance with Australian standards will be constructed around fuel/chemical storage areas to prevent contaminated runoff from entering the stormwater drainage system.

The management measures outlined in Section 6.5.3 will be implemented in order to minimise the export of pollutants in stormwater discharged from the LNG facility.

7.4 Monitoring and maintenance

7.4.1 Monitoring

The quality of stormwater discharged from the hydrotest pond and sediment basin of the LNG facility will be monitored at or near the outlets for the parameters and frequencies as outlined in Table 7.2.

Table 7.2 Monitoring program

Parameters	Release limits	Construction phase monitoring frequency	Operation phase monitoring frequency
pH	7.0 -8.5	Prior to discharge, on a monthly basis during the construction period and within 24 hours of a rainfall event that exceeds 25mm depth of rainfall	Prior to discharge, on a quarterly basis during the operation and within 24 hours of a rainfall event that exceeds 25mm depth of rainfall
Dissolved Oxygen (%)	80		
Turbidity (NTU)	20		
Suspended Solids (mg/L)	30		
Total Nitrogen (µg/L)	250		
Total Phosphorus (µg/L)	20		
Hydrocarbons	No visible sheen		
Observations*	NA	Daily	Daily

*Note: Observations include the recording of the appearance of the sedimentation basin and hydrotest pond, i.e. colour, turbidity, odour, surface crusts, films or floating material, algae, surface rubbish, spills, etc.

Procedures for sampling will be:

- Sampling and analysis to be undertaken in accordance with the procedures detailed in the Water Quality Sampling Manual: 3rd edition 1999 EPA or more recent additions. Special attention will be made to not disturb the sediment when obtaining water samples.
- A suitably qualified person will be responsible for sampling and analysis of parameters released to Port Curtis, using a NATA registered laboratory.
- A suitably qualified person will prepare and forward a quarterly laboratory report to the Project Manager during the construction period and to the LNG facility Site Manager during the operations period.
- The laboratory reports will be kept on-site for a period of no less than 5 years.

7.4.2 Maintenance

Maintenance of the stormwater management structures will take place to minimise impacts to surface water quality and quantity in accordance with the schedule set out in Table 7.3.

Table 7.3 Stormwater maintenance schedule

Structure	Potential issues	Maintenance
Drains and swales	Subsidence, erosion, weeds, litter, sediment build-up	Remove litter and weeds Repair subsidence/erosion areas and reinforce Remove built-up sediment
Sediment basin / hydrotest pond	Structural damage, erosion or leaks	Repair at first indication. If extensive structural repair is required, lower water level within the basin prior to repair works.
	Excessive accumulation of sediment	Remove accumulated sediment and dispose to approved location.

Inspections of the stormwater devices will be carried out weekly and after rainfall events exceeding 25mm, as part of general site inspections. Additionally, the sediment basin will be cleaned of accumulated sediments annually in September, towards the end of the dry season in order to work efficiently during rain periods throughout the wet season.

7.5 Responsibility

During the construction period, the construction contractor will be responsible for monitoring the performance of all stormwater management structures. The construction contractor will report any failures of stormwater management structures to the Project Manager or other contractors responsible for delivering the construction of the LNG facility.

During operations phase the LNG facility's Site Manager will be responsible for monitoring, reporting and corrective action regarding stormwater management structures throughout this period.

7.6 Reporting

The results of the inspection of stormwater management structures undertaken by the environmental officer, are to be reported to the Site Manager and Project Manager for the LNG facility on a regular basis during construction and operation on a monthly basis. Failures and repairs to stormwater devices will be recorded by the site's environmental officer.

The results of the inspection of stormwater discharge (following rain events), will be communicated as soon as practicable to the Site Manager. Monthly reports of environmental issues including stormwater management will be prepared and distributed to the Project Manager and Project Director.

A register will be maintained of the reports and will be kept available for inspection by relevant regulatory agencies.

7.7 Corrective actions

Any failures in the stormwater management devices during major rainfall events will be immediately repaired to prevent uncontrolled discharge, erosion or scour. These failures will necessitate a review of the design and/or replacement of stormwater management devices. The change in devices will be the responsibility of the Site Manager or this person's delegate.

Appropriate remedial work for restoring any disturbed areas on site will be the responsibility of the Site Manager or this person's delegate. For off site remedial work, advice will be sought from DERM, other relevant Stage government agencies, and neighbouring LNG proponents, as required.

In the event of a failure of stormwater management devices, a review will be conducted to assess the efficiency of this Stormwater Management Plan and identify strategies to improve stormwater management.

8. Conclusions and Recommendations

The investigations undertaken to assess the water quantity and quality impacts of the LNG facility included the following:

- An assessment of waterways and water bodies within the LNG facility site area including determining the existing hydrologic and water quality conditions.
- A summary of the LNG facility's water demand and potential sources.
- A review of impacts of proposed development.
- Potential mitigation measures for stormwater flow and quality management during both the construction and operational phases of the LNG facility.
- Water quality management and monitoring requirements.

The proposed site for the LNG facility includes mangroves and tidal flats and timbered hillsides and is traversed by small ephemeral natural drainage lines. The mangroves and tidal flats and corridors 60-180m wide along the natural drainage lines are prone to inundation in the 100 years ARI design flood event. It is proposed to fill the tidal flats and to construct a number of benches on the hillsides in order to provide flood-free platforms for the LNG facility and ancillary facilities.

The proposed site development will result in significant changes in the local drainage through and adjoining the LNG facility site. Run-off from the hills east the LNG facility site is to be diverted around the southern side of the LNG facility, with run-off from the slopes along the northern side of the LNG facility being diverted along the northern boundary of the site.

Run-off from within the LNG facility extent is to be collected and conveyed to a sediment basin and hydrotest pond via a network of shallow swale drains and connecting culverts. Based on the MUSIC modelling, the swale drains, sediment basin and hydrotest pond are predicted to remove 80% of suspended solids, 59% of total phosphorus and 33% of total nitrogen from run-off discharged to Port Curtis from the LNG facility development. A CPI separator will remove fuels and oils from the stormwater to be treated. The predicted removal rates of pollutants from storm run-off are comparable to the load reduction targets recommended for south-east Queensland by Health Waterway, 2006.

To manage the stormwater on site, a site-based stormwater management plan has been prepared as part of this study. The stormwater management plan outlines objectives, key pollutant risks, management actions, monitoring requirements, corrective actions and responsibilities.

The water balance calculations indicate that the 360kL/d estimated shortfall between desalination plant capacity and LNG facility demand at maximum output should be able to be supplied from captured stormwater runoff with 100% reliability. The calculations confirmed that it is unlikely that a stormwater runoff will provide an adequate source of supply to meet all the LNG facility operation requirements.

Water required for potable use, LNG facility operation, fire fighting and other utility purposes will be sourced from the desalination plant with supplementary supply from stormwater runoff stored in the hydrotest pond.

References

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Appendix A Design Rainfall Data, Curtis Island

Intensity Frequency Duration Design Rainfall Data for Curtis Island

Duration (mins)	1 Year ARI (mm/hour)	2 Year ARI (mm/hour)	5 Year ARI (mm/hour)	10 Year ARI (mm/hour)	20 Year ARI (mm/hour)	50 Year ARI (mm/hour)	100 Year ARI (mm/hour)
5	110.00	143.00	184.00	210.00	244	291	328
6	103.00	134.00	173.00	197.00	230	274	309
10	85.30	110.00	142.00	162.00	189	225	253
20	63.50	82.00	105.00	119.00	138	163	183
30	52.10	67.20	85.80	97.10	112	133	150
60	35.40	45.70	58.60	66.50	77.2	91.7	103
120	22.90	29.70	38.50	44.00	51.4	61.4	69.3
180	17.40	22.70	29.70	34.20	40.1	48.1	54.6
360	10.90	14.30	19.10	22.20	26.2	31.8	36.3
720	6.84	9.08	12.40	14.60	17.5	21.6	24.9
1440	4.36	5.87	8.33	10.00	12.2	15.3	17.8
2880	2.74	3.75	5.57	6.85	8.51	10.9	13
4320	2.02	2.78	4.25	5.30	6.68	8.71	10.4

Appendix B RAFTS Model Results Summary

RAFTS Results for 100 year ARI - Existing Case								
NODE	Maximum Flow	Critical Duration	30 mins	45 mins	60 mins	90 mins	120 mins	180 mins
	(m3/s)		(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)
E1	6.61	90 mins	4.6	5.8	6.3	6.6	6.4	6.0
E2	13.17	90 mins	8.9	11.4	12.7	13.2	12.9	12.2
E3	6.08	120 mins	3.7	5.1	5.7	6.1	6.1	5.7
D4	19.18	90 mins	12.5	16.0	18.1	19.2	19.0	17.9
F3	6.21	120 mins	3.3	4.5	5.3	6.1	6.2	6.0
F1	3.14	120 mins	2.0	2.6	2.9	3.1	3.1	3.0
F2	3.38	90 mins	2.7	3.1	3.4	3.4	3.2	3.1
D1	6.23	90 mins	4.7	5.6	6.1	6.2	6.0	5.7
D2	31.44	90 mins	20.3	25.8	29.4	31.4	31.1	29.5
E4	5.29	90 mins	3.4	4.5	5.0	5.3	5.3	5.0
F4	9.23	120 mins	4.0	5.6	6.9	8.6	9.2	9.2
D3	44.23	120 mins	26.3	33.4	38.5	43.0	44.2	42.8
F5	8.30	120 mins	4.2	5.7	7.0	8.1	8.3	8.1
Out	47.42	120 mins	29.3	36.9	42.5	48.3	50.7	49.7

RAFTS Results for 100 year ARI – Post-development Case

			100 Years	100 Years	100 Years	100 Years	100 Years	100 Years
NODE	**Maximum Flow**	**Critical Duration**	**30 mins**	**45 mins**	**60 mins**	**90 mins**	**120 mins**	**180 mins**
	(m3/s)		(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)
forest-4	7.96	60 mins	6.48	7.09	7.96	7.84	7.45	6.83
nth-out	7.76	60 mins	6.32	6.97	7.76	7.62	7.26	6.59
lng-4	3.80	30 mins	3.80	3.52	3.71	2.94	2.83	1.98
lng-5	6.67	30 mins	6.67	5.77	6.32	4.98	4.74	3.92
open-1	7.68	30 mins	7.68	7.17	7.65	6.26	5.94	5.13
tanks-1	8.45	60 mins	7.53	7.87	8.45	7.89	7.63	6.75
lng-3	3.80	30 mins	3.80	3.52	3.71	2.94	2.83	1.98
lng-2	6.67	30 mins	6.67	5.77	6.32	4.98	4.74	3.92
lng-1	8.40	60 mins	8.28	7.67	8.40	6.74	6.36	5.64
boil	1.42	30 mins	1.42	1.33	1.40	1.13	1.10	0.73
fridge	0.79	30 mins	0.79	0.74	0.78	0.63	0.61	0.41
propane	7.22	60 mins	6.29	6.60	7.22	6.88	6.44	5.74
jct-5	14.20	60 mins	12.80	13.06	14.20	12.76	12.26	10.54
tanks-2	14.35	60 mins	12.18	13.64	14.35	13.72	13.34	12.69
tanks	22.61	60 mins	19.71	21.31	22.61	21.46	20.77	19.19
open-2	4.77	60 mins	4.60	3.89	4.77	3.97	3.79	2.83

NODE	Maximum Flow	Critical Duration	100 Years 30 mins	100 Years 45 mins	100 Years 60 mins	100 Years 90 mins	100 Years 120 mins	100 Years 180 mins
hydro	24.48	60 mins	21.53	23.23	24.48	23.98	22.95	22.02
port	6.77	30 mins	6.77	6.33	6.68	5.38	5.19	3.52
man-out	13.54	120 mins	7.19	8.98	11.25	13.32	13.54	13.33
forest-3	3.29	60 mins	2.85	2.83	3.29	2.87	2.71	2.42
forest-1	0.52	60 mins	0.45	0.44	0.52	0.41	0.39	0.35
camp-1	3.64	60 mins	3.58	3.21	3.64	2.95	2.83	2.08
camp-2	5.04	30 mins	5.04	4.43	4.86	3.96	3.71	3.25
mtce-2	3.18	30 mins	3.18	2.95	3.12	2.49	2.40	1.65
mtce-1	5.46	30 mins	5.46	5.08	5.37	4.30	4.15	2.84
forest-2	1.44	60 mins	1.21	1.25	1.44	1.36	1.27	1.14
camp-4	5.75	60 mins	4.96	5.12	5.75	5.33	4.93	4.58
camp-3	10.76	60 mins	9.87	9.59	10.76	10.12	9.46	8.60
sed-1	10.76	60 mins	9.87	9.59	10.76	10.12	9.46	8.60
jct-0	12.23	60 mins	10.07	10.84	12.23	12.01	11.37	10.38
forest-5	3.96	60 mins	3.36	3.51	3.96	3.77	3.53	3.15
temp	8.99	30 mins	8.99	8.20	8.59	6.75	6.48	4.74
sed-2	8.99	30 mins	8.99	8.20	8.59	6.75	6.48	4.74
jct-1	16.18	90 mins	13.01	14.79	16.06	16.18	15.62	15.35

			100 Years	100 Years	100 Years	100 Years	100 Years	100 Years
NODE	Maximum Flow	Critical Duration	30 mins	45 mins	60 mins	90 mins	120 mins	180 mins
meter	2.75	30 mins	2.75	2.56	2.70	2.16	2.09	1.43
sub	1.82	30 mins	1.82	1.71	1.80	1.45	1.40	0.94
utility	4.95	30 mins	4.95	4.36	4.81	3.93	3.72	3.14
sed-3	4.95	30 mins	4.95	4.36	4.81	3.93	3.72	3.14
jct-2	17.91	90 mins	13.85	16.21	17.55	17.91	17.20	16.63
E1	6.61	90 mins	4.55	5.77	6.33	6.61	6.43	6.03
E2	13.17	90 mins	8.92	11.43	12.66	13.17	12.94	12.16
forest-6	35.14	90 mins	25.85	31.05	34.10	35.14	33.98	32.80
flares-1	1.82	30 mins	1.82	1.71	1.80	1.45	1.40	0.94
open-3	36.07	90 mins	26.18	31.59	34.93	36.07	35.05	33.75
flares-2	1.86	30 mins	1.86	1.74	1.84	1.48	1.43	0.97
forest-7	37.15	90 mins	26.65	32.23	35.89	37.15	36.21	34.83
batter	37.27	90 mins	26.57	32.18	35.92	37.27	36.35	34.93
sth-out	37.27	90 mins	26.56	32.18	35.93	37.27	36.34	34.93
total	54.80	90 mins	37.44	45.48	51.68	54.80	53.89	51.55

Appendix C HEC-RAS Model Results

HEC-RAS Results (100 Year ARI – Existing Case)

Cross Section ID	Flow	Creek Invert Level	Flood Level	Velocity
	(m^3/s)	(mAHD)	(mAHD)	(m/s)
C446	5.3	3.60	4.47	0.1
C358	5.3	3.98	4.45	0.1
C268	5.3	3.98	4.40	0.2
C169	5.3	3.98	4.21	0.3
C93	5.3	2.98	3.12	1.1
C46	5.3	1.99	2.49	0.3
B768	13.2	14.66	15.04	1.1
B706	13.2	13.80	14.25	0.5
B647	13.2	13.09	13.41	1.1
B554	13.2	11.93	12.69	0.4
B483	13.2	11.93	12.19	0.8
B405	16.2	10.89	11.33	0.5
B305	16.2	9.62	9.87	0.9
B233	16.2	8.19	8.62	0.5
B153	16.2	7.24	7.58	0.6
B44	19.2	5.97	6.48	0.5
B-30	19.2	4.59	4.95	1.5
B-106	19.2	3.80	4.38	0.4
A1915	3.1	14.56	15.12	0.8
A1846	6.2	12.94	13.99	0.4
A1780	6.2	11.93	12.82	1.0
A1693	6.2	10.94	11.84	0.7
A1646	6.2	10.94	11.16	0.6
A1571	6.2	9.94	10.22	0.4
A1501	6.2	8.79	8.97	1.0
A1403	6.2	7.17	7.49	0.3
A1314	6.2	5.91	6.05	0.9
A1237	6.2	3.00	4.15	0.7

Cross Section ID	Flow	Creek Invert Level	Flood Level	Velocity
	(m^3/s)	(mAHD)	(mAHD)	(m/s)
A1180	6.2	2.57	4.08	0.3
A1055	31.4	2.38	2.65	1.5
A933	31.4	1.99	2.52	0.3
A852	31.4	1.99	2.50	0.3
A726	36.1	1.99	2.47	0.2
A598	36.1	1.99	2.46	0.2
A474	44.2	1.63	2.44	0.2
A347	44.2	1.23	2.43	0.1
A231	47.4	0.48	2.42	0.1
A139	47.4	0.00	2.42	0.1
A39	47.4	0.00	2.42	0.1

HEC-RAS Results (100 Year ARI – South Bypass Channel Post-development Case)

Distance from Outlet	Flow	Creek Invert Level	Flood Level	Velocity
(m)	(m^3/s)	(mAHD)	(mAHD)	(m/s)
1960	3.30	23.20	23.92	1.13
1840	3.30	18.40	19.36	0.57
1800	12.20	16.80	18.05	2.50
1780	12.20	16.00	17.04	1.79
1480	16.20	8.92	10.01	1.12
1430	16.20	8.72	9.82	1.11
1300	17.90	8.20	9.34	1.17
1110	17.90	7.44	8.59	1.16
1000	17.90	7.00	8.17	1.13
820	17.90	6.28	7.69	0.89
810	35.10	6.24	7.61	1.35
660	35.10	5.64	7.02	1.33
490	36.10	4.96	6.42	1.28
Culvert #2				
460	36.10	4.80	6.23	1.31
290	37.20	4.12	5.75	1.15
Culvert #1				
260	37.30	4.04	5.45	1.37
0	37.30	3.00	3.81	2.65

Appendix D Site Inspections

Overview of site inspections

Two waterway-focussed site investigations to Laird Point were conducted. A reconnaissance survey was carried out on the 16 June 2009, with a second investigation held on the 7 October 2009. Details of these surveys are below. In addition, a site investigation was undertaken to assess ASS conditions on the site on 13-19 July 2009.

The reconnaissance survey in June was conducted during the dry season and from background research, no water was expected to be found within the study area. The Bureau of Meteorology recorded no rainfall for Gladstone or South End (on Curtis Island) for at least three weeks prior to the reconnaissance survey.

One water body was found within the Laird Point study area during the first reconnaissance survey. This was a small, established farm dam (Plate 8.1). A groundwater bore is located near the farm dam, which pumps water to the surface to fill the dam during dry periods (to provide water for stock). The groundwater bore and farm dam are no longer used. The dam contained very little vegetation at the time of the reconnaissance survey, consisting of generally filamentous and suspended algae. Soils in the vicinity were dusty, consisting of sandy silty clays and gravel, with some areas showing bedrock and cobble-sized material.

Plate 8.1 Laird Point farm dam, June 2009

The water in the dam was sampled and analysed, though it should be noted that this water is not representative of the surrounding surface environment and cannot be compared to water quality guidelines due to its being sourced from the nearby bore.

The farm dam was experiencing an algae bloom at the time of sampling, which would contribute to the organic speciation of nitrogen found within the water column. Additionally, the elevated chloride and sodium levels reflect the origin of the water, being from the groundwater bore.

Another site visit was carried out on 7 October 2009. The farm dam was found to be dry due to the extremely dry conditions of the previous months and the inactivity of pumping groundwater to the dam. Plate 8.2 shows the state of the farm dam in October 2009.

Plate 8.2 Laird Point farm dam, October 2009

A natural melaleuca wetland was found on site during the soils investigation survey from 13 – 19 July 2009 (Plate 8.3). Information regarding this wetland is in the Nature Conservation chapter. The wetland had suspended algae throughout the shallow water column, with no flow into or out of the wetland occurring at the time. No water sampling was carried out for this wetland, due to the site investigation being focussed on soils at that time.

Plate 8.3 Laird Point wetland, July 2009

In October 2009, the wetland was also found to be dry. Plate 8.4 highlights the conditions of the wetland during October.

Plate 8.4 Laird Point wetland, October 2009

Additional traversing of creek lines within the LNG facility site boundaries also confirmed the absence of water. Plate 8.5 to Plate 8.10 are characteristic photos of the watercourses and drainage lines within the Project area. These photographs provide evidence of pastoral use; erosion that occurs during heavy rainfall; areas of overland flow; collection of leaf litter; soil types and bedrock. The locations for the photos are shown on Figure 3.5.

Plate 8.5 Evidence of pastoral animals in the wetland

Plate 8.6 Watercourse showing defined flow path

Plate 8.7 Overland flow path, indicated by lack of vegetation

Plate 8.8 Scour erosion within overland flow path

Plate 8.9 Drainage line showing rock channel bed

Plate 8.10 Watercourse showing erosion

One other small wetland was found during the October field investigations. This was a melaleuca soak area on the southern side of the mudflats. The melaleucas were present in a slight depression that, although dry at the time of the assessment, would collect water from surface runoff during wet periods. Limited standing surface water would be present within the shallow depression, with the melaleucas surviving through groundwater. Plate 4-11 shows the Melaleuca soak.

Plate 8.11 Melaleuca soak, October 2009

Appendix E MUSIC Model Input Data

Climatic Data:

Rainfall Rockhampton 1950-59

- Mean Annual Rainfall 999mm
- Mean Annual Potential Evaporation 1701mm

Table 8.1 Soil Parameters: (Ref: BCC Guidelines)

Parameter	LNG Facility	Camp	Site TOTAL?
Field Capacity (mm)	80	80	80
Infiltration Coefficient *a*	200	200	200
Infiltration Exponent *b*	1	1	1
Rainfall Threshold (mm)	1	1	1
Soil Capacity (mm)	120	120	120
Initial Storage (%)	25	25	25
Daily Recharge (%)	25	25	25
Daily Drainage (%)	5	5	5
Initial Depth (mm)	50	50	50
Effective Impervious Area (%)	65	30	0

Table 8.2 Runoff Quality: (Ref: BCC Guidelines)

Landuse	Parameter	**TSS** ($\log_{10}$(mg/L)		**Total-P** ($\log_{10}$(mg/L)		**Total-N** ($\log_{10}$(mg/L)	
		Baseflow	**Stormflow**	**Baseflow**	**Stormflow**	**Baseflow**	**Stormflow**
LNG Facility (Industrial)	Mean	0.78	1.92	-1.11	-0.59	0.14	0.25
	Std Dev	0.45	0.44	0.48	0.36	0.20	0.32
Camp (Residential)	Mean	0.78	1.90	-1.11	-0.59	0.14	0.25
	Std Dev	0.45	0.44	0.48	0.36	0.20	0.32
Site (Forest)	Mean	0.51	1.90	-1.79	-1.10	-0.59	-0.075
	St Dev	0.28	0.20	0.28	0.22	0.22	0.24